

16. Assessment of Potential Terrestrial Ecology Effects

16.1 INTRODUCTION

This chapter of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS) identifies and evaluates the potential effects of the proposed Brucejack Gold Mine Project (the Project) on terrestrial ecosystems. Terrestrial ecosystems consist of living and non-living components interacting through the exchange of energy, nutrients, and waste. They are dynamic and can be defined at multiple spatial scales, ranging from the classification of site-specific plant communities to broad ecoregions. They differ in the type, quantity, and quality of functions they provide. In addition to providing timber resources, non-timber botanical resources, and habitat for fish and wildlife species, they also serve important roles in the regulation of ground and surface water; the enrichment and stability of soils and terrain; the cycling of nutrients; and the sequestering, storage, and release of carbon. Furthermore, they provide a wide array of cultural, commercial and personal recreation, and non-material aesthetic benefits. A full description of terrain, soils, ecosystems, and vegetation is located in [Appendix 16-A](#), Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies.

16.2 REGULATORY AND POLICY FRAMEWORK

The applicable legislation, organizations, guidelines, and best management practices of relevance to the management of terrestrial ecosystems and vegetation are listed and described below:

- (British Columbia; BC) *Mines Act* (1996a);
- (BC) *Forest and Range Practices Act* (2002b);
- (Canada) *Species at Risk Act* (SARA; 2002c);
- NatureServe (NatureServe 2012);
- British Columbia Conservation Data Centre (BC CDC; BC MOE 2007a);
- (BC) *Weed Control Act* (1996d);
- (BC) Northwest Invasive Plant Council (NWIPC; 2012);
- (BC) *Wildlife Act* (1996e);
- (BC) *Environmental Management Act* (2004);
- (Canada) *Fisheries Act* (1985);
- (BC) *Fish Protection Act* (1997);
- *Health, Safety and Reclamation Code for Mines in British Columbia* (the Code; BC MEMPR 2008); and
- *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* (CCME 2007).

Mines Act

The British Columbia Ministry of Energy and Mines (BC MEM) requires that Terrestrial Ecosystem Mapping (TEM) of a proposed mine site be completed for all mining permit applications.

The BC MEM requires characterization of baseline metal concentrations in plant tissues. This information is used to assess changes over time and to guide reclamation planning (BC MEMPR 2008).

Forest and Range Practices Act

The *Forest and Range Practices Act* (2002b) governs all forestry activities including logging, road building, reforestation, and floodplain area management. The Act requires that all forestry-related development be conducted in accordance with the rules and regulations identified in the Act to ensure the protection of environmental values. The *Forest and Range Practices Act* (2002b) addresses ecosystems as wildlife habitat through the Identified Wildlife Management Strategy. As unpaved roads have potential to contribute significantly to soil erosion, road construction within forested areas of BC is governed by the *Forest and Range Practices Act*. The Act requires that road construction adheres to codes provided in the Forest Service Road Use Regulation (BC Reg. 70/2004), which focuses extensively on erosion prevention.

Species at Risk Act

The purpose of SARA (2002c) is to prevent species at risk from becoming extirpated or extinct and ensure the appropriate management of species to prevent them from becoming at risk. Certain plant and lichen species are also protected under SARA as part of wildlife habitat and in accordance with the Canadian Biodiversity Strategy. The Canadian Biodiversity Strategy provides federal legislation that supports the conservation of particular species and populations to ensure continuance of biological diversity over time (Federal-Provincial-Territorial Biodiversity Working Group 1995).

Weed Control Act

The *Weed Control Act* (1996d) regulates the management of noxious plants in BC. The Act requires all land occupiers to avoid establishment and dispersal of noxious weeds as defined by the Act.

Northwest Invasive Plant Council

The NWIPC developed as a committee in 1992, and a not-for-profit organization in 2004, following a request by the inter-ministerial Invasive Plant Committee to pilot a single agency regional delivery model for invasive plant programs. The NWIPC provides support and coordination advice to those involved in invasive plant management and has a stated goal of “preventing further damage to the ecosystems of the northwest and central BC from invasive alien plants” (NWIPC 2012). The NWIPC’s board of directors represent a range of stakeholder groups, including local and provincial government, Aboriginal peoples, agriculture industries, utilities, and environmental groups. The NWIPC is governed by bylaws and a constitution and provides strategy documents for managing invasive species. A current list of the “most unwanted weeds” in the region is maintained on the NWIPC website (NWIPC 2012).

Wildlife Act

The provincial *Wildlife Act* (1996e) provides for conservation of specific ecosystems and ecosystem components that provide habitat for species managed by the BC MOE.

Environmental Management Act

The *Environmental Management Act* (2004) brings together the provisions of the previous *Waste Management Act* (1996b) and *Environment Management Act* (1996a) into a single statute, and prohibits the introduction of deleterious substances into the environment in any manner or quantity that may cause pollution to the environment as defined in the Act. This includes substances that would degrade or contaminate soil and water, which could in turn have deleterious effects on terrestrial ecosystems. The Contaminated Sites Regulation (BC Reg. 375/96) included in BC’s *Environmental Management Act*

(2004) lists Soil Criteria for Toxicity to Soil Invertebrates and Plants. These provide numerical standards to define whether a site is contaminated, to determine liability for site remediation, and to assess reclamation success.

Fisheries Act

The federal *Fisheries Act* (1985) provides the legal framework to protect fish habitat from flooding and potential loss of land due to stream erosion and instability. Section 35 establishes rules guiding development within the Fisheries Sensitive Zones and watercourses. Section 36 establishes rules for erosion control related to land development activities, such as clearing land, grading slopes, and road construction and maintenance.

Fish Protection Act

The *Fish Protection Act* (1997) and associated amendments to the provincial *Water Act* (1996c) regulate provincial approvals of alterations and work in and around watercourses. The regulations focus on floodplain retention, which may be involved in vegetation removal and introduction of harmful debris (clay, silt, sand, rock, or any material, natural or otherwise) into the waterways.

Health, Safety and Reclamation Code for Mines in British Columbia

The Code (BC MEMPR 2008) requires that the environmental protection of land and water resources, as well as the reclamation of disturbed land be planned in advance and that plans follow standards outlined by the Code. The Code specifies standards (Reclamation and Closure, Part 10) that must be achieved during mining activities and requires regular site inspections and annual reporting to ensure compliance.

16.3 BASELINE CHARACTERIZATION

16.3.1 Regional Overview

In order to present the regional ecological context in which the Project resides, the area is described using both BC Ecoregion Classification and Biogeoclimatic Ecosystem Classification (BEC) systems. The BC Ecoregion Classification system, developed originally by the BC MOE in 1985, serves as a framework to identify small-scale ecosystems and to better understand and depict habitat diversity across BC (Demarchi 2011). Ecoregions represent broad areas of major physiographic and minor macroclimatic variation. Within ecoregions, ecosections depict areas of minor physiographic and minor macroclimatic variation. BEC interprets the interactions of dominant vegetation, soils, and topography to identify geographic areas (biogeoclimatic zones and subzones) with a relatively uniform climate. BEC ecosystems identified within the area of the Project are presented in Section 16.3.4, Characterization of Terrestrial Ecology Baseline Condition.

The Project overlaps three ecoregions: the Skeena Mountains, Boundary Ranges, and Nass Ranges ecoregions (Figure 16.3-1). Towards the coast, the Boundary Ranges Ecoregion consists of extensive ice fields capping granitic intrusions remnant of the Coast Range Arc, and is dissected by several major river valleys, including the Nass Valley. Inland and east of the Nass Valley is the Skeena Mountains Ecoregion, which consists of high, rugged mountains within a moist, coastal - interior transition climate, supporting many glaciers. The Nass Ranges Ecoregion, within a climate somewhat transitional between coastal and interior regimes (Demarchi 1996), represents a mountainous area west of the Kitimat Ranges (south of the Project).

Three ecosections are present in the Project region, including two within the Nass Ranges Ecoregion (the Meziadin Mountains and Nass Basin Ecosections), and one within the Boundary Ranges Ecoregion (the Southern Boundary Ranges Ecosection). The Meziadin Mountains Ecosection is a rugged,

mountainous area on the leeward side of the main Boundary Ranges. The mountains are predominantly underlain by volcanic and sedimentary rock, and the area is heavily glaciated. Ice that formed in the Boundary Ranges during the last years of the Pleistocene Epoch moved east into the Nass Basin, coalescing with ice moving south from the adjacent Skeena Mountains which then moved down and out the Nass Valley. Remnants of this glacial advance remain on the mountain summits in the form of retreating glaciers and ice fields. There is a strong rain shadow effect here, as the western summits protect this area from Pacific air that arrives from over the Boundary Ranges to the west.

Near Highway 37, the Brucejack Access Road crosses through the Nass Basin Ecosection, a basin of low relief encircled by sharply rising mountains that includes the Boundary Ranges to the west and the Skeena Mountains to the east. Bedrock underlying this basin is predominantly volcanic and sedimentary, and the relief is more subdued than that found in other adjacent ecosections. Glaciers that formed in the Boundary Ranges and Skeena Mountains during the most recent glaciation flowed down, out, and over these flat lands, and south, down the Nass River. The climate is intermediate between the cool, wet conditions of the outer coast and the drier conditions of the interior, resulting in forested ecosystems that have both coastal and continental characteristics.

The western and southern areas associated with the Project cross into the Southern Boundary Ranges Ecosection, an area of rugged mountains that are capped with glaciers, small ice fields, and exposed granitic and metamorphic bedrock. Moist Pacific air moves over this ecosection, bringing intense precipitation to the windward slopes and adjacent mountains in the northern interior of BC.

16.3.1.1 Protected Areas

BC's provincial parks protect nationally and internationally significant ecological and cultural values. Ecological reserves are areas selected to preserve representative and special natural ecosystems, plant species, and animal species. The closest protected area to the Project is the Border Lakes Provincial Park. North of the Project lies the Ningunsaw River Ecological Reserve, established to ensure preservation of a cross-elevation sequence of three BEC zones that represent a transition between coastal and interior climates.

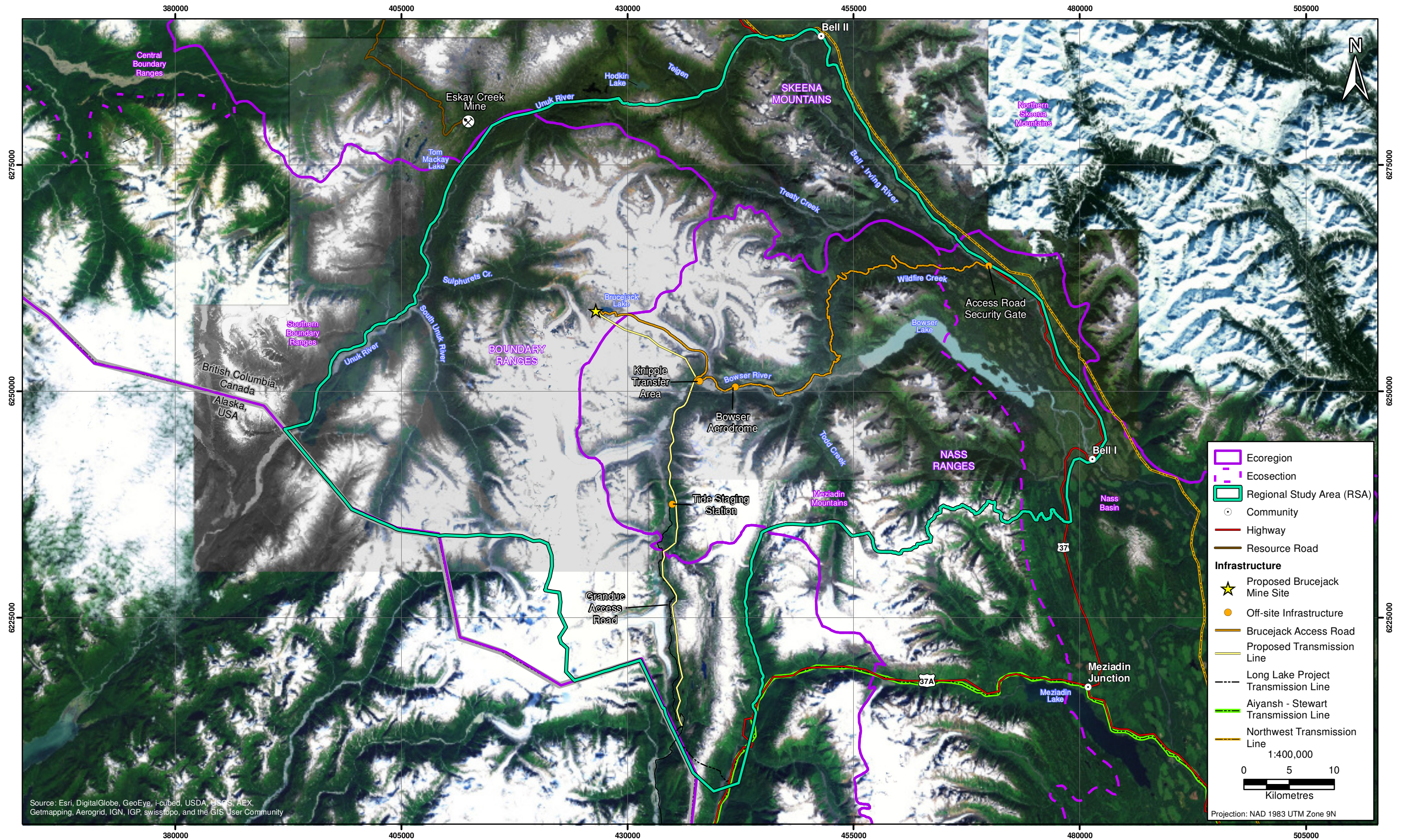
16.3.2 Historical Activities

Several historical and current human activities are within close proximity to the proposed Project area. These include mining exploration and production, hydroelectric power generation, forestry, and road construction and use.

The Granduc Mine was a copper mine located approximately 25 km south of the Project site, which operated from 1970 to 1978 and 1980 to 1984. The mine included underground workings and a mill site near Summit Lake, connected by an 18.4 km tunnel. In addition, a 35 km all-weather access road was built from the communities of Stewart, BC and Hyder, Alaska to the former mill site near Summit Lake. The area of the former mill site near Summit Lake is currently used as staging for several mineral exploration projects in the region. The terminus of the Granduc Access Road is 25 km south of the proposed Brucejack Mine Site and is currently used by mineral exploration traffic and tourists accessing the Salmon Glacier viewpoint.

The Sulphurets Project was an advanced underground exploration project of Newhawk Gold Mines located at the currently proposed Brucejack Mine Site. Underground workings were excavated between 1986 and 1990 as part of an advanced exploration and bulk sampling program. Reclamation efforts following Newhawk Gold Mine's advanced exploration work included deposition of waste rock and ore within Brucejack Lake.

Figure 16.3-1
Distribution of Ecoregions



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

The exploration phase of the Project commenced in 2011 and has included a drilling program, bulk sample program, construction of an exploration access road from Highway 37 to the west end of Bowser Lake and rehabilitation of an existing access road from the west end of Bowser Lake to the Brucejack Mine Site.

In 2010, construction began on the Long Lake Hydroelectric Project located approximately 42 km south of the Project. It includes redevelopment of a 20-m-high rock fill dam located at the head of Long Lake, and a new 10-km-long 138-kV transmission line.

Historical forestry activities occurred within the immediate Project area between Highway 37 and Bowser Lake, south of the Wildfire Creek and Bell-Irving River confluence.

North of the Project is the Eskay Creek Mine, an underground gold and silver mine that operated from 1995 to 2008 and is currently in the decommissioning phase. It has a rather small surface disturbance, with the total area of ecosystems disturbed by the mine and the Eskay Creek Spur Road estimated at less than 50 ha (Murphy and Napier 1996; Barrick Gold Inc. 2004).

Relatively little forest harvesting has occurred throughout the region, due largely to the remoteness of the area and poor commercial timber quality. The previous harvesting activity that has occurred is largely concentrated around the Bell-Irving River and Highway 37 and on the slopes south of Wildfire Creek. Harvesting along Highway 37 is extensive, with little intact forest remaining between Meziadin Junction and Bell II.

Additional details regarding historical and current human activities near the Project are included in Section 6.9.2, Projects and Activities Considered.

16.3.3 Baseline Studies

Terrestrial ecosystem baseline studies were undertaken in 2012 and 2013 within a Local Study Area and Regional Study Area. The goal of the baseline studies was to characterize the ecosystems, vegetation, terrain, and soils that could potentially be affected directly or indirectly by the Project. Specific objectives included the following:

- map and characterize the terrain, surficial materials, and soils in the LSA;
- map and characterize ecosystems in the LSA, including sensitive and rare ecosystems;
- map and characterize ecosystems in the RSA;
- identify soil characteristics that may be sensitive to disturbances and features that could potentially affect the construction, operation, and decommissioning of the Project facilities;
- identify plant species present in the LSA, including culturally and/or economically important plants, invasive plants, and those species tracked by the BC CDC, NatureServe, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and protected under SARA or otherwise considered rare or of conservation interest;
- determine soil and vegetation baseline metal concentrations; and
- collect sufficient information to develop the effects assessment, management and mitigation plans, and the reclamation and closure plan.

16.3.3.1 Data Sources

Existing information regarding terrestrial ecosystems was collected in order to augment baseline studies. These sources included the following:

- data made available from First Nations and local stakeholders or through ethnographic reports;

- BEC line work and descriptions (2008 and 2012);
- Ecoregion Classification line work and descriptions;
- NatureServe Conservation Ranks (for provincially, nationally, and globally rare plants and lichens);
- BC CDC (for provincially blue- and red-listed plants and ecosystems);
- SARA;
- publically available data from other terrestrial ecosystems baseline studies conducted in the general vicinity of the Project;
- Vegetation Resource Inventory (information on the location and type of vegetation resources in the province);
- Digital Elevation Models;
- Terrain Resource Information Management;
- data acquired via data sharing agreements;
- the Cassiar Iskut-Stikine Land and Resource Management Plan (LRMP; BC ILMB 2000); and
- the Nass South Sustainable Resource Management Plan (SRMP; BC MFLNRO 2012).

16.3.3.2 *Methods*

The methods used for baseline studies including those for terrain mapping, predictive and terrestrial ecosystem mapping, field data collection and analysis, rare plant and lichen survey design, metal collection and quality assurance and control are summarized in the following sections.

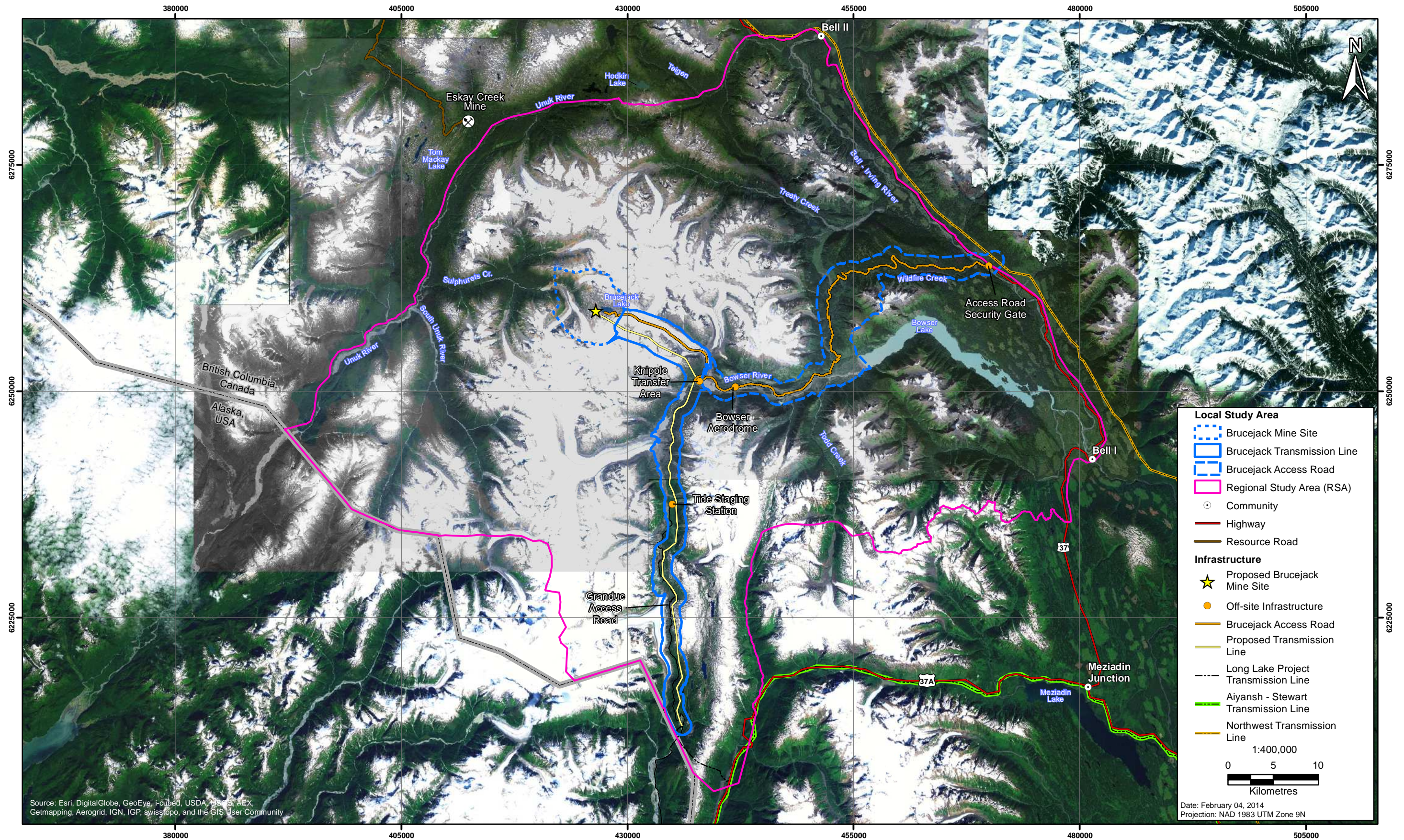
Baseline Study Area

The Project is situated approximately 20 km northwest of Bowser Lake or 65 kilometres north-northwest of the town of Stewart, BC. It is located within the Regional District of Kitimat-Stikine, an administration providing local government services to member municipalities within northwestern BC. Portions of the proposed Project infrastructure are within Skii km Lax Ha traditional territory and, to a lesser extent, Tahltan traditional territory and the Nass Area. It is also situated within the Kalum and Skeena-Stikine Forest Districts, and the Nass and the Cassiar Timber Supply Areas, administrative boundaries within which forest resources are presently managed by the British Columbia Ministry of Forests, Lands and Natural Resource Operations. The Project also overlaps portions of the CIS LRMP area, completed in October 2000 (BC ILMB 2000), and the Nass South SRMP area, completed in June 2012 (BC MFLNRO 2012).

Ecosystems and vegetation were characterized for two study areas, an LSA and a RSA (Figure 16.3-2). The LSA is 31,847 ha and is defined by a buffer extending at least to the height of land or for 1.0 km around the outer limits of the proposed infrastructure and linear developments. Watershed height-of-land borders are often used to define study areas, as they are physical barriers to transference of many Project-related effects. Buffers are used to account for the potential effects that could migrate beyond the Project footprint, such as those related to hydrologic change and dust.

In certain areas other physical features were also used to define the LSA, when they were considered likely to be the limit of the potential effects of the Project. For example, along the Brucejack Transmission Line, the western bank of the Salmon River forms much of the western LSA boundary, as downstream effects of upstream construction, such as erosion and sedimentation, are unlikely to impact beyond this physical barrier.

Figure 16.3-2
Terrestrial Ecology Study Areas



The LSA was divided into three separate sub-areas for the purposes of this assessment because of the variety of landforms and vegetation types present in the LSA, the different types of effects that may result from the various infrastructure components, and the relatively large geographical separation among some of the various infrastructure components. These three areas include the Brucejack Access Road sub-area, the Brucejack Mine Site sub-area, and the Brucejack Transmission Line sub-area. The Brucejack Access Road sub-area is 13,835 ha, and has a climate that transitions from coastal at the western edge to continental at the eastern edge. The Brucejack Mine Site sub-area is 5,040 ha, and is situated above the tree line in alpine and parkland ecosystems. The Brucejack Transmission Line sub-area is 12,972 ha, and extends from around the Premier mine site to the Brucejack Mine Site.

The RSA is 374,433 ha, and took into account the area that provides habitat for wildlife species that may come into contact with proposed Project infrastructure during the course of a season or a lifetime. Other ecological factors, such as height of land, were also considered when delineating boundaries.

Terrain Mapping

Terrain mapping involves the delineation and identification of permanent terrain units based upon observable characteristics such as surficial material, terrain texture, surface expression, and geomorphic processes. Attributes were described using BC's Terrain System Classification for British Columbia (Howes and Kenk 1997), and recorded in a database linked to the ArcGIS terrain data. During development of the preliminary TEM, the terrain polygons were further split, where appropriate, to parse out discrete ecosystems. Not all terrain polygons were necessarily cut, however, as ecological and vegetation development is often dictated by the underlying terrain features.

Predictive and Terrestrial Ecosystem Mapping

Two different ecosystem mapping methodologies, PEM and TEM, were used to map terrestrial ecosystems within the RSA and LSA, respectively.

PEM is an automated, computer-based method that uses available imagery, spatial data, and ecological knowledge to predict the type and distribution of ecosystems within a given area. PEM is typically used to provide ecological context over large study areas and is a useful tool for landscape level planning.

TEM involves both the classification of surficial materials and the delineation of ecosystems, and uses the terrain mapping as the base layer. Initial mapping involves polygon delineation and the assigning of general attributes to the individual polygons. Detailed attributes are assigned using the field data collected from ground plots. Polygon attribute data included terrain modifiers such as texture, parent material, surficial expression, and geomorphic process. Ecosystem attributes included information regarding BEC unit, site series, vegetation association, seral stage, and structural stage. This information was used to modify the polygon descriptions so that spatially disparate yet ecologically similar polygons were described in a similar manner.

Structural stage (the existing vegetation developmental stage) mapping was completed for the LSA concurrently with the delineation of site series during TEM through air photo interpretation. For the RSA, structural stage was assigned during PEM, based on the classified satellite imagery land cover outputs. On this one-dimensional imagery, some structural stages can be difficult to distinguish from one another. However, field surveys indicated forests were largely structural stages 6 and 7, with a minor component of structural stage 5. Therefore, all areas classified as "conifer" in the land cover map were assumed to be structural stages 6 and 7 for the purposes of this study and the wildlife assessments. Likewise, all areas classified as herb and shrub were assigned a structural stage of 2 and 3, respectively. Manually delineated floodplain forests based on visual image interpretation were assigned a structural stage of 4/5. General assumptions were made for the structural stages of the

wetlands identified from the Terrain Resource Information Management base. As marshes, by definition, are herb-dominated, they were assigned a structural stage of 2; swamps can be a range of structural stages but are most commonly shrub-dominated so were assigned a structural stage of 3.

Project-specific soil maps were developed based on the results of terrain mapping, TEM, wetland mapping, and slope gradient class mapping, and are detailed in Section 7.2 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#). The soil polygons delineated on the soil map are based on the TEM line work. The relationship between soil moisture regime and soil development (related to soil order classification) was derived from a combination of the soil (mineral soils) and wetland (primarily organic soils) inspection data, field guide landscape relationships for the forest region (Banner et al. 1993), and the Biophysical Soil Landscapes Inventory of the Stikine-Iskut Area (Fenger and Kowall 1992). The individual Soil Map Units (SMUs) are defined by a combination of attributes, including soil climate, parent material (terrain surficial material), drainage (as derived from soil moisture regime), and probable soil development to the Canadian System of Soil Classification order level of classification (Soil Classification Working Group 1998).

Soils Inspections

Soil inspections (including profile descriptions) were carried out following the guidelines established in the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Environment Lands and Parks and BC Ministry of Forests Research Branch 1998). Soils classification, to the order level, is inferred primarily from soil morphologic observation interpretations, with very limited lab data. Soil orders are as described in the Canadian System of Soil Classification (Soil Classification Working Group 1998).

Soil inspection information is used to characterize the Soil Map Units developed for soil mapping. Soil mapping, as described in Section 6.2.3 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#), is largely an interpretive exercise based upon field data, terrain attributes, and local climate and is completed primarily to identify sensitive soils and to support soil salvage and reclamation planning.

Soils Map Units

SMUs are developed to describe the range of soil resources in the LSA. They are the basic unit used to describe the soil within a mapping polygon. SMUs aggregate the soil development and terrain types into groups that can be interpreted for various uses and/or management. A common example is the use of SMUs to identify soils suitable for use as a growing medium to support reclamation objectives.

Ecosystems of Conservation Interest

A search of the online databases maintained by the BC CDC was conducted, and a list of blue- or red-listed ecosystems potentially occurring in the study area was compiled and compared to the results of the ground field surveys and the ecosystem mapping. Rankings depend on factors such as rarity, intrinsic vulnerability, environmental specificity, threats, and long- and short-term trends in population size or area (BC MOE 2007a). The identification of unusual substrates and vegetation patterns during the air photo interpretation stage of TEM was used to locate potential field inspection sites for ecosystems of conservation interest.

Culturally/Economically Important Plants

Based on information provided by the Skii km Lax Ha (Appendix A of Rescan 2013) and from a literature search on economically important harvestable plants in the North (Sharmin, Holly Ridenour, and Philpot 1998; Berch and Cocksedge 2003), a list of culturally/economically important plant species was

compiled. From this list, three species—soapberry, devil’s club, and pine mushroom—were selected for further study, which included mapping of likely habitat based on known habitat attributes.

Rare Plant and Lichen Surveys

Rare plant and lichen surveys were conducted in 2012 and 2013 to determine the presence of species that are red (extirpated, endangered, or threatened) or blue (of special concern) listed and/or have a conservation-priority S-ranking (subnational, i.e., provincial, conservation ranking; protection under the *Species at Risk Act*; SARA), those ranked as threatened or endangered by COSEWIC or otherwise considered rare within the LSA and at select sites within the surrounding area.

Surveys were timed to optimize plant identification (e.g., during flowering and/or fruiting) and occurred twice during the summers of 2012 (July 12 to 17 and August 31 to September 3) and 2013 (July 9 to 16 and August 15 to 20).

All surveys were conducted by a qualified botanist using a controlled intuitive wander method. Survey efforts focused on sites where proposed infrastructure overlapped with likely rare plant habitat within the LSA. Outside of the LSA, rare plant surveys were conducted at select sites to provide a regional context of plant and lichen species.

Invasive Plant Surveys

A list of invasive plants, according to the NWIPC and the BC *Weed Control Act* (1996d), was compiled prior to fieldwork. Detailed invasive plant surveys occurred in conjunction with the rare plant surveys within the LSA and within the surrounding area. Additionally, presence/not detected level surveys for invasive plants were conducted throughout the study area in conjunction with mapping field surveys.

Laboratory Metals Analysis

Tracking metal concentrations in soils and plant tissues is a typical requirement for mine applicants and is used to guide reclamation planning and establishing end land use objectives (BC MEMPR 2008). The metals analyses determine baseline metal levels in the area of proposed infrastructure as well as control sites outside of the expected zone of influence of a project’s environmental effects. These data comprise the basis to evaluate any changes in metal levels due to the Project. Samples collected and analyzed included soil, and lichen and plant tissue. Results from the baseline metals analysis are located in [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#).

Quality Assurance and Quality Control

Quality assurance and quality control was carried out throughout each phase of the Project. Initial polygon delineation for TEM and terrain mapping was checked for slivers and other errors by senior geographic information system staff. Once polygons were attributed, image interpretation and data entry was assessed by a senior ecologist and terrain specialist. Data collected in the field was entered into a Microsoft Access database, with the data entry checked by the senior ecologist. Each data card set was assessed for entry and interpretive errors. Review of final mapping of terrain and ecosystems was carried out by a senior terrain specialist and senior ecologist.

16.3.4 Characterization of Terrestrial Ecology Baseline Condition

The results of the 2012 to 2013 baseline studies are summarized in the following sections. Included is a description of the BEC units within the RSA and LSA as well as a more detailed summary of surficial terrain, ecosystems, plants and lichens of conservation interest, and laboratory metals analysis within each sub-area of the LSA.

16.3.4.1 Regional Study Area

Nine BEC units occur within the RSA, including both coastal and interior units (Table 16.3-1; Figure 16.3-3a and 16.3-3b). Six of the nine BEC units are forested and cover about 42% of the RSA, while the three alpine and parkland BEC zones collectively contribute more than 58% of the RSA.

Table 16.3-1. BEC Units in the Regional Study Area

| BEC Unit Name | Description | BEC Unit Label | RSA Extent (ha) | RSA Extent (%) |
|---|---------------------------------|----------------|-----------------|----------------|
| Boreal Altai Fescue Alpine - Undifferentiated Parkland Subzone | Alpine/Parkland | BAFAunp | 36,843 | 10 |
| Coastal Mountain-heather Alpine - Undifferentiated Parkland Subzone | Alpine/Parkland | CMAunp | 11,2604 | 30 |
| Coastal Western Hemlock - Wet Maritime Subzone | Low elevation forest (coastal) | CWHwm | 11,883 | 3 |
| Engelmann Spruce - Subalpine Fir Undifferentiated Subzone | Subalpine forest (interior) | ESSFun | 25,015 | 7 |
| Engelmann Spruce - Subalpine Fir Undifferentiated Parkland Subzone | Subalpine forest (interior) | ESSFunp | 12,810 | 3 |
| Interior Cedar Hemlock - Very Wet Cold Subzone | Low elevation forest (interior) | ICHvc | 59,522 | 16 |
| Mountain Hemlock, Windward Moist Maritime | Subalpine forest (coastal) | MHmm1 | 4,570 | 1 |
| Mountain Hemlock - Leeward Moist Maritime Variant* | Subalpine forest (coastal) | MHmm2 | 43,498 | 12 |
| Mountain Hemlock, Moist Maritime Parkland | Alpine/Parkland | MHmmp | 67,676 | 18 |
| Total | | | 374,422 | 100 |

Generally the coastal BEC units (CWHwm, MHmm1, MHmm2 and CMAunp) are more prevalent in the west, while the transitional and interior BEC units (ICHvc, ESSFun, ESSFunp and BAFAunp) are more common in the east. In the coastal areas, the typical elevation transition is from CWHwm along the valley bottoms to about 800 m, depending on continentality, where it is succeeded by the MHmm2. The MHmm2 is succeeded by the CMAunp where late season snowpack persists to the point that forest does not grow. Parklands units occur in the transition from forest to alpine, where edaphic and microclimate conditions allow for variations in the depth of snowpack, facilitating a mosaic of tree islands and non-forested alpine ecosystems.

16.3.4.2 Boreal Altai Fescue Alpine – Undifferentiated Parkland (BAFAunp)

BAFAunp is found at high elevations in the province's interior. It is the transitional zone in between forested subzones at lower elevations and the true alpine at higher elevations. Vegetation is dominated by spruce and subalpine fir (BC MOFR 2006), dwarf willows, sedges, lichens and grasses (Banner et al. 1993).

16.3.4.3 Coastal Mountain-Heather Alpine – Undifferentiated Parkland (CMAunp)

The CMAunp occurs at high elevations on the coastal mountains. The parkland region is the transitional zone in between forested subzones at lower elevations and the true alpine at higher elevations. This zone is a very wet environment, and tends to have a deeper snowpack which extends to lower elevations than other BEC alpine zones which in turn extends the zone down in elevation as compared to other alpine zones. The CMA parkland vegetation consists of mountain heathers (*Cassiope* spp.), while mountain hemlock (*Tsuga mertensiana*), yellow-cedar (*Chamaecyparis nootkatensis*) and subalpine fir (*Abies lasiocarpa*) are the treeline tree species that are primarily in krummholz form (BC MOFR 2006).

Figure 16.3-3a
 Distribution of General Ecosystem Types
 in the Regional Study Area - Map 1

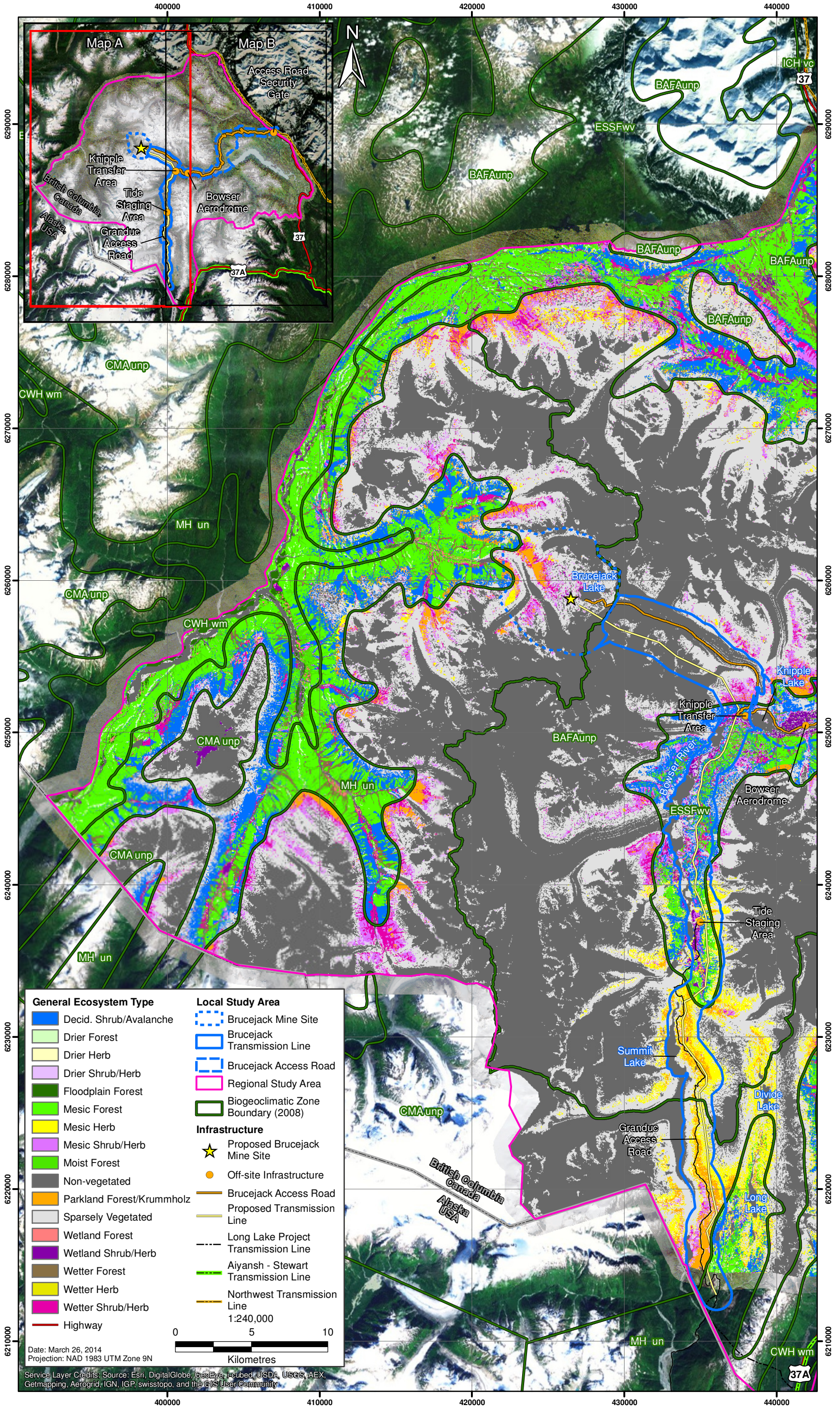
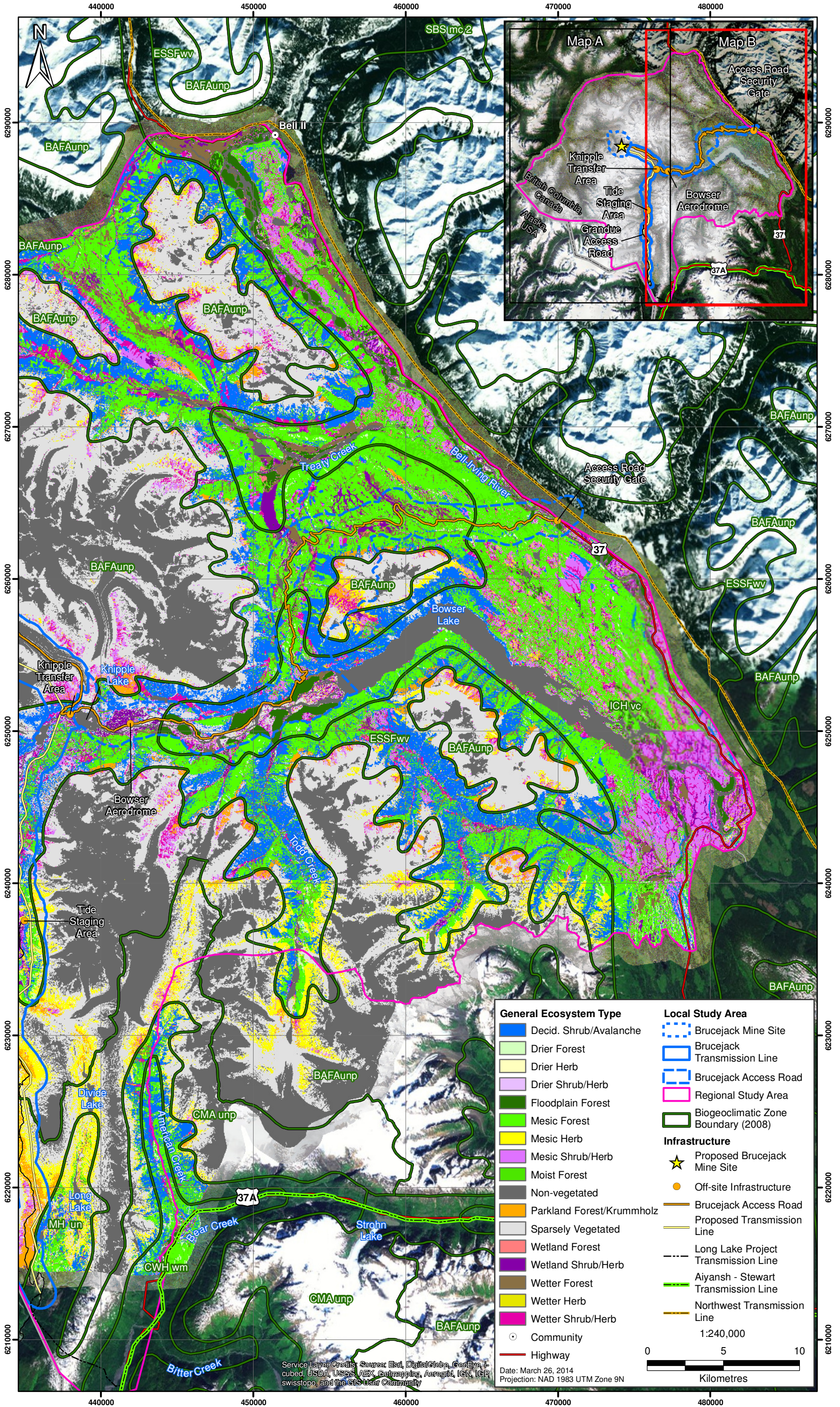


Figure 16.3-3b
 Distribution of General Ecosystem Types
 in the Regional Study Area - Map 2



16.3.4.4 Coastal Western Hemlock Wet Maritime Subzone (CWHwm)

The CWHwm is the most northerly of the CWH subzones, and has heavier snow and a shorter growing season than more southerly subzones (Banner et al. 1993). It occurs at elevations from sea level to 600 m. The summer is cool and moist, fall is very wet, and winter is cool and has heavy, wet snowfalls. Based on data from the nearby town of Stewart, which is representative of this subzone, mean annual temperature is around 5.1 °C while mean annual precipitation is around 1,843 mm (Banner et al. 1993). This subzone is noted for its low plant species diversity compared to southerly subzones. Zonal sites are typically dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*). Blueberries, both oval-leaved blueberry (*Vaccinium ovalifolium*) and Alaskan blueberry (*Vaccinium alaskaense*), are abundant in the understory (except in floodplain sites), and typically occur with false azalea (*Menziesia ferruginea*), bunchberry (*Cornus canadensis*), five-leaved bramble (*Rubus pedatus*), and spiny wood fern (*Dryopteris expansa*). Western red cedar (*Thuja plicata*), yellow cedar (*Chamaecyparis nootkatensis*) and amabilis fir (*Abies amabilis*) are uncommon or absent (Banner et al. 1993).

16.3.4.5 Mountain Hemlock Leeward Moist Maritime Variant (MHmm2)

The Mountain Hemlock (MH) zone is the subalpine zone of BC's Coast Mountains, and is the coastal counterpart to the interior's ESSF zone. As with the ESSF, continuous forests give way to patchy clumps of trees, subalpine heath and lush meadows at higher elevations (Banner et al. 1993).

The ecological classification of the Mountain Hemlock BEC unit in the RSA is currently incomplete; subzones and/or variants are not yet recognized or documented for this area. However, data collected by field personnel during the 2008 baseline field studies for the adjacent KSM project (which has the same RSA) resulted in reclassification of the RSA location from MHun subzone to the MHmm2 variant. The MHmm2 in the region generally starts at 900 to 950 m in elevation, becomes parkland at 1,100 to 1,150 m and alpine at 1,450 m (Banner 2009). It has a climate transitional between the coast and interior, characterized by long, moist, cold winters and short, cool, moist summers. Heavy snow, a short growing season, wet soils and exposure to wind and cold reduces the forest productivity in this zone (Banner et al. 1993). Forests on zonal sites are dominated by amabilis fir (*Abies amabilis*) and mountain hemlock, with western hemlock occurring at lower elevations and subalpine fir occurring less commonly (Pojar, Klinka, and Demarchi 1991).

16.3.4.6 Interior Cedar Hemlock Very Wet Cold Subzone (ICHvc)

The ICH zone is a transitional zone between the wetter CWH zone to the west and the drier Sub-Boreal Spruce (SBS) zone to the east, and contains both coastal and interior plant species. The ICHvc ranges in elevation from 240 to 1,000 m. The subzone is cool and moist year-round with a thick and long-lasting snowpack, thus zonal sites are typically productive forests containing moisture-loving species such as devil's club (*Oplopanax horridus*) and oak fern (*Gymnocarpium dryopteris*; Ketcheson et al. 1991; Banner et al. 1993).

16.3.4.7 Engelmann Spruce Wet Very Cold— Subalpine Fir Subzone (ESSFwv)

The ESSF zone is broadly transitional between true coastal and interior BEC units. The ESSF zone is the highest forested zone in BC, occurring on rugged mountainous terrain throughout the province at elevations above other forested zones (Coupe, Stewart, and Wikeem 1991; Banner et al. 1993). The ESSFwv (wet, very cold ESSF) is the most northerly ESSF subzone in BC, occupying the northwestern part of the province (north of the Skeena River), typically between 900 and 1,550 m in elevation. It is one of the wetter subzones in the ESSF, with mean annual precipitation ranging from 650 to 1,100 mm. It has a snowier winter and a moister growing season than other ESSF subzones. Growing season moisture deficits are unlikely. Snow may persist for six to nine months of the year (Banner et al. 1993).

The forests are predominately coniferous. Zonal sites represent moderately productive forests, and are dominated by subalpine fir. The ESSFwv subzone commonly has a moderately dense ericaceous shrub layer and a very productive herbaceous layer on zonal sites (Coupe, Stewart, and Wikeem 1991). The dominant understory plants are black huckleberry, oval-leaved blueberry, false azalea, five-leaved bramble, bunchberry, red-stemmed feathermoss (*Pleurozium schreberi*), and leafy liverworts.

16.3.4.8 Local Study Area

The Brucejack Mine Site sub-area, comprising approximately 16% of the LSA, overlaps the smallest number of BEC units and occurs within an area comprised largely of non- and sparsely vegetated alpine ecosystems (Figure 16.3-3c to 16.3-3e). The Brucejack Access Road sub-area, comprising approximately 43% of the LSA, is dominated by forested ecosystems, including wetlands and floodplain ecosystems. The Brucejack Transmission Line sub-area, comprising approximately 41% of the LSA, overlaps the greatest number of BEC units and grades from old forest in the south to early seral ecosystems and non-vegetated areas in the north. The distribution of terrestrial ecosystems and dominant surficial materials mapped within the respective sub-areas are presented within Tables 16.3-2 and 16.3-3.

Table 16.3-2. BEC Unit Summary within Sub-areas of the Terrestrial Ecosystems Local Study Area

| BEC Unit | Brucejack Mine Site (ha) | Brucejack Access Road (ha) | Brucejack Transmission Line (ha) | Total (ha) | % LSA |
|---------------|--------------------------|----------------------------|----------------------------------|---------------|-------------|
| ICHvc | 0 | 6,181 | 0 | 6,181 | 19% |
| ESSFwv | 0 | 6,407 | 40 | 6,447 | 20% |
| ESSFwvp | 0 | 507 | 61 | 568 | 2% |
| MHmm1 | 0 | 0 | 1,563 | 1,563 | 5% |
| MHmm2 | 679 | 4 | 4,152 | 4,835 | 15% |
| MHmmp | 609 | 0 | 3,254 | 3,863 | 12% |
| CMAun | 3,753 | 0 | 3,626 | 7,379 | 23% |
| BAFAun | 0 | 736 | 4 | 739 | 2% |
| UNCLASSIFIED* | 0 | 0 | 272 | 272 | 1% |
| Total | 5,040 | 13,834 | 12,972 | 31,847 | 100% |

* Aerial imagery unavailable for the very southern end of the Brucejack Transmission Line sub-area.

The preliminary ecosystem mapping was refined by the TEM field survey data, in order to have the attributes ascribed best reflect on the ground conditions. A total of 1,428 TEM polygons were mapped within the LSA, with polygons ranging from as large as 3,100 ha (a glacier) to less than 1 ha. The median TEM polygon size is approximately 11.0 ha, very consistent with the average size expected within the provincial TEM Standards (RIC 1998).

Terrestrial ecosystems of particular sensitivity include vegetated alpine and parkland ecosystems, old forests, floodplain and floodplain ecosystems, and provincially rare (blue- and red-listed) ecosystems. Although alpine and parkland BEC units comprise nearly 40% (25 and 14% for alpine and parkland, respectively) of the entire LSA, much of this area is dominated by non-vegetated and sparsely vegetated units such as glaciers, exposed bedrock, moraine and talus. Vegetated alpine and parkland ecosystems comprise 11% (2 and 9% for alpine and parkland, respectively) of the LSA. Old forest ecosystems comprise approximately 13% of the LSA, largely within the Brucejack Access Road sub-area. Ecosystems listed by the BC CDC, consisting of forested floodplain and wet, herb- and shrub-dominated wetlands and thickets, comprise approximately 4% of the LSA, entirely within the Brucejack Access Road sub-area. Floodplain and floodplain ecosystems, not including listed ecosystems, comprise approximately 7% of the LSA, largely within the Brucejack Access Road sub-area. Descriptions of the baseline terrestrial ecosystems, by sub-area, are provided below.

Figure 16.3-3c
 Exploration Access Road Sub-area Terrestrial Ecosystem Map

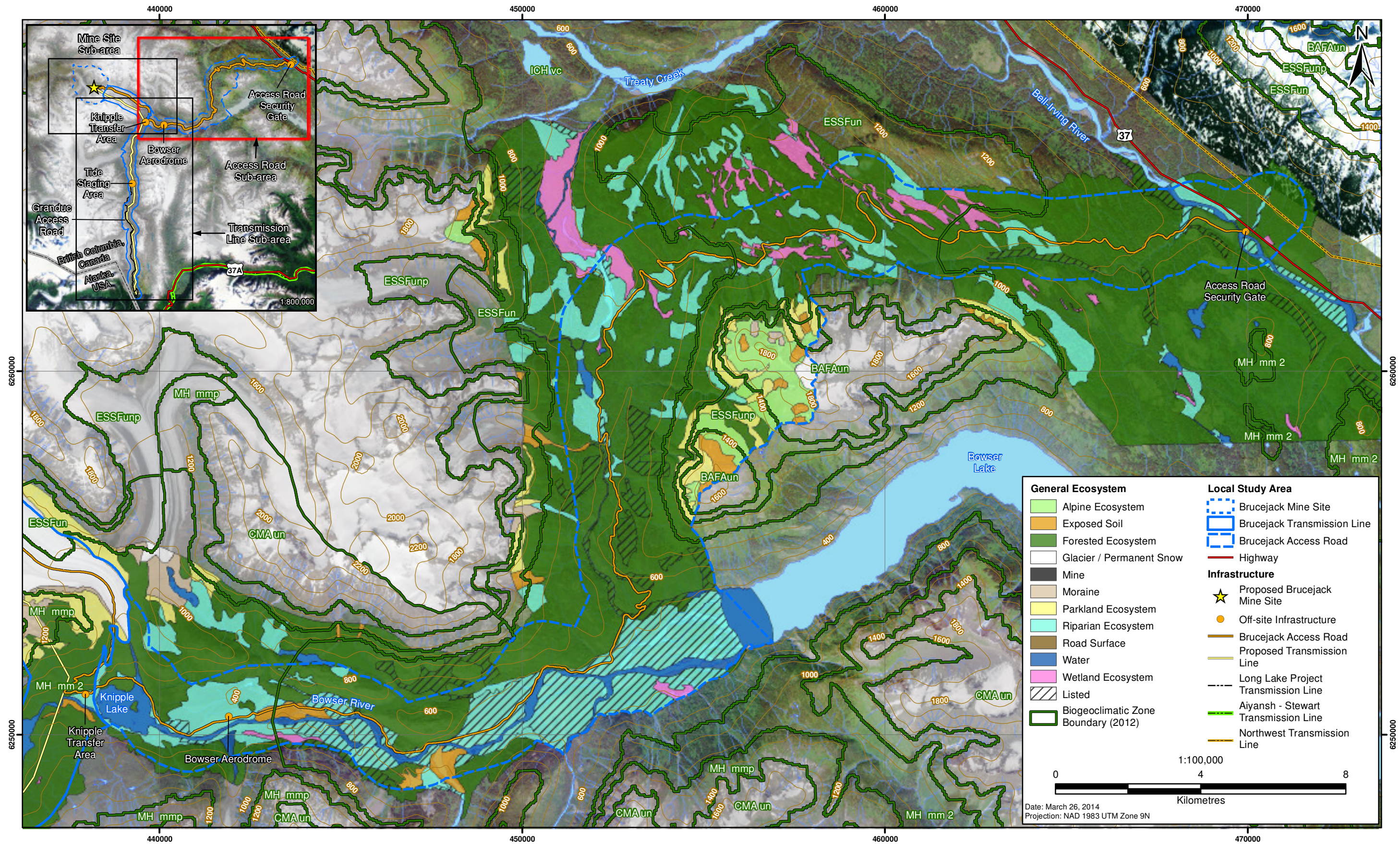


Figure 16.3-3d
Brucejack Mine Site Sub-area Terrestrial Ecosystem Map

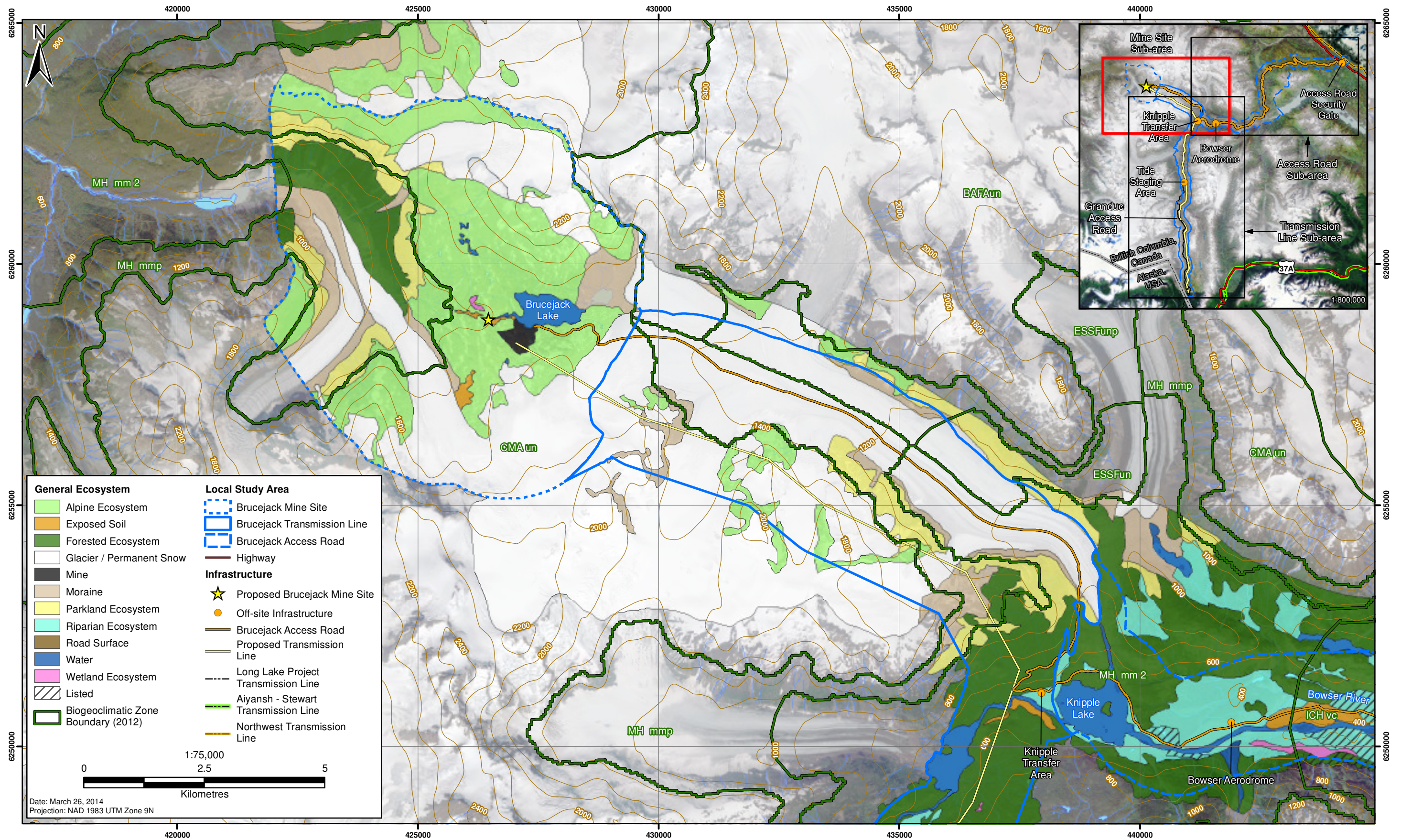
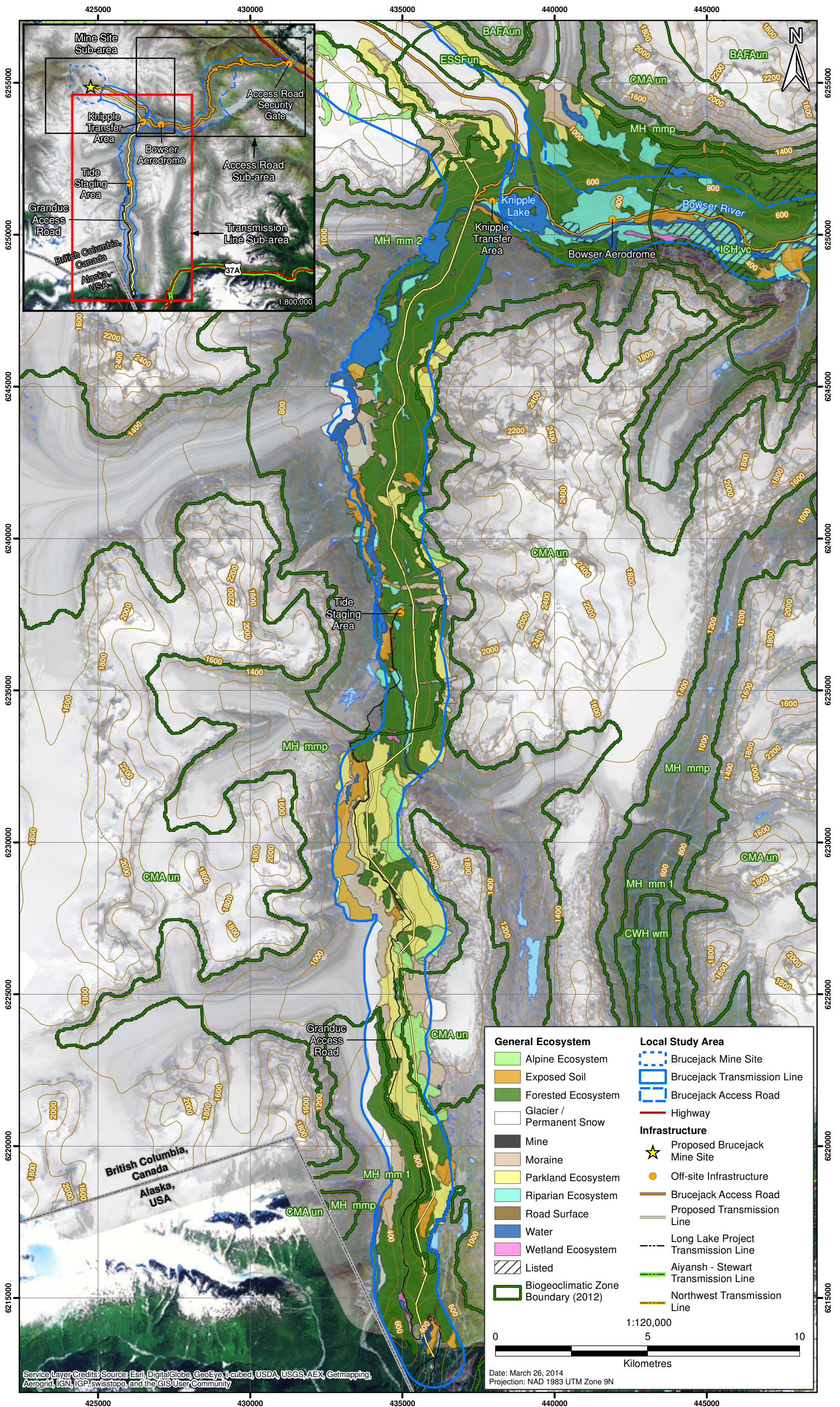


Figure 16.3-3e

Brucejack Transmission Line Sub-area Terrestrial Ecosystem Map



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Date: March 26, 2014
Projection: NAD 1983 UTM Zone 9N

Table 16.3-3. Surficial Material Summary within Sub-areas of the Terrestrial Ecosystems Local Study Area

| Surficial Material ¹ | Map Code | Brucejack Mine Site (ha) | Brucejack Access Road (ha) | Brucejack Transmission Line (ha) | Total (ha) | % LSA |
|---------------------------------|----------|--------------------------|----------------------------|----------------------------------|---------------|-------------|
| Moraine | M | 559 | 4,689 | 2,975 | 8,223 | 26% |
| Colluvium | C | 854 | 3,662 | 3,173 | 7,688 | 24% |
| Ice | I | 1,835 | 38 | 2,769 | 4,642 | 15% |
| Rock | R | 1,540 | 675 | 1,789 | 4,005 | 13% |
| Fluvial | F | 11 | 1,989 | 109 | 2,108 | 7% |
| Fluvial; active | FA | 0 | 995 | 524 | 1,519 | 5% |
| Glaciofluvial | FG | 0 | 647 | 416 | 1,062 | 3% |
| Water features | various | 82 | 580 | 394 | 1,056 | 3% |
| Weathered bedrock | D | 142 | 132 | 432 | 705 | 2% |
| Organic | O | 4 | 399 | 10 | 413 | 1% |
| Glaciolacustrine | LG | 0 | 0 | 271 | 271 | 1% |
| Anthropogenic | A | 0 | 0 | 57 | 57 | 0% |
| Unclassified | (blank) | 0 | 0 | 55 | 55 | 0% |
| Undifferentiated | U | 0 | 23 | 0 | 23 | 0% |
| Lacustrine | L | 13 | 6 | 0 | 20 | 0% |
| Total | | 5,040 | 13,834 | 12,972 | 31,847 | 100% |

¹ Based on leading surficial material decile.

A total of nearly 100 combinations of SMUs were developed from terrain mapping and field data. For management and discussion purposes these SMUs are sorted into Soil Groups reflecting their general soil management issues such as reclamation potential, salvage depth, and/or suitability.

A Generalized Soil Legend summarizing the characteristics of the SMUs, by grouping, is presented in Table 7.2-4 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#). Descriptions of the SMUs are presented in Section 7.2.2 of [Appendix 16-A](#).

16.3.4.9 Brucejack Mine Site Sub-area: Terrain and Ecosystems

Ice and rock were the dominant surficial materials mapped, occupying nearly 70% of the 5,040 ha Brucejack Mine Site sub-area. Three BEC units overlap this sub-area: the CMAun, MHmmp, and MHmm2 BEC units. The CMAun subzone occurs at high elevations throughout the coastal mountains of BC. The MHmmp (parkland) subzone is transitional between the forested subzones, such as CWHwm and MHmm2 at lower elevations, and the CMAun at higher elevations (BC MOFR 2006). The CMAun BEC unit is a relatively moist environment, tends to have a deeper snowpack, and begins at lower elevations than the other alpine zones (CCME 2007). Although the current (2012) version of the provincial BEC classification identifies MHmmp within nearly the entire upper Sulphurets Valley, the extent of MHmm2 was increased during the TEM on some warm aspects to reflect the occurrence of dense forest canopies on the slopes.

Non-vegetated and sparsely vegetated ecosystems dominate the Brucejack Mine Site sub-area (Plate 16.3-1), covering approximately 80% of the total sub-area. Of this, approximately 37% consists of non-vegetated ecosystems including glaciers, permanent snow/ice, lakes, and ponds. Sparsely vegetated ecosystems include rock outcrops, talus, and moraine. Patches of snow, névé, and firn

persist late into the year. Vegetation cover increases to the west towards the Sulphurets Valley. In this sub-area, vegetation classes of the Alpine Group (W. MacKenzie 2012) are present as a mosaic across the landscape, the distribution of which is determined by soil depth, drainage, and microclimate.



Plate 16.3-1. General landscape mosaic of Alpine Group (fellfield ecosystems) near the proposed Brucejack Mine Site.

Most of the ecosystems within the Brucejack Mine Site sub-area are early seral, disclimax, or edaphic climax ecosystems. Early seral ecosystems, such as the areas mapped as alder thicket, are those early in the successional status chrono-sequence. These include non- and sparsely vegetated, pioneer seral, and young seral communities. Edaphic ecosystems include those maintained by local climatic and soil conditions that enable an ecosystem to perpetuate itself. For example, ecosystems affected by saturated soils will develop specific plant assemblages that will be maintained as long as the soil conditions remain. Such is the case with late snowbed ecosystems, which are maintained by the persistence of snowpack late into the growing season. Disclimax ecosystems include those maintained by repeated disturbance events, such as snow avalanches.

Vegetation community development in the Brucejack Mine Site sub-area is influenced by the recent deposition of the soil parent material, excessive snow pack, wind, and cold temperatures. For example, Alpine Tundra Class vegetation communities are dominated by hardy ericaceous shrubs that can withstand the desiccating winds common in alpine environments. Alpine Meadow Class vegetation communities develop in areas of deeper winter snowpack over deep or fine-textured soils, thus confining the vegetation community to those plants tolerant of saturated conditions. Vegetation classes mapped in the Brucejack Mine Site sub-area occur largely within the Alpine Group, including Alpine Fellfield, Heath, and Meadow classes. Alpine Fellfield are exposed ecosystems where the effects of frost and wind give rise to a characteristic low plant cover. Soils are either absent or exist as thin veneers, often derived from *in-situ* bedrock weathering, remnant glacial till, and colluvium. Thin annual snowpack leads to active freeze-thaw cycles that push plants out of the soil. Since soils are typically very high in coarse fragments, vegetation cover is thin and growth is poor. Heath ecosystems

are mountain-heather-dominated snowbeds that are widespread and common in snow-accumulating sites and upon stable substrates. Mountain-heather species are always prominent and site moisture is typically mesic and drier. Alpine Meadow ecosystems are forb-dominated (or large sedge-dominated) ecosystems of subalpine and alpine elevations. These ecosystems occur on fresh to moist, usually well-developed, soils that have a continuous winter snowpack. Sites with seepage or unstable soils favour the Alpine Meadow Class over alpine heath ecosystems.

16.3.4.10 Brucejack Access Road Sub-area: Terrain and Ecosystems

Moraine and colluvium were the dominant surficial materials mapped, occupying approximately 60% of the 13,834 ha Brucejack Access Road sub-area. Five BEC units were mapped within this sub-area, the largest sub-area within the LSA: the ICHvc, ESSFwv, ESSFwvp, MHmm2, and BAFAun. Reflecting the dominant interior climatic influence, very little (less than 5 ha) of the coastal-influenced MHmm2 variant was mapped.

The ICHvc and ESSFwv subzones occupy approximately 90% of the Brucejack Access Road sub-area. Forested ecosystems on mesic and moist soils account for nearly one-third of this area (Plate 16.3-2). Most of these forests are mature and old, classified as structural stages 6 and 7a, respectively. The forests mapped as structural stage 7a meet the age requirements of old forest (> 250 years old), but do not consistently possess the complex structure typically associated with old growth, including an abundance of snags, coarse woody debris in various stages of decomposition, and a complex light regime. Shrub-dominated and young seral forests occur in areas that were recently harvested, are subject to active flooding, or are in younger stages due to recent wildfire disturbance. Upland ecosystems within the ICHvc subzone, occurring almost entirely on mesic or wetter soils, typically possess a dense cover of hybrid white spruce and western hemlock trees. Subalpine fir becomes the dominant tree species at higher elevations and in areas where colder air persists.



Plate 16.3-2. Mature forested ecosystem close to Highway 37, along the Brucejack Access Road.

Subalpine fir (*Abies lasiocarpa*) is the dominant tree species within the floodplain ecosystems of the ICHvc subzone, along with black cottonwood (*Populus balsamifera*) and some hybrid white spruce (*Picea glauca x engelmannii*). Treed ecosystems often occur as elevated islands within braided stream systems and are very common in the Bowser River delta, between Bowser and Knipple Lakes. The ESSFwv subzone, mapped above the ICHvc subzone, is distinguished by a less vigorous shrub understory, a lack of Western hemlock (*T. heterophylla*), and dominance of subalpine fir (*A. lasiocarpa*) in the tree layer. As elevation increases, so does snow depth and persistence, resulting in a mosaic of seepage ecosystems. Where seepage persists during the growing season, herbaceous meadows often occur within a matrix of forested ecosystems (Plate 16.3-3). This maintenance of wet soils throughout the growing season allows for vigorous growth of herbaceous communities and prohibits the establishment of conifer trees. They occur most commonly along the concave topography associated with lower and toe slopes. Sitka valerian (*Valeriana sitchensis*), Indian hellebore (*Veratrum viride*), and Arctic lupine (*Lupinus arcticus*) are typical herb species within these ecosystems.



Plate 16.3-3. Herbaceous fen located just east of Todedada Wetland near the maximum elevation of the Brucejack Access Road.

Near the Bowser River delta, an abundance of flood and early seral ecosystems occur on the active fluvial deposits. Floodplain ecosystems in this area include low, medium, and high bench ecosystems. The low bench ecosystems are often dominated by willows (*Salix* spp.), including variable willow (*Salix commutata*) and Barclay's willow (*Salix barclayii*). Medium and high bench floodplain ecosystems typically occur on soils with relatively xeric to submesic moisture regimes, with edaphic indicator species such as Drummond's mountain-avens (*Dryas drummondii*), soopolallie (*Shepherdia canadensis*), and various species of lichens. The delta narrows to the west, towards Knipple Lake where the road continues along the high bench floodplain, bounded by steep colluvial slopes to the north and the outflow to the south. Forested ecosystems are less common in this area due to recent de-glaciation and soils that are either poorly developed or absent. The edaphic climatic influence of the existing glaciers reduces the length of the growing season in this area.

16.3.4.11 Brucejack Transmission Line Sub-area: Terrain and Ecosystems

Colluvium, moraine, and ice were the dominant surficial materials mapped, occupying approximately 70% of the 12,972 ha sub-area. Seven BEC units were mapped within this sub-area: the ESSFwv, ESSFwvp, MHmm1, MHmm2, MHmmp, CMAun, and BAFAun. Reflecting the dominant coastal climatic influence, small areas (approximately 105 ha) of ESSFwv, ESSFwvp, and BAFAun were mapped.

Beginning near the Premier Mine site in the south, this sub-area extends approximately 53 km to the top of the Knipple Glacier (southeast of the Brucejack Camp). The southern reaches are comprised of shallow colluvial veneers over bedrock and steep slopes, often exceeding 60%. Ecosystems in this area, although mapped as the MHmm1 variant, are transitional to the CWHwm subzone (which occurs in lower elevation valleys to the south of the LSA), based on the prominence of Western hemlock in the main tree canopy (Plate 16.3-4). In addition, within this transition area, there is a marked and observable difference in vegetation communities between site series. Within the MH BEC units, the plant community variability between ecosystems is often much lower than within other zones. This is due, to a large extent, to excessive snowpack, persistence of cold wet soils throughout the growing season, and thick mor humus forms that extend across a range of soil moisture and nutrient classes (edatopes).

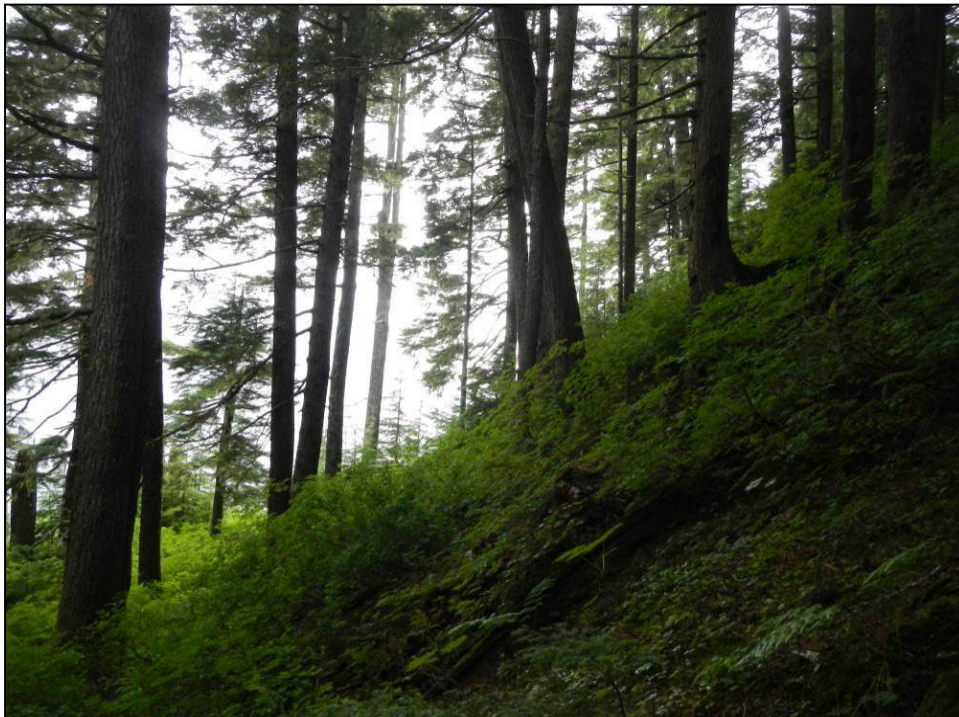


Plate 16.3-4. Zonal forests of the CWHwm subzone, along the south end of the Brucejack Transmission Line.

As the corridor proceeds north, the MHmm1 variant becomes well established. Western hemlock becomes a minor component of the canopy, eventually being replaced by mountain hemlock (*Tsuga mertensiana*). The understory becomes less vigorous and diverse as the climate becomes colder and wetter. Soils become thin veneers over bedrock, while the most productive forests occupy steep mid-slope positions that allow for soils to drain freely, reducing the productivity-dampening effect of saturated rooting zones. As the corridor approaches the Salmon Glacier, the transition from the forested MHmm1 variant to parkland (MHmmp) is apparent. Tree island ecosystems become more common, scattered throughout mountain-heather and herbaceous meadow communities (Plate 16.3-5). Tree islands occupy micro topography where edaphic conditions allow for the establishment of tree species. This includes sites that shelter trees from prevailing winds, boulder fields that provide shelter for seed germination, and convex

topographies that shed excess water. Reflecting the transition to an interior climate, coniferous stands in this area are dominated by subalpine fir, although mountain hemlock was found to a limited extent. Common ericaceous shrubs include bog blueberry (*Vaccinium uliginosum*), black huckleberry (*Vaccinium membranaceum*), and oval-leaved blueberry (*Vaccinium ovalifolium*), while partridgefoot (*Luetkea pectinata*) is dominant in areas with thin or discontinuous soils.



Plate 16.3-5. An example of the ecosystems within the MHmmp, at site BJ003, near the Salmon Glacier.

The MHmmp BEC unit persists for much of the corridor, until it transitions to the MHmm2 variant, approximately 10 km south of Knipple Lake. However, this transition is a distinction based largely on elevation and climatic data, and describes, in theory, what vegetated ecosystems could develop. On the ground, localized cold air effects from glaciers and the physical impact on terrain conditions from recent de-glaciation overrides the ecological seral trajectory. Recent de-glaciation and periglacial processes, as well as large-scale disturbances such as the draining of Tide Lake, have resulted in a mosaic of alpine-like vegetation communities, tree islands, scoured rock, and exposed terraces, similar to those within the parkland BEC unit.

Also common on recent disturbances such as glaciofluvial and fluvial terraces are pioneer seral willow (*Salix* spp.) and mountain-avens (*Dryas drummondii*) communities (Plate 16.3-6). Early seral, willow-dominated ecosystems often occur on mesic soils with little to no profile development, including on recently deposited morainal, glaciofluvial, and colluvial materials. Vegetation cover is scattered but can exceed 10% so that the barren classification does not apply. Vegetation composition is variable in these areas but nearly always includes a component of early colonizing willows (*Salix* species). The mountain-avens vegetation association is also an early seral association that is found in areas with recently deposited coarse-textured materials that results in moisture deficits throughout the growing season (Plate 16.3-7). Dominated by smooth-leaved mountain-avens, with scattered Sitka alder (*Alnus crispa*), soopolallie (*S. canadensis*), and a variety of willow species, they typically occur on low bench floodplains of medium to large rivers, where sands, gravels, and cobbles are deposited cumulatively. They can also occur on recently deposited moraine with high coarse fragment content.



Plate 16.3-6. Drummond's mountain-avens vegetation community 5 km south of Knipple Lake.



Plate 16.3-7. A variety of non-vegetated and early seral ecosystems exist along the Bowser River between Knipple Lake and Granduc. The white and dark layers of sediments indicate coarser and finer lacustrine material.

16.3.5 Listed Ecosystems

A search of the online databases maintained by the BC CDC was conducted, and a list of blue- or red-listed ecosystems potentially occurring in the RSA and LSA was compiled (Appendix 2 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#)). Red-listed ecosystems are those that have, or are candidates for, extirpated, endangered, or threatened status in BC. Blue-listed ecosystems are those of special concern (formerly vulnerable) in BC. Placing taxa on these lists flags them as being at risk and requiring investigation (BC MOE 2012). Rankings depend on factors such as rarity, intrinsic vulnerability, environmental specificity, threats, and long- and short-term trends in population size or area (BC MOE 2012).

Twelve terrestrial and wetland ecosystems that are blue- or red-listed by the BC CDC were either mapped within the LSA or RSA, or were identified during the terrestrial ecosystem or wetland field surveys within the LSA or RSA (Table 16.3-4). Several blue-listed ecosystems are difficult to model and delineate as their landscape position and moisture regimes are similar to others. For this reason, PEM has consolidated the following ecosystems into combined units (CWHwm/06 and 07, CWHwm/09 and 10, and ICHvc/05 and 04).

Table 16.3-4. Listed Ecosystems Mapped or Predicted in the Study Areas

| Scientific Name | English Name | Ecosystem Unit/ Map Code | CDC Status | LSA (ha) | RSA (ha) |
|---|---|---|---------------|-------------|---------------|
| Terrestrial Ecosystems | | | | | |
| <i>Picea sitchensis</i> - <i>Rubus spectabilis</i> Wet Maritime | Sitka spruce - Salmonberry Wet Maritime | CWHwm05/SS | Blue | 0 | 248 |
| <i>Tsuga heterophylla</i> - <i>Picea sitchensis</i> - <i>Hylocomium splendens</i> | Western hemlock - Sitka spruce - Step moss | CWHwm02/HM | Blue | 0 | 531 |
| <i>Populus trichocarpa</i> - <i>Abies lasiocarpa</i> - <i>Oplopanax horridus</i> ; <i>Populus trichocarpa</i> / <i>Picea</i> spp. - <i>Cornus stolonifera</i>) | Black cottonwood - Subalpine fir - Devil's club; Black cottonwood/Spruce (hybrid) - Red-osier dogwood) | ICHvc00/Fm03; [ICHvc05/CD ^{1,2}] | Blue | 32 [982] | 3,276 |
| <i>Populus trichocarpa</i> - <i>Alnus rubra</i> - <i>Rubus spectabilis</i> | Black cottonwood - Red alder - Salmonberry | CWHwm06/CD ¹ | Blue | 0 | 424 |
| <i>Populus trichocarpa</i> - <i>Abies lasiocarpa</i> - <i>Oplopanax horridus</i> (<i>Populus trichocarpa</i> / <i>Picea</i> spp. - <i>Cornus stolonifera</i>) | Black cottonwood - Subalpine fir - Devil's club; Black cottonwood/Spruce (hybrid) - Red-osier dogwood | ESSFwv00/Fm03 | Blue | 45 | 27 |
| <i>Alnus incana</i> - <i>Equisetum arvense</i> | Mountain alder - Common horsetail | ICHvc00/FI01 | Blue | 0 | Not mapped |
| Wetland Ecosystems | | | | | |
| <i>Alnus incana</i> - <i>Athyrium filix-femina</i> (<i>Alnus incana</i> - <i>Cornus stolonifera</i> - <i>Athyrium filix-femina</i> , <i>Alnus incana</i> - <i>Lysichiton americanum</i> - <i>Athyrium filix-femina</i>) | Mountain alder - Red-osier dogwood - Lady fern | ICHvc00/52 (FI02, Ws01) | Blue | 117 | 1,399 |
| <i>Carex sitchensis</i> - <i>Sphagnum</i> spp. | Sitka sedge - Peat-mosses | ICHvc00/Wf51 | Red | 0 | 1,023 |
| <i>Tsuga heterophylla</i> - <i>Sphagnum girgensohnii</i> | Western hemlock - Common green peat-moss | CWHwm08/HS | Blue | 0 | 222 |

(continued)

Table 16.3-4. Listed Ecosystems Mapped or Predicted in the Study Areas (completed)

| Scientific Name | English Name | Ecosystem Unit/ Map Code | CDC Status | LSA (ha) | RSA (ha) |
|--|--|------------------------------------|---------------|-------------|-------------|
| Wetland Ecosystems (cont'd) | | | | | |
| <i>Picea sitchensis</i> - <i>Lysichiton americanum</i> (<i>Thuja plicata</i> - <i>Tsuga heterophylla</i> - <i>Lysichiton americanum</i>) | Sitka spruce - Skunk cabbage (Western red cedar - Western hemlock - Skunk cabbage) | CWHwm09/ SC ¹ (Ws54) | Blue | 0 | 177 |
| <i>Myrica gale</i> - <i>Carex sitchensis</i> | Sweet gale - Sitka sedge | CWHwm00/Wf | Red | 0 | 30 |
| <i>Carex sitchensis</i> - <i>Oenanthes sarmentosa</i> | Sitka sedge - Pacific water-parsley | CWHwm00/Wm50 | Blue | 0 | 72 |

¹ Areas of these ecosystems may be less than stated, particularly for those predicted by PEM. Lumped units include: CWHwm06/CD and 07/CW; CWHwm09/SC and 10/LS; ICHvc05 (CD) and 04/DD.

² Although not technically listed by the BC CDC, correspondence with BC CDC personnel suggests that this is an issue of limited data on their distribution.

Table 16.3-5 summarizes the BC CDC-listed ecosystems mapped within the respective sub-areas. Listed ecosystems, consisting of floodplain forest ecosystems and wet, alder-dominated shrub ecosystems, comprise approximately 4% of the LSA, with all of them occurring within the lowest elevation BEC unit (ICHvc) within the Brucejack Access Road sub-area. As the ICHvc/00 WH ecosystem (generic herb-dominated wetland) *could* represent the red-listed ICHvc/00 Wf51 wetland, which has been previously identified within the RSA, it is also considered a CDC listed ecosystem.

Table 16.3-5. Listed Ecosystems Mapped within Each Sub-area of the Local Study Area

| BEC Unit(s) | Ecosystem Name | Map Code | General Ecosystem Type | Brucejack Mine Site (ha) | Brucejack Transmission Line (ha) | Brucejack Access Road (ha) | Total Area (ha) | % of LSA |
|--------------|---|----------|------------------------|--------------------------|----------------------------------|----------------------------|-----------------|-------------|
| ICHvc/05 | ActSx - Dogwood | CD | Floodplain Forest | 0 | 0 | 982 | 982 | 3.1% |
| ICHvc/00 | Black cottonwood - Subalpine fir - Devil's club | Fm03 | Floodplain Forest | 0 | 0 | 32 | 32 | 0.1% |
| ESSFwv/00 | Black cottonwood - Subalpine fir - Devil's club | Fm03 | Floodplain Forest | 0 | 0 | 45 | 45 | 0.1% |
| ICHvc/00 | Herb Wetland (undescribed) | WH | Wetland Shrub/Herb | 0 | 0 | 30 | 30 | 0.1% |
| ICHvc/00 | Mountain alder - Lady fern | 52 | Wetland Shrub/Herb | 0 | 0 | 117 | 117 | 0.4% |
| Total | | | | 0 | 0 | 1,206 | 1,206 | 3.8% |

16.3.6 Culturally and/or Economically Important Plant Species

Based on information provided by the Skii km Lax Ha (Appendix A of Rescan 2013) and from a literature search on economically important harvestable plants in the north (Sharmin, Holly Ridenour, and Philpot 1998; Berch and Cocksedge 2003) a list of culturally/economically important plant species was compiled.

Within the LSA culturally/economically important plants include, but are not limited to, blueberry (*Vaccinium* spp.), soapberry (*Shepherdia canadensis*), thimbleberry (*Rubus parviflorus*), raspberry (*Rubus ideaus*), salmonberry (*Rubus spectabilis*), devil's club (*Oploplanax horridus*), and pine mushroom (*Tricholoma magnivelare*).

Based on their known local importance, three species—soapberry, devil’s club and pine mushroom—were selected for further study. According to the country foods survey conducted by Rescan with the Skii km Lax Ha in 2013 (Rescan 2013), berries make up the majority of wild plants currently consumed by the Skii km Lax Ha. Soapberries are the most important plant in terms of consumption, being consumed daily. As for other plants, devil’s club is intensively utilized in the springtime, as much as four to five times per week (BC Reg. 70/2004); the inner bark of devil’s club is steeped in boiling water and drunk as tea for medicinal purposes. According to the literature results, pine mushroom is considered the most economically important mushroom in the north.

Soapberry Habitat

Soapberry habitat is typically located in low and mid-elevation semi-open forests and its occurrence increases with more continental climates. The primary characteristic defining soapberry habitat is dry to moderately dry well drained soils. This species is not present on level moist or wet sites or in areas with distinct organic soils.

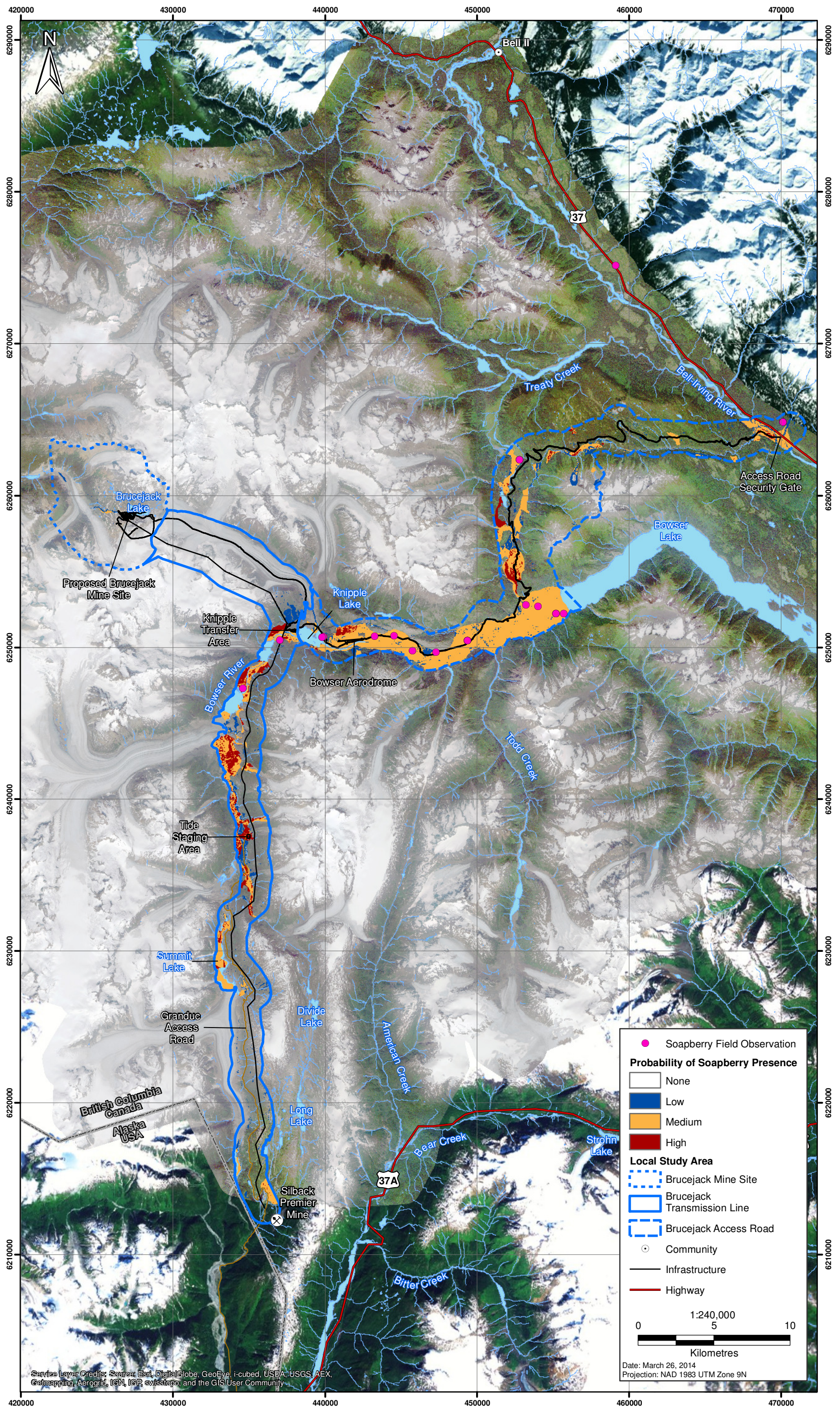
Potential soapberry habitat was refined based on local site characteristics. Because soil drainage is an important characteristic defining soapberry habitat, terrain mapping was used as the primary feature to identify potential habitat. Rapidly drained glaciofluvial and fluvial deposits with a soil moisture range from subxeric (2) to mesic (4) were used as a primary determinant for potential soapberry habitat. Areas dominated by shrubs and young forests less than 80 years old provide appropriate habitat conditions. Habitat criteria were also refined to identify areas of low slope and south facing aspects.

Based on these criteria, ecosystems with potential to support soapberry are distributed throughout the lower elevation regions of the LSA. The areas of moderate to high probability of soapberry presence are centered along the Bowser River and along drainages of the surrounding uplands (Figure 16.3-4). Ecosystems within the Brucejack Mine Site sub-area have a medium to low likelihood of providing soapberry habitat (Table 16.3-6 and Figure 16.3-4).

Table 16.3-6. Distribution of Culturally/Economically Important Plant Species Habitat

| LSA Sub-area | Likelihood of Habitat | Soapberry Predicted Habitat (ha) | Devil’s Club Predicted Habitat (ha) | Pine Mushroom Predicted Habitat (ha) | Total Predicted Habitat (ha) |
|------------------------------------|-----------------------|----------------------------------|-------------------------------------|--------------------------------------|------------------------------|
| Brucejack Mine Site | | | | | |
| | High | - | - | - | - |
| | Medium | 10 | 923 | - | 934 |
| | Low | 24 | 1,367 | - | 1,390 |
| | None | 5,007 | 2,751 | 5,041 | 12,799 |
| Brucejack Access Road | | | | | |
| | High | 241 | 6,045 | 752 | 7,037 |
| | Medium | 3,525 | 5,182 | 1,218 | 9,926 |
| | Low | 613 | 1,652 | 3,115 | 5,379 |
| | None | 9,463 | 962 | 8,756 | 19,180 |
| Brucejack Transmission Line | | | | | |
| | High | 555 | 21.4 | - | 577 |
| | Medium | 971 | 5,524 | - | 6494 |
| | Low | 357 | 3,363 | - | 3,721 |
| | None | 11,090 | 4,065 | 12,973 | 28,128 |

Figure 16.3-4
 Predicted Habitat for *Sheperdia canadensis* (Soapberry) in the Local Study Area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Over 550 ha of habitat with high potential to support soapberry were identified within the Brucejack Transmission-Line sub-area, primarily west of the transmission line. Within the Brucejack Access Road sub-area, the model identified 241 ha of high-probability habitat and 3,525 ha of medium-probability habitat. Consistent with field observations of soapberry, the predicted habitat is located along the Bowser River Valley between Knipple Lake and Bowser Lake.

Devil's Club Habitat

Devils club occurs primarily within low elevation forests on rich, wet sites (Figure 16.3-5). It is an indicator species for the ICHvc subzone and the 06 site series in the ESSFwv subzone, though it is also observed in the MHmm1 and MHmm2 subzones. This species frequently occupies sites where abundant seepage occurs, as well as sites along streams.

BEC units were considered the primary criteria defining potential devils club habitat. There is high potential for devils club to occur within the BEC units for which it has been identified as an indicator species (ICHvc and ESSFwv06) in addition to wet sites in the MHmm1 and MHmm2 subzones (site series 03 and 05). Additional criteria included terrain information such that colluvial, morainal, fluvial, and glaciofluvial materials associated with a wet soil moisture regime and low slope were considered more likely to support devils club.

Of the three species considered, the extent of potential high quality habitat was greatest for devil's club based on the model results. The high probability habitat is exclusively located within the Brucejack Access Road sub-area, while small patches of medium and low probability habitat were identified within the Brucejack Mine Site and Brucejack Transmission Line sub-areas (Figure 16.3-5). The high probability habitat is distributed throughout the forested, lower elevation regions of the LSA, north of Bowser Lake. The medium probability habitat is primarily situated within the Bowser River valley between Knipple Lake and Bowser Lake. This is consistent with field observations of devil's club which are distributed throughout the forested lower elevation regions. Parkland and alpine ecosystems common within the Brucejack Mine Site and Brucejack Transmission Line sub-areas are unlikely to support devil's club.

Pine Mushroom Habitat

Harvesting of pine mushrooms, although limited, has occurred in the past along the Eskay Creek Mine Road about 40 km northwest of the Project area (Coast Mountain Hydro Corp 2002). Lower elevations along the Brucejack Access Road occur within the ICHvc subzones in wetter climate, which may support some habitat for pine mushroom development.

Pine mushrooms are restricted to sites with poor-to-medium soil nutrients and soil moisture that is drier than typical for the BEC zones they occur within (Trowbridge, MacAdam, and Kranabetter 1999; Wiensczyk and Berch 2001; Figure 16.3-5). Within these areas, prime pine mushroom habitat occurs in low elevation forest communities predominantly between the ages of 80 to 160 years, although they are also noted to occur in mature forests up to 250 years (Trowbridge, MacAdam, and Kranabetter 1999). All forests containing quality pine mushroom habitat have an open canopy that allows light to penetrate to the forest floor (Gamiet, Ridenour, and Philpot 1998). Additional site characteristics include soils that are well to rapidly drained, coarse textured, with high coarse fragment content.

To locally refine the potential mushroom habitat, BEC units considered of nil potential to support mushroom habitat (CMAunp and BAFAunp) were excluded. Further communication (M. Kranabetter, pers. comm.) indicated that high-elevation BEC units in this area (ESSFwv and MHmm2) are not suitable pine mushroom habitat. The ICHvc was included, as pine mushrooms were identified in the field within this ICHvc subzone on dry slopes above Treaty Creek, which lies just a few kilometres to the north of the Brucejack Access

Road. At the site level, mushroom habitat was further refined through an assessment of the terrain and soils information to identify level areas supporting rapidly drained fluvial or glaciofluvial deposits, as well as slopes and crests with morainal veneers over bedrock, or associated with glaciofluvial terraces.

Generally speaking, the ecosystems within the LSA do not support high quality pine mushroom habitat. Nevertheless, model results indicate that some of the lower elevation forested communities within the local study area contain site characteristics that could support pine mushrooms (Figure 16.3-6). A total of 752 ha of higher quality habitat were identified on slopes north of the Bowser River between Knipple Lake and Bowser Lake and in open forests between Bowser Lake and Treaty Creek within the ICHvc. However, the ICHvc is generally considered too cold to support quality pine mushroom habitat and thus pine mushroom populations are not expected to be extensive, if they do occur. The high(er) and medium quality potential habitat is exclusively located within the Brucejack Access Road sub-area.

16.3.7 Invasive Plants

A list of invasive plants, according to the NWIPC and the BC *Weed Control Act* (1996d), was compiled prior to fieldwork. Detailed invasive plant surveys occurred in conjunction with the rare plant surveys within the LSA and within the surrounding area. Additionally, presence/not detected level surveys for invasive plants were conducted throughout the study area in conjunction with mapping field surveys. The results of the baseline field surveys (i.e., plant species list) were compared to the NWIPC and the BC *Weed Control Act* (1996d) plant list in order to identify any invasive plants present in the study area. No invasive plants were found within the LSA.

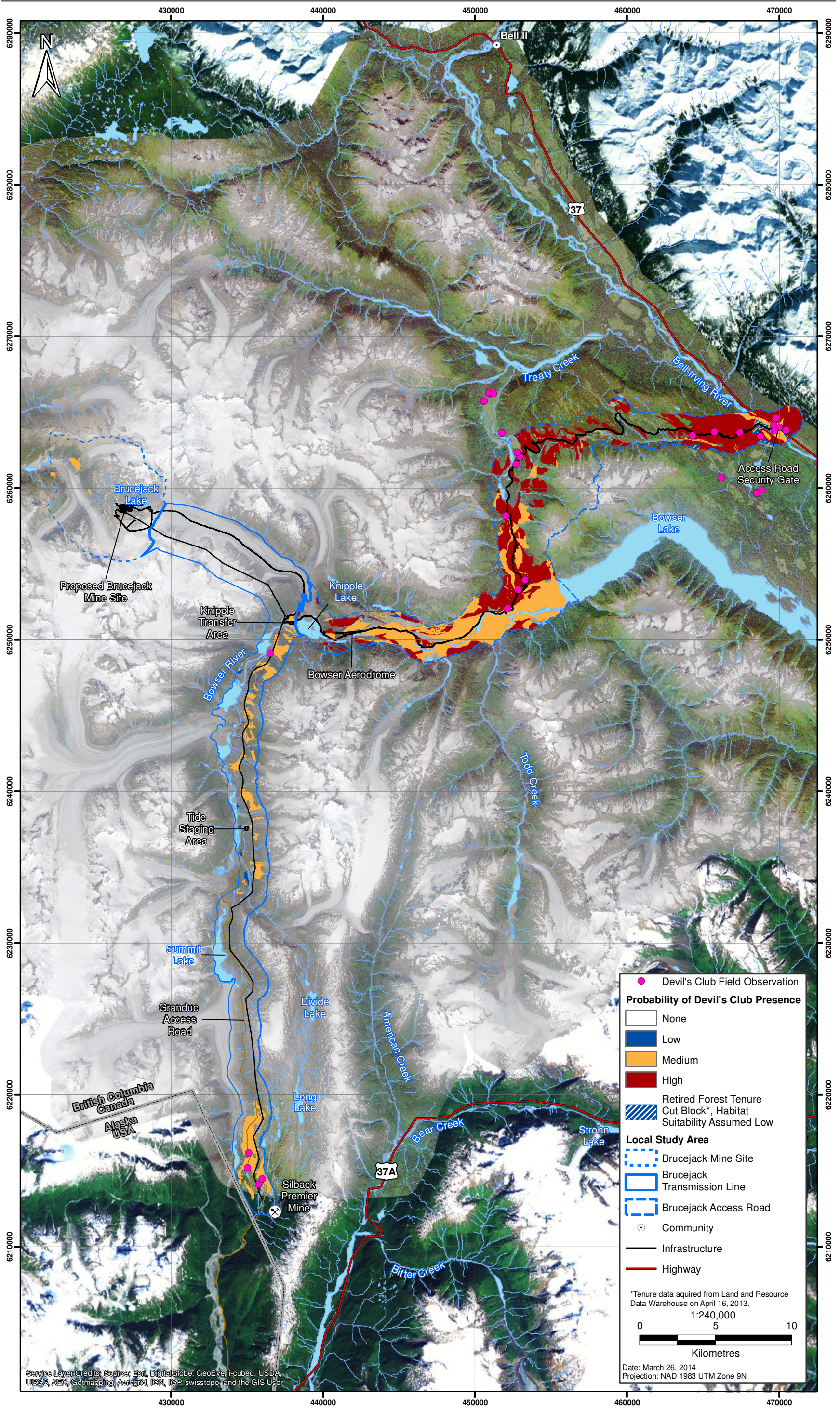
16.3.8 Rare Plant and Lichen Species

Rare plant and lichen surveys were conducted to determine the presence of provincially or globally rare plant or lichen species within the LSA and at select sites within the surrounding area. All surveys were conducted by a qualified botanist using a controlled intuitive wander method, where the surveyor focuses on habitats and landscape features that yield the highest numbers of species and which have the greatest likelihood of harbouring rare species.

Seventy-six rare plant or lichen species were identified within the LSA, consisting of 19 vascular plant, 42 lichen, and 15 moss species, some of which are of high global priority due to their world-wide rarity, habitat limitations, small populations, vulnerability to extirpation, or other considerations (see Figure 16.3-7a and 16.3-7b; Table 7.4-1 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#)). Of these, 59 species listed by the BC CDC were identified in the LSA, including 34 macrolichens, 13 vascular plants, and 12 mosses. Of the 17 species considered rare but previously undocumented in BC, new to science, or ranked as SU (i.e., uncertain by the BC CDC), 6 are vascular plants, 8 are lichens, and 3 are mosses. None of the rare species found are currently listed under SARA or by COSEWIC. In total, 231 tracked species occurrences (element occurrences) were recorded. Tables 7.4-2 to 7.4-4 of [Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#), list the names of the lichens, mosses, and vascular plants identified.

Most rare plants were found in open, non-forested areas, or where forest canopy cover is light. Most rare species are rare because they require rare habitats. Some rare species were found in the shade of trees, but the habitat characteristics significant to these species are associated with special habitat features such as cliffs, rock outcrops, or ecotonal areas between forested and non-forested habitat. Some non-forested habitats were found to have overall high species richness and numerous rare plants and lichens. Rare plant habitat types are listed in Table 16.3-7.

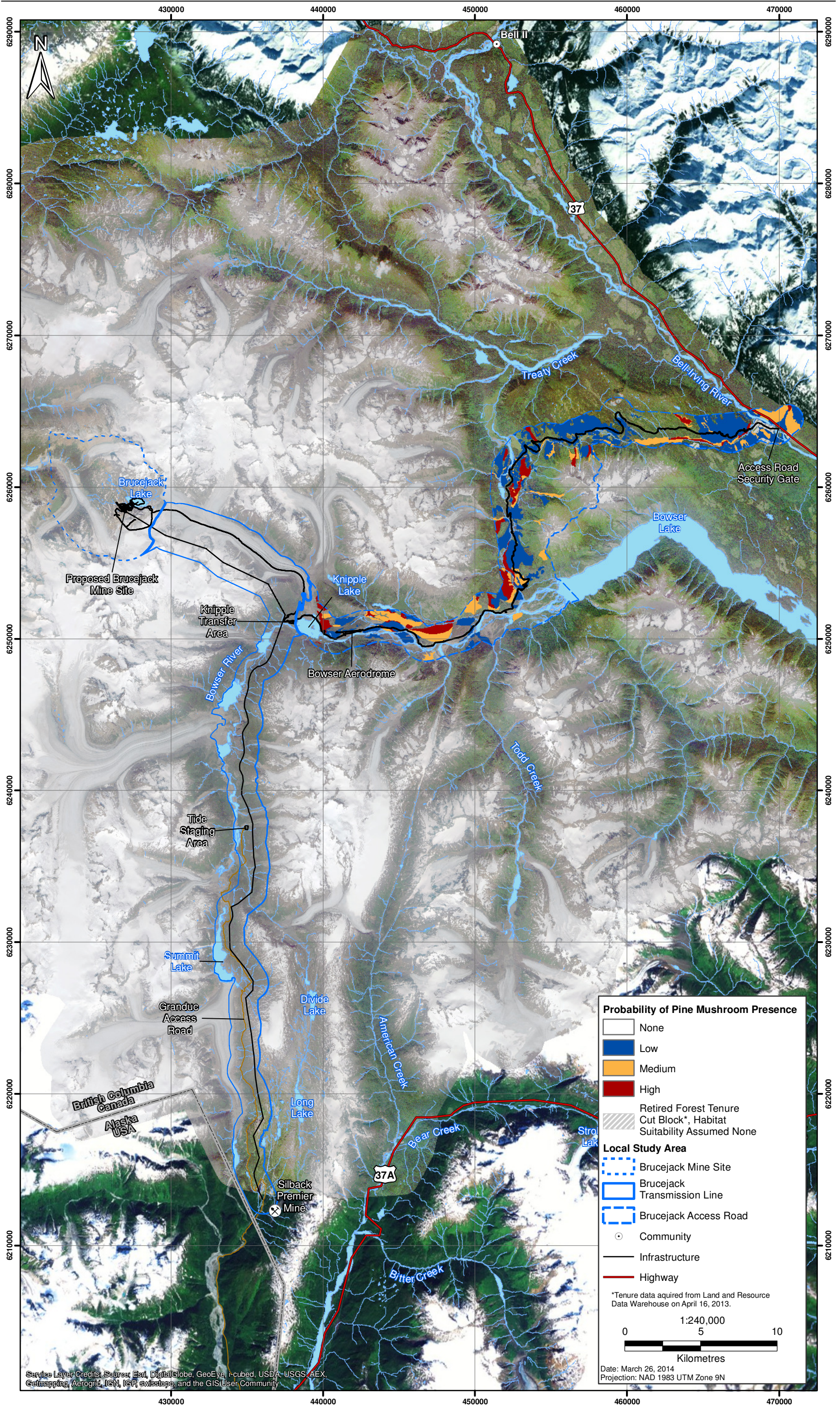
Figure 16.3-5
 Predicted Habitat for *Oplopanax horridus* (Devil's Club) in the Local Study Area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aergrid, IGN, IGP, swisstopo, and the GIS User

Figure 16.3-6

Predicted Habitat for *Tricholoma magnivelare* (Pine Mushroom) in the Local Study Area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA-USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 16.3-7a
Rare Plant and Lichen Observations within the Mine Site and Access Road Sub-areas

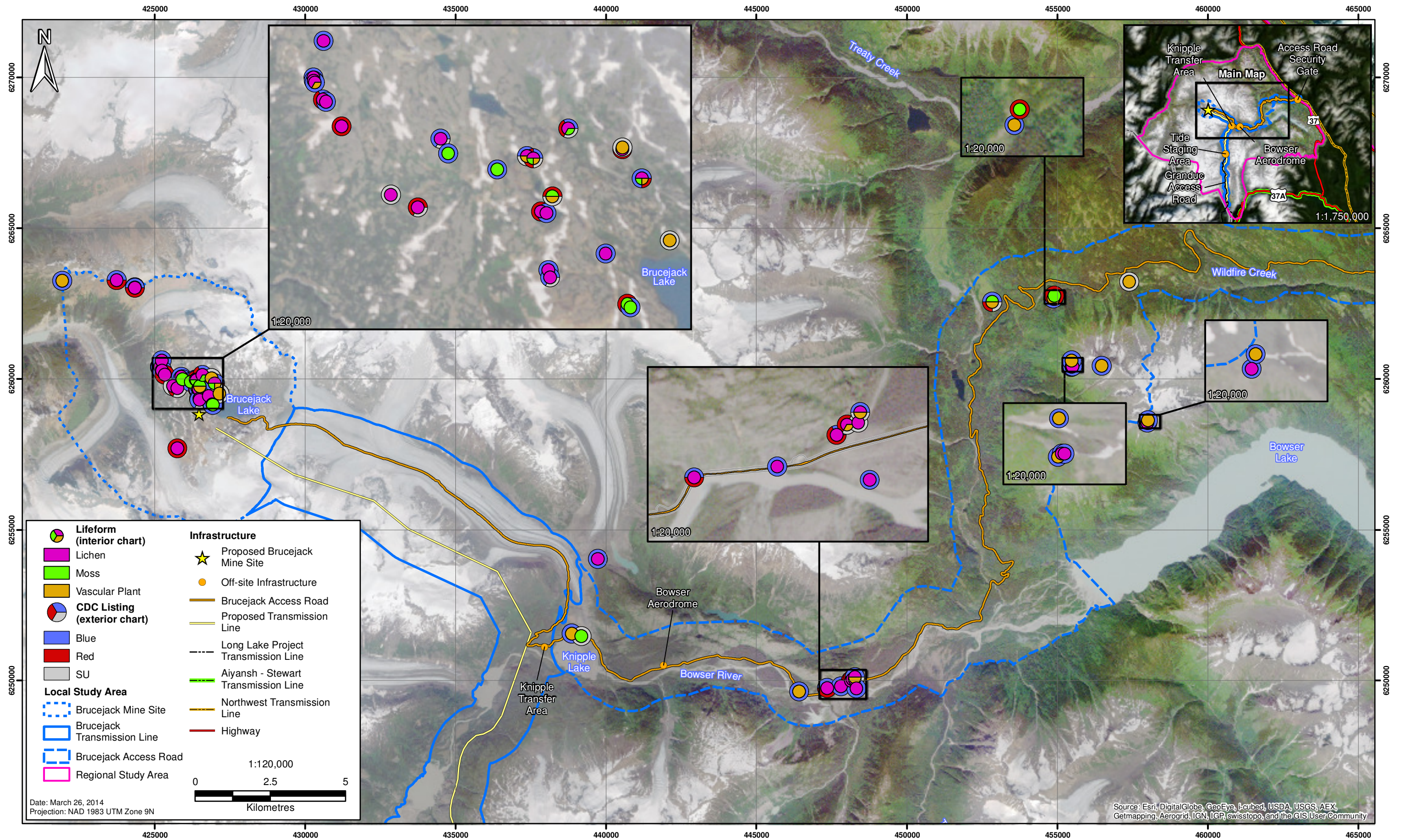


Figure 16.3-7b
Rare Plant and Lichen Observations within the
Transmission Line Sub-area

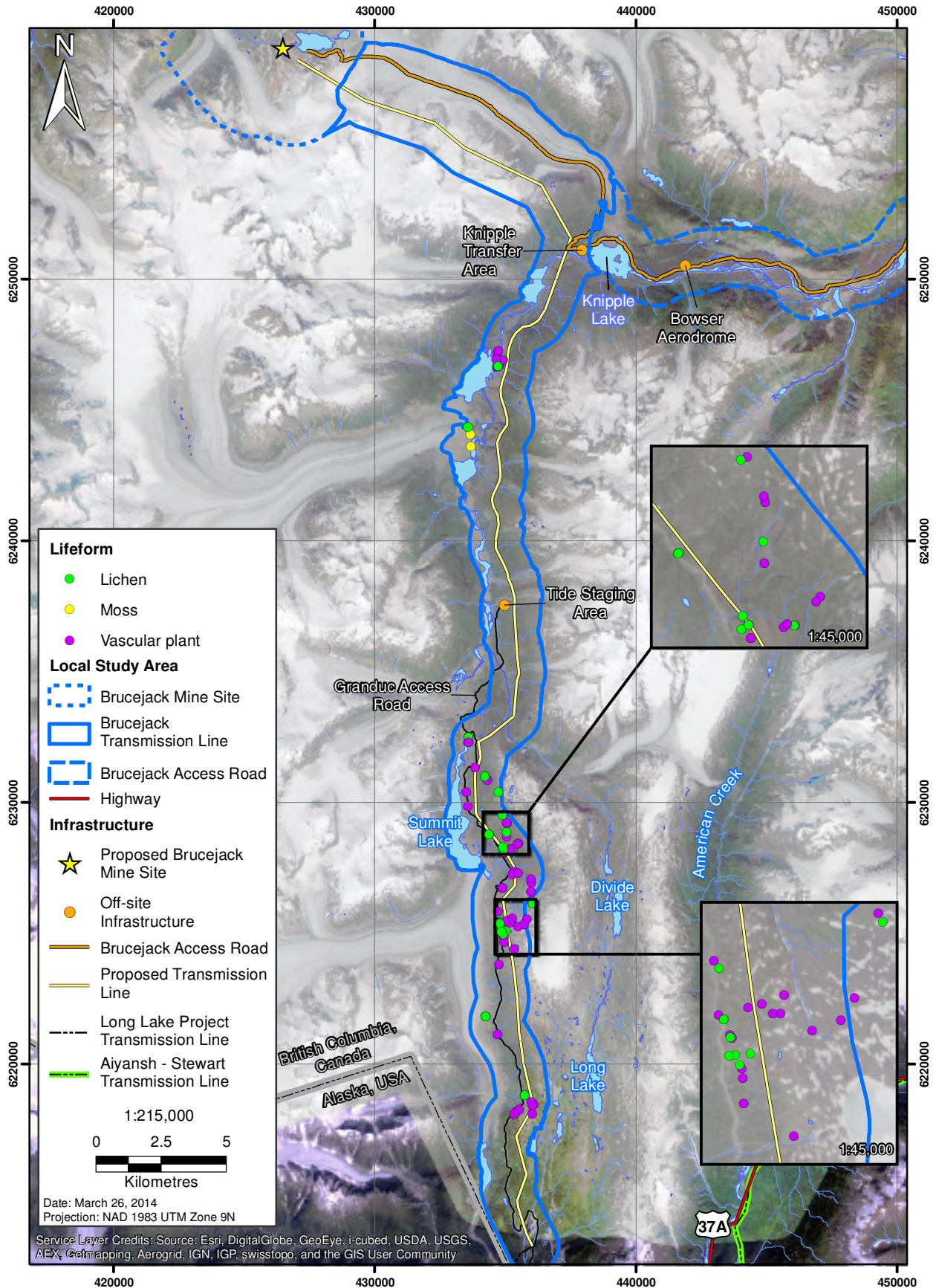


Table 16.3-7. Rare Plant Habitat Types within the Local Study Area

| Alpine Ecosystems | Non-alpine Ecosystems |
|---------------------|-------------------------------------|
| Cliffs | Cliffs |
| Ephemeral Pools | Fens |
| Moist Meadow | Gossan Outcrops |
| Rock Pinnacles | Lakeshores |
| Scree | Marshes |
| Stable Rocky Tundra | River Back-Channels and Gravel Bars |

16.3.9 Laboratory Metal Analyses

As part of the baseline studies, soil, lichens, berries, and sedge samples were collected to establish baseline metal concentrations. The metals analyses determine baseline metal levels in the area of proposed infrastructure as well as control sites outside of the expected zone of influence of project environmental effects. These data comprise the basis to evaluate any changes in metal levels due to the Project. Results from the baseline metals analysis may be used for country foods assessments and/or future monitoring programs.

Samples for metals analysis were collected in order to determine baseline metals for soils, vegetation tissue, berries, and lichens. A total of 50 samples (including three duplicates), from 34 soil inspection sites were obtained from across the study areas. Seven of the nineteen metals analyzed for exceeded industrial use criteria at least once. These included Sb, As, Cr, Cu, Ni, Tl, and V. Soil metals not exceeding industrial use criteria included Ba, Be, Cd, Co, Pb, Hg, Mo, Se, Ag, Sn, U, and Zn. Arsenic is the most frequently occurring metal of concern (31 of 50 samples tested exceed the industrial guideline concentration of 12 mg/kg).

A total of 22 lichen samples (including three duplicates) were collected from within the LSA or at reference sites. The two species of lichen samples collected were black footed reindeer lichen (*Cladina stygia*) and eyed foam lichen (*Stereocaulon tomentosum*). These samples were analyzed for a suite of 39 metals. Notably, three of these samples, all within the Brucejack Mine Site, contained higher concentration of arsenic than the rest of the samples. These sites also correspond to sites with elevated arsenic in the soils.

A total of 31 berry samples were collected. Five species were targeted for sampling including oval-leaved blueberry (*Vaccinium ovalifolium*), black huckleberry (*Vaccinium membranaceum*), bog blueberry (*Vaccinium uliginosum*), highbush cranberry (*Viburnum edule*), and soapberry (*Shepherdia canadensis*). Fourteen metals were found to be above the detection limit. Of these, nine (Al, Ba, Ca, Fe, Mg, Mo, Ni, P, and K) had the highest 90th percentile value along the Brucejack Transmission Line. As noted above, As was in exceedance in soils at several locations. However, these levels did not appear to be reflected in berry samples.

A total of 30 water sedge (*Carex aquatilis*) samples were collected from 10 sites within the Brucejack Access Road sub-area. These samples were analyzed for a suite of 25 metals. Metals with the highest overall concentrations were calcium, magnesium and manganese.

16.4 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT

This section of the assessment of terrestrial ecology includes a description of the scoping process used to identify potentially affected Valued Components (VCs), select assessment boundaries, and identify the potential effects of the Project that are likely to arise from the Project’s interaction with an

intermediate¹ component or receptor VC². Scoping is fundamental to focusing the Application/EIS on those issues where there is the greatest potential to cause significant adverse effects.

The scoping process for the assessment of terrestrial ecosystems consisted of four steps, which are listed and described in the text below:

- *Step 1:* undertaking an issues scoping process to select components, receptor valued component, and indicators based on a consideration of the Project's potential to interact with terrestrial ecology;
- *Step 2:* consideration of feedback on the results of the scoping process from technical experts and the EA Working Group³;
- *Step 3:* defining assessment boundaries for terrestrial ecology VCs; and
- *Step 4:* identification of key potential effects on terrestrial ecology VCs.

The VC selection process is discussed in more detail in the following sections.

16.4.1 Selecting Receptor Valued Components

Receptor VCs are used to focus the Application/EIS on the issues of concern. Receptor VCs are specific attributes of the biophysical and socio-economic environments that have environmental, social, economic, heritage, or health significance. To be considered for assessment, a component must be of recognized importance to society, the local community, or the environmental system, and there must be a perceived likelihood that the receptor VC will be affected by the proposed Project. VCs are scoped during consultation with key stakeholders, including Aboriginal communities and the EA Working Group. Selection also considered information from the BC CDC (MOF 1992), the BC MOE's Sensitive Ecosystem Inventory (BC MOE 2007b), the SARA (2002c) Public Registry (Government of Canada 2010), the Nass South SRMP (BC MFLNRO 2012), and the CIS LRMP (BC ILMB 2000). Consideration of certain receptor VCs may also be a legislated requirement, or be a known concern because of previous project experience.

Terrestrial ecology was selected as a receptor VC because of its key role in the maintenance of wildlife habitat, nutrient cycling, productivity, biodiversity, site stabilization, and carbon sequestration. It is recognized that Aboriginal groups place value on all ecosystems and their interconnections and as such all vegetated ecosystems were included in the assessment. Certain terrestrial ecosystems act as refugia, providing habitat for at-risk components of regional, provincial, federal, or global biodiversity. Terrestrial ecosystems also provide habitat for plants and lichens of cultural and/or economic importance.

Subject areas may be classified as an intermediate component or as a receptor VC and be further refined into sub-components and indicators as described in Section 6.4.1.1, Scoping Potential Interactions between the Project and Candidate Components. Terrestrial ecology was identified as a receptor VC as a result of the scoping process, along with the following sub-components:

- alpine ecosystems;
- parkland ecosystems;

¹ Intermediate components are specific attributes of the biophysical environment that if affected (i.e., if there is a positive or negative change in the baseline condition), act as a pathway to pass on those changes to receptor components (thereby also having the potential to affect or change the baseline condition of a receptor component).

² Receptor VCs are specific attributes of the biophysical and socio-economic environments that have environmental, social, economic, heritage, or health significance.

³ The EA Working Group is a forum for discussion and resolution of technical issues associated with the proposed Project, as well as providing technical advice to BC EAO and CEA Agency, which remain ultimately responsible for determining significance. It comprises representatives of provincial, federal, and local government, and Aboriginal groups.

- forested ecosystems;
- floodplain ecosystems;
- rare ecosystems;
- culturally/economically important plants; and
- rare plants and lichens and associated habitat.

Results from predictive studies and effects assessments for the following intermediate components and receptor VCs will be used to support the effects assessment for terrestrial ecology:

- Air quality;
- Terrain and soils;
- Surface water quantity; and
- Surface water quality.

16.4.2 Potential Interactions between the Project and Terrestrial Ecology

As described in Section 6.4.1.1, Scoping Potential Interactions between the Project and Candidate Components, a VC-scoping exercise was conducted during the development of a draft Application Information Requirements (AIR) to explore potential Project interactions with candidate VCs, and to identify the key potential adverse effects associated with that interaction. The results of the scoping exercise were circulated for review and approval by the EA Working Group and feedback from that process and from additional comments have been integrated into the Application/EIS.

Table 16.4-1 provides an impact-scoping matrix of Project components and activities that have a possible or likely interaction with the terrestrial ecology receptor VCs. A full impact-scoping matrix for all intermediate and receptor VCs, including Project components and activities not expected to interact with the terrestrial ecology VCs, is provided in Table 16.4-1.

Interactions between the Project and terrestrial ecology were assigned a colour code as follows:

- not expected (white);
- possible (grey); and
- likely (black).

Table 16.4-1. Interaction of Project Components and Physical Activities with Terrestrial Ecology Receptor Valued Components

| Project Components and Physical Activities by Phase | Terrestrial Ecology Receptor VCs |
|---|----------------------------------|
| <i>Construction Phase</i> | |
| Activities at existing adit | |
| Air transport of personnel and goods | |
| Avalanche control | |

(continued)

Table 16.4-1. Interaction of Project Components and Physical Activities with Terrestrial Ecology Receptor Valued Components (continued)

| Project Components and Physical Activities by Phase | Terrestrial Ecology Receptor VCs |
|--|----------------------------------|
| <i>Construction Phase (cont'd)</i> | |
| Chemical and hazardous material storage, management and handling | |
| Construction of back-up diesel power plant | |
| Construction of Bowser Aerodrome | |
| Construction of detonator storage area | |
| Construction of electrical tie-in to BC Hydro grid | |
| Construction of electrical substation at mine site area | |
| Construction of equipment laydown areas | |
| Construction of helicopter pad | |
| Construction of incinerator | |
| Construction of Knipple Transfer Area | |
| Construction of local site roads | |
| Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator) | |
| Construction of mine portal and ventilation shafts | |
| Construction of Brucejack Operations Camp | |
| Construction of ore conveyer | |
| Construction of tailings pipeline | |
| Construction and decommissioning of Tide Staging Area construction camp | |
| Construction of truck shop | |
| Construction and use of sewage treatment plant and discharge | |
| Construction and use of surface water diversions | |
| Construction of water treatment plant | |
| Development of the underground portal and facilities | |
| Employment and Labour | |
| Equipment maintenance/machinery and vehicle refueling/fuel storage and handling | |
| Explosives storage and handling | |
| Grading of the mine site area | |
| Helicopter use | |
| Installation and use of Project lighting | |
| Installation of surface and underground crushers | |
| Installation of transmission line and associated towers | |
| Machinery and vehicle emissions | |
| Potable water treatment and use | |
| Pre-production ore stockpile construction | |
| Procurement of goods and services | |

(continued)

Table 16.4-1. Interaction of Project Components and Physical Activities with Terrestrial Ecology Receptor Valued Components (continued)

| Project Components and Physical Activities by Phase | Terrestrial Ecology Receptor VCs |
|---|----------------------------------|
| <i>Construction Phase (cont'd)</i> | |
| Quarry construction | |
| Solid waste management | |
| Transportation of workers and materials | |
| Underground water management | |
| Upgrade and use of exploration access road | |
| Use of Granduc access road | |
| <i>Operation Phase</i> | |
| Air transport of personnel and goods and use of aerodrome | |
| Avalanche control | |
| Backfill paste plant | |
| Back-up diesel power plant | |
| Bowser Aerodrome | |
| Brucejack Access Road use and maintenance | |
| Brucejack Operations Camp | |
| Chemical and hazardous material storage, management, and handling | |
| Concentrate storage and handling | |
| Contact water management | |
| Detonator storage | |
| Discharge from Brucejack Lake | |
| Electrical induction furnace | |
| Electrical substation | |
| Employment and Labour | |
| Equipment laydown areas | |
| Equipment maintenance/machine and vehicle refueling/fuel storage and handling | |
| Explosives storage and handling | |
| Helicopter pad(s) | |
| Helicopter use | |
| Knipple Transfer Area | |
| Machine and vehicle emissions | |
| Mill building/concentrators | |
| Non-contact water management | |
| Ore conveyer | |
| Potable water treatment and use | |
| Pre-production ore storage | |
| Procurement of goods and services | |

(continued)

Table 16.4-1. Interaction of Project Components and Physical Activities with Terrestrial Ecology Receptor Valued Components (continued)

| Project Components and Physical Activities by Phase | Terrestrial Ecology Receptor VCs |
|---|----------------------------------|
| <i>Operation Phase (cont'd)</i> | |
| Project lighting | |
| Quarry operation | |
| Sewage treatment and discharge | |
| Solid waste management/incinerators | |
| Subaqueous tailings disposal | |
| Subaqueous waste rock disposal | |
| Surface crushers | |
| Tailings pipeline | |
| Truck shop | |
| Transmission line operation and maintenance | |
| Underground backfill tailing storage | |
| Underground backfill waste rock storage | |
| Underground crushers | |
| Underground: drilling, blasting, excavation | |
| Underground explosives storage | |
| Underground mine ventilation | |
| Underground water management | |
| Use of mine site haul roads | |
| Use of portals | |
| Ventilation shafts | |
| Warehouse | |
| Waste rock transfer pad | |
| Water treatment plant | |
| <i>Closure Phase</i> | |
| Air transport of personnel and goods | |
| Avalanche control | |
| Chemical and hazardous material storage, management, and handling | |
| Closure of mine portals | |
| Closure of quarry | |
| Closure of subaqueous tailing and waste rock storage (Brucejack Lake) | |
| Decommissioning of Bowser Aerodrome | |
| Decommissioning of back-up diesel power plant | |
| Decommissioning of Brucejack Access Road | |
| Decommissioning of camps | |
| Decommissioning of diversion channels | |

(continued)

Table 16.4-1. Interaction of Project Components and Physical Activities with Terrestrial Ecology Receptor Valued Components (completed)

| Project Components and Physical Activities by Phase | Terrestrial Ecology Receptor VCs |
|---|----------------------------------|
| <i>Closure Phase (cont'd)</i> | |
| Decommissioning of equipment laydown | |
| Decommissioning of fuel storage tanks | |
| Decommissioning of helicopter pad(s) | |
| Decommissioning of incinerators | |
| Decommissioning of local site roads | |
| Decommissioning of Mill Building | |
| Decommissioning of ore conveyer | |
| Decommissioning of Project lighting | |
| Decommissioning of sewage treatment plant and discharge | |
| Decommissioning of surface crushers | |
| Decommissioning of surface explosives storage | |
| Decommissioning of tailings pipeline | |
| Decommissioning of transmission line and ancillary structures | |
| Decommissioning of underground crushers | |
| Decommissioning of waste rock transfer pad | |
| Decommissioning of water treatment plant | |
| Employment and Labour | |
| Helicopter use | |
| Machine and vehicle emissions | |
| Procurement of goods and services | |
| Removal or treatment of contaminated soils | |
| Solid waste management | |
| Transportation of workers and materials (mine site area and access roads) | |
| <i>Post-closure Phase</i> | |
| Discharge from Brucejack Lake | |
| Employment and Labour | |
| Environmental monitoring | |
| Procurement of goods and services | |
| Subaqueous tailing and waste rock storage | |
| Underground mine | |

White = interaction not expected between project components/physical activities and a receptor VC

Grey = possible interaction between project components/physical activities and a receptor VC

Black = likely interaction between project components/physical activities and a receptor VC

Interactions coded as not expected (white) are considered to have no potential for adverse effects on a receptor VC or receptor valued components, and are not considered further.

16.4.2.1 Consultation Feedback on Valued Receptor Valued Components

Some site-specific information has been provided by Skii km Lax Ha and is included in the *Brucejack Gold Mine Project: Skii km Lax Ha Traditional Knowledge and Traditional Use Report* (Appendix A of Rescan 2013a) and integrated into Chapter 25, Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes, and Chapter 26, Assessment of Asserted of Established Aboriginal Rights and Interests. Desk-based ethnographic information has been collected for the Tahltan Nation and is included in the *Brucejack Gold Mine Project: Ethnographic Overview Report* (Appendix 25-A) and is also included in Chapters 25 and 26. At this time, a Tahltan-specific TK/TU report has not been completed for the Project, and Nisga'a Nation is involved in an Economic, Social, and Cultural Impact Assessment as opposed to a TK/TU study (see Chapter 27, Assessment of Nisga'a Nation Treaty Rights, Interests, and Information Requirements). In the absence or shortage of specific information about ecosystems of cultural importance, and recognizing that Aboriginal groups place value on all ecosystems and their interconnections, ecosystems of cultural importance are assessed within each terrestrial ecology receptor VC depending on their location within the landscape (Section 16.5.3, Determination of Consequence of an Effect).

16.4.2.2 Summary of Valued Receptor Valued Components Included/Excluded in the Application/EIS

Potential effects on terrestrial ecology receptor VC resulting from the Project, or similar industrial developments, were raised by Aboriginal groups, government, community members, experts, and professionals. These issues, summarized in Table 16.4-2, were raised in a variety of forums and reports including public/stakeholder comments, reviews of best management practices, scientific literature, and land use plans.

Table 16.4-2. Terrestrial Ecology Receptor Valued Components Included in the Application/EIS

| Receptor VC | Identified by* | | | | Rationale for Inclusion |
|---------------------|----------------|---|-----|----|---|
| | AG | G | P/S | IM | |
| Alpine Ecosystems | x | x | x | x | <ul style="list-style-type: none"> Identified as important historical travel routes for the Tahltan Nation (Rescan Environmental Services Ltd. 2013) and likely used by other Aboriginal groups for travel routes and hunting areas; sensitive to disturbance; provide habitat for plants and lichens of cultural importance; habitat for rare plant and lichen species; represent important habitat for highly valued wildlife species including mountain goats and grizzly bears; and discussed as an important management consideration in the CIS LRMP and Nass South SRMP. |
| Parkland Ecosystems | | x | x | x | <ul style="list-style-type: none"> Sensitive to disturbance; represent important habitat for highly valued wildlife species such as grizzly bears; and provide habitat for plants and lichens of cultural importance. |
| Forested Ecosystems | x | x | x | x | <ul style="list-style-type: none"> Identified as an important management consideration in the CIS LRMP and Nass South SRMP; important habitat for a variety of wildlife, including grizzly bear and marten; contribute to soil building processes through the contribution of root exudates, root penetration, and litter decomposition; provide biological processes, which are critical for efficient nutrient cycling, including productivity and carbon storage; and habitat for several plant species valued by Aboriginal groups (see Chapters 20 and 21). |

(continued)

33 ha). Footprints for staging areas such as the Knipple Transfer Area below Knipple Glacier (8.0 ha) were hand digitized with Purview (stereo viewing software that is used in ESRI ArcGIS) using recent digital stereo images to incorporate current disturbed area outside of the proposed footprint. The Tide Staging Area, north of the old Granduc Mine airstrip, was also buffered by 50 m to account for area lost for this staging area (approximately 5 ha).

The construction of the Brucejack Access Road was carried out under a separate permit (Permit MX-1-832); therefore, the effects due to construction are not part of this assessment. The use of the road is part of the assessment. The Brucejack Access Road and cleared right-of-way (ROW) was buffered to characterize ongoing and potential future changes in ecosystem function related to the road and road use, upgrades, and maintenance.

16.4.3.2 *Temporal Boundaries*

The temporal boundaries of the Project correspond to the following four phases:

- **Construction:** 2 years;
- **Operation:** 22 years;
- **Closure:** 2 years (includes project decommissioning, abandonment and reclamation activities); and
- **Post-closure:** minimum of 3 years (includes ongoing reclamation activities and post-closure monitoring).

16.4.3.3 *Administrative Boundaries*

The Project is situated within the Regional District of Kitimat-Stikine, an administration providing local government services to member municipalities within northwestern BC. It is situated within the Kalum and Skeena-Stikine Forest Districts, and the Nass and Cassiar Timber Supply Areas, administrative boundaries within which forest resources are managed by the British Columbia Ministry of Forests, Lands and Natural Resource Operations.

The Project also overlaps portions of the CIS LRMP area, completed in October 2000 (BC ILMB 2000), and the Nass South SRMP area completed in June 2012 (BC MFLNRO 2012). LRMPs are sub-regional resource plans that establish the framework for land use and resource management objectives and strategies (BC ILMB and Ministry of Agriculture and Lands 2006); SRMPs are landscape-level plans developed to address sustainable management of land, water, and resources. They focus on similar issues and values as regional plans or LRMPs (e.g., timber, biodiversity, and tourism) but at a more detailed level.

Smaller watershed sustainability plans, as developed by the Gitanyow First Nation, for example, have been incorporated within larger land management plans, including the Nass South SRMP. Within wilp Wii'litsxw traditional territory (downstream of the Project), the SRMP also provides protection of ecologically sensitive areas, high-value habitats, and traditional use sites (BC MFLNRO 2012).

Within their traditional territories, current Gitksan watershed planning includes sustainable development plans for each of the nine watersheds that incorporate considerations regarding Aboriginal title, contribute to capacity building, and enhance economic conditions. Development planning tools may include full-cost accounting of social and environmental values, environmental assessment to avoid or minimize negative impacts, and ecosystem management (Gwaans 2007). Issues of concern are identified at a watershed level and may include information regarding plant resources, fish and wildlife habitat, culturally modified trees, historical sites, and information about the respective wilp (Gitksan Chiefs' Office 2010).

16.4.4 Identifying Potential Effects on Terrestrial Ecology

Potential Project-related effects on terrestrial ecology receptor VCs were identified through reviews of relevant literature (e.g., Project description, data made available from First Nations and local stakeholders or through ethnographic reports, scientific literature, data acquired via data sharing agreements, government documents, and publically available data associated with relevant adjacent projects) and professional judgement and experience. Based on this review, seven potential effects were identified: high impact surface disturbance (including soil erosion and compaction as well as loss of soil fertility), dust effects (eutrophication and acidification of soils), edge effects, introduction and/or spread of invasive plant species, windthrow, fragmentation, and alteration of hydrological connectivity. These effects result in loss and/or alteration of ecosystem function and extent, which is discussed in more detail below.

16.4.4.1 *Loss of Ecosystem Function and Extent*

Loss of ecosystem function and/or extent can occur as a result of removal or sustained discontinuity of the ecological processes that support an ecosystem and its associated functions.

The vast majority of loss of ecosystem function and extent will occur at a local level due to physical clearing during site preparation at the Brucejack Mine Site and Bowser Aerodrome, and to a lesser extent at the Knipple Transfer Area and Tide Staging Area. Incremental losses are also expected during closure and reclamation due to slope stabilization and re-contouring, re-vegetation, and reclaimed area maintenance activities. The implications of this effect on each terrestrial ecology receptor VC are discussed in more detail in Section 16.5.2, Determination of Probability of an Effect.

16.4.4.2 *Alteration of Ecosystem Function and Extent*

Alteration of ecosystem function or extent may occur at a landscape level as a result of soil erosion and compaction, loss of soil fertility, dust deposition (and subsequent eutrophication and/or acidification) during each phase of the Project. Edge effects (e.g., species isolation, increased species diversity, and favourable conditions for invasive plants), windthrow (i.e., trees uprooted or broken due to wind), and fragmentation (i.e., the breaking apart of habitat and its associated ecological processes) may occur throughout the life of the Project but mostly during the Construction phase along the Brucejack Transmission Line and during the Operation phase along the Brucejack Access Road. The introduction and/or spread of invasive plants could occur during any phase of the Project along the Brucejack Access Road, the Brucejack Transmission Line, and at the Brucejack Mine Site. The interruption or removal of hydrological connectivity along the Brucejack Transmission Line during Construction and Operation and along the Brucejack Access Road during the Operation phase is expected to occur at the local level but may extend to the landscape level depending on the extent of alteration.

Each of these effects in relation to the terrestrial ecology receptor VC is described in more detail in the following sections.

Soil Erosion and Compaction

Soil compaction, typically caused by construction activities and associated heavy equipment traffic, can affect vegetation establishment and growth. It can also result in increased surface runoff and soil erosion. The area of land affected by surface compaction, and the severity of this adverse effect, are generally expected to be most prevalent during the Construction and Closure phases.

Roads constructed on slopes can interfere with subsurface water flow and runoff, making the slopes vulnerable to erosion and slope failures (Noss 1995; Gunn 2009). Furthermore, some level of land subsidence is expected in the mining area (see [Appendix 11-C, Subsidence Potential at the Brucejack Gold](#)

Mine Project, and 11-D, *Rock Mechanics Assessment at the Brucejack Gold Mine Project*). Much of the area currently associated with the mine site is a combination of rock and weathered bedrock; however, there are some well-developed and ecologically important soils in the surrounding lower-lying areas. Soils in these areas could be affected by ground subsidence related to underground mining activities. The exact effect of land subsidence on soil erosion is difficult to establish; however, due to potential changes in slope stability, soil mass movement can be anticipated near the underground mine works.

Loss of Soil Fertility

While stripping and stockpiling operations are necessary to conserve soil for future mine reclamation, the process itself can result in soil degradation through the loss of soil structure, compaction, and erosion. With time, such activity can result in the loss of native plant reproductive material, organic matter, and faunal and microbial activity. Mixing of fertile topsoils with subsoils during soil salvage can result in a reduction of soil quality.

Soil fertility can also be affected by alteration of soil drainage patterns due to Project development. Exposed soil surfaces are known to reduce infiltration, capture and channelize surface runoff, and modify subsurface flow paths (W. H. MacKenzie and Shaw 2000; Sayers, Hall, and Meadowcroft 2002), which all affect the soil moisture regime and thus a number of related soil characteristics, such as soil fertility. Soil erosion associated with roads also decreases soil productivity in surrounding areas (Ohlson et al. 2003).

Roads can also affect soil fertility by increasing solar radiation and air movement in previously shaded environments, which leads to changes in soil temperature and moisture (Harris 1988; Sheldon 2005; Hanson et al. 2008), alters composition and activity of soil micro-organisms (S. C. Brown, Smith, and Batzer 1997), and increases the risk of fire occurrence (Mitsch and Gosselink 2000; Arienti et al. 2009). Fires, in turn, affect a variety of physical and chemical properties of soil, including the loss of organic matter and reduced infiltration, which, interacting with removal of slope stabilizing vegetation, may result in increased runoff and soil erosion (Azous and Horner 2010).

Edge Effects

Edge effects are expected along the Brucejack Access Road in areas where forests meet cleared areas. At these locations, the edge of the forest is exposed to increased sunlight, temperature, soil desiccation, and wind. Temperatures in clearings are higher during the day and lower at night compared to adjacent forests. These changes to the microclimate can extend 100 to 150 m into the forest. Southerly aspects also tend to experience greater edge effects than northerly aspects (Kremsater and Bunnell 1999).

The altered abiotic environments at forest edges, in turn, alter the structure and composition of the vegetation community. Seral, shade-intolerant species that thrive on open sites will increase in abundance. Invasive species often proliferate in edge habitats where seed rain from adjacent clearings is high and the soils and vegetation are disturbed (H. T. Murphy and Lovett-Doust 2004).

Windthrow

Ecosystems along the Brucejack Access Road are at varying degrees of risk of windthrow depending on their site-specific conditions and exposure to wind. Forest ecosystems develop in response to a variety of environmental conditions, including slope topography, soil moisture and nutrients. These environmental conditions influence species-dependent differences in rooting depths, height-to-diameter ratios, and height-to-crown length ratios (Stathers, Rollerson, and Mitchell 1994), all of which influence a site's ability to withstand windthrow. Windthrow risk is greatest where wind speeds are high and/or where soil and terrain properties do not allow for deep-rooting, such as in wet soils, on steep rocky slopes, or on

exposed crests and ridges, such as those along the Brucejack Transmission Line route. For example, in the ESSF BEC zone, frequent storms, shallow and wet soils, and complex topography result in an elevated windthrow risk (Huggard, Klenner, and Vyse 1999). Although windthrow effects in BC have been documented to extend more than 100 m into forest stands (Burton 1991), most windthrow damage is expected within 10 to 20 m of forest edges (Stathers, Rollerson, and Mitchell 1994). The risk of windthrow is expected to be highest during the first few years after forest clearing. Windthrow can cause tree mortality which, in turn, may cause increased fire hazard and insect epidemics when downed trees are not salvaged (Stathers, Rollerson, and Mitchell 1994).

Fragmentation

Fragmentation of forested ecosystems is expected to occur as a result of the continued use of the Brucejack Access Road during Operation and along the Brucejack Transmission Line during Construction and Operation. Fragmentation alters ecological processes, including nutrient flows, energy transfers, interactions with pollinators, and genetic exchanges; each influences the development of ecosystem structure, composition, and function (Olivier Honnay et al. 2005; Society for Ecological Restoration 2013). Fragmentation has different effects on populations depending on the specific requirements of the species. In general, the overall effects of fragmentation may not be known for some duration after the actual breaking apart of the habitat.

Alteration of Hydrology

Hydrological processes influence the geomorphic, biogeochemical, and ecological processes of ecosystems (Creed et al. 2011). Interruption or removal of hydrologic connectivity or an increase in surface or sub-surface flow has implications for sediment, moisture, and nutrient flows, which can influence ecosystem development, ecological integrity, and ultimately function.

Unmitigated surface disturbance during the Construction, Operation, and Closure phases at the Mine Site Area could increase sedimentation and erosion of soils and parent materials (see Chapter 13, Assessment of Potential Surface Water Quality Effects).

Linear features, primarily roads and related components such as culverts and stream crossings, can influence hydrological connectivity through the interruption, re-routing, removal, or increase of surface and/or sub-surface flow. This change may alter ecosystem development depending on the magnitude of the change and on the receiving topography, bedrock geology, surficial geology, soil type, and depth.

The continued use of the Brucejack Access Road is expected to influence hydrological pathways downslope and may contribute to erosion, especially in the steeper terrain along the route.

Structures and roads can change how water moves in a system through a variety of ways. Furthermore, the continued use and subsequent compaction of the Brucejack Access Road is expected to maintain impervious surfaces, which would reduce infiltration rates into ground water and change the timing and quantity of water flow into ecosystems (Azous and Horner 2010). Compaction of soil and loss of pore space can also reduce infiltration rates and obstruct or reduce ground water flow, depending on soil depth, porosity, and other characteristics that influence ground water (Schack-Kirchner, Fenner, and Hildebrand 2007).

Fugitive Dust Deposition

There is a low risk of alteration of ecosystem function at the Brucejack Mine Site, along the Brucejack Access Road and the Brucejack Transmission Line due to fugitive dust. Fugitive dust emission will occur during vehicle traffic along local site roads, but will be limited within the Mine Site Area as a

substantial amount of vehicle traffic will occur underground. Areas cleared for infrastructure (i.e., laydown areas) can also be sources of dust; predictive modelling and detailed effects assessment are presented in Chapter 7, Air Quality Predictive Study.

Fugitive dust, depending on the amount and frequency of dusting, the chemical properties of dust, and receptor plant species, can cause physical injuries to vegetation, including the alteration of photosynthetic receptors, respiration, and transpiration (Farmer 1993 in Trombulak and Frissell 2000). Plant growth may be affected by a number of factors including dust-induced changes in soil pH and nutrient availability (Walker and Everett 1991; Farmer 1993; Auerbach, Walker, and Walker 1997), radiation absorption and leaf temperature (Eller 1977) and chemistry (McCune 1991; CEPA/FPAC Working Group 1998; Anthony 2001). Evergreen shrubs could experience greater cumulative dusting than deciduous shrubs as they retain leaves from year to year (Auerbach, Walker, and Walker 1997).

Potential effects on ecosystem function and rare plants and lichens include particulate matter from fuel combustion by vehicles, the induction melting furnace, incinerators, and diesel generators. Waste rock and tailings will be stored sub-aqueously (minimizing the need to stockpile material), and blasting and crushing will primarily occur underground, which will limit the potential for dust emissions from these sources. Additional air emissions will occur from a waste incinerator that will primarily dispose of food waste and packaging as well as other domestic camp waste.

Ecosystem Eutrophication

Increases in nutrient availability in alpine ecosystems may lead to changes in plant species composition and diversity as a result of competitive displacement of sensitive organisms (lichens, mosses, and evergreen dwarf shrubs) by fast-growing, opportunistic species of grasses and herbs (Bowman and Steltzer 1998; R Bobbink and Lamers 2002; Fenn et al. 2003; R. Bobbink et al. 2010). Reduction in the richness and density of mycorrhizal fungi recorded in alpine grasslands have also been linked with increased levels of available macronutrients (Liu et al. 2012).

Atmospheric nitrogen deposition of 5 to 10 kg N/ha/year has been suggested as the critical load for ombrothrophic bogs and alpine heath ecosystems, beyond which significant environmental changes may be expected (WHO 2000). Studies conducted in the alpine ecosystems of Colorado (Baron et al. 2000) suggest, however, that even smaller increases in atmospheric nitrogen deposition (2 to 3 kg N/ha/year) lead to measurable changes in terrestrial and wetland ecosystem properties. Studies of Arctic heath vegetation (Gordon, Wynn, and Woodin 2001) show that small additions of phosphorus (1 to 5 kg P/ha/year) sustained for several years can alter species composition and increase ecosystem sensitivity to nitrogen addition.

The concentrations of elements considered as plant macro nutrients (nitrogen, phosphorus, potassium, calcium, and magnesium) are expected to increase in the soil in several areas of the LSA. Yearly rates of nitrogen deposition in the LSA (resulting mainly from diesel engine emissions) are expected to range between 0.4 and 12.3 kg/ha/year (modelling methodology is provided in Chapter 7, Air Quality Predictive Study). Concentrations of phosphorus and potassium in the soil are expected to increase in the areas affected by dust deposition.

The predicted levels of eutrophication may affect several sensitive ecosystems in the LSA, including *Herb Meadow*, *Mountain Hemlock-Subalpine Fir-Mountain Heather*, *Mountain Heather-Partridgefoot*, *Krummholtz*, *Rock Outcrop*, and *Subalpine Fir-Lodgepole Pine-Cladonia* assemblage. These ecosystems are typically characterized by very poor to poor nutrient regime and they often provide unique habitat for rare species of lichens, mosses, and vascular plants.

With the exception of the *Subalpine Fir-Lodgepole Pine-Cladonia* and *Rock Outcrop* assemblages, only a relatively small proportion of sensitive ecosystems will be affected by the annual rates of deposition exceeding 5 kg of nitrogen or phosphorus per hectare.

Soil Acidification

Nitrogen oxides (NO_x) and sulfur dioxide (SO₂) emissions in Europe, North America, and most recently Asia have been associated with increased atmospheric acid deposition (Cowling 1982; Gorham 1992; Cowling and Nilsson 1995; Zhao et al. 2009), which appears to be one of the main factors affecting soil acidification in some regions (Reuss, Cosby, and Wright 1987; Galloway 1995). Nitric and sulphur oxides react with water molecules in the atmosphere and produce acidic nitrates and sulphates. Atmospheric deposition of sulphates and nitrates can cause leaching of base cations from the soil and lead to soil acidification defined by the World Health Organization (WHO 2000) as *a decrease in acid neutralizing capacity of the inorganic fraction of the soil*.

While the acidity of affected soil solution often increases, especially in coarse soils characterized by low buffering capacity, the most typical effects of acid deposition include a long-term net decline in soil exchangeable base cation concentrations leading to impoverishment of the nutrient status of the vegetation (Blaser et al. 1999; Watmough S.A. 2002; Fernandez et al. 2003).

Soil acidification increases ecosystem vulnerability to other stress factors such as frost, drought, pests and intrusion of invasive species. A complex interactions between acidification and increased metal toxicity or nutrient imbalances caused by nitrogen addition have been suggested as a common cause of reduced ecosystem health (Heij and Schneider 1991; Greaver et al. 2012) and reduced species diversity (De Schrijver et al. 2011).

Within the LSA, the predicted rates of aerial deposition of phosphorus range from 0.01 to 48.3 kg P/ha/year (mean 4.2 kg P /ha/year) and the rates of potassium deposition range from 0.01 to 193 kg K/ha/year (mean 16.9 kg K /ha/year). Figures 16.4-1 and 16.4-2 show the predicted extent of nutrient deposition.

Most soils in the LSA are strongly acidic, shallow, coarse to medium textured, with free carbonates typically absent (Section 11.3.4, Characterization of Terrain and Soils Baseline Condition). Results of air quality modelling (Chapter 7, Air Quality Predictive Study) suggest that the predicted annual acid precipitation associated with the SO₂ and NO_x emissions generated by Project development will exceed the World Health Organization critical load guideline in approximately 3% of the LSA (Figure 16.4-3). The exceedance of the critical load (of 250 eq/ha/year) in the affected areas is predicted to vary between 2 and 709 eq/ha/year (mean 200 eq/ha/year).

Soil acidification increases ecosystem vulnerability to other stress factors such as frost, drought, pests, and intrusion of invasive species. Complex interactions between acidification and increased metal toxicity or nutrient imbalances caused by nitrogen addition have been suggested as a common cause of reduced ecosystem health (Heij and Schneider 1991; Greaver et al. 2012) and reduced species diversity (De Schrijver et al. 2011).

The predicted acid deposition may affect a number of sensitive ecosystems located in the vicinity of Bowser Aerodrome, including *Krummholtz*, *Subalpine Fir-Lodgepole Pine-Cladonia*, *Mountain Hemlock-Subalpine Fir-Blueberry*, *Mountain Hemlock-Subalpine Fir-Mountain Heather*, *Mountain Heather-Partridgefoot* and *Rock Outcrop*. These ecosystems are typically characterized by crest or upper slope location, shallow, coarse, non-calcareous soils, very poor to poor nutrient regime and they often provide unique habitat for rare species of lichens, mosses and vascular plants. Ecosystems supporting lichen communities are particularly vulnerable to sulphate and nitrate deposition (Fenn et al. 2003).

Figure 16.4-1

Predicted Annual Rates of Nitrogen Deposition in the Vicinity of the Proposed Project

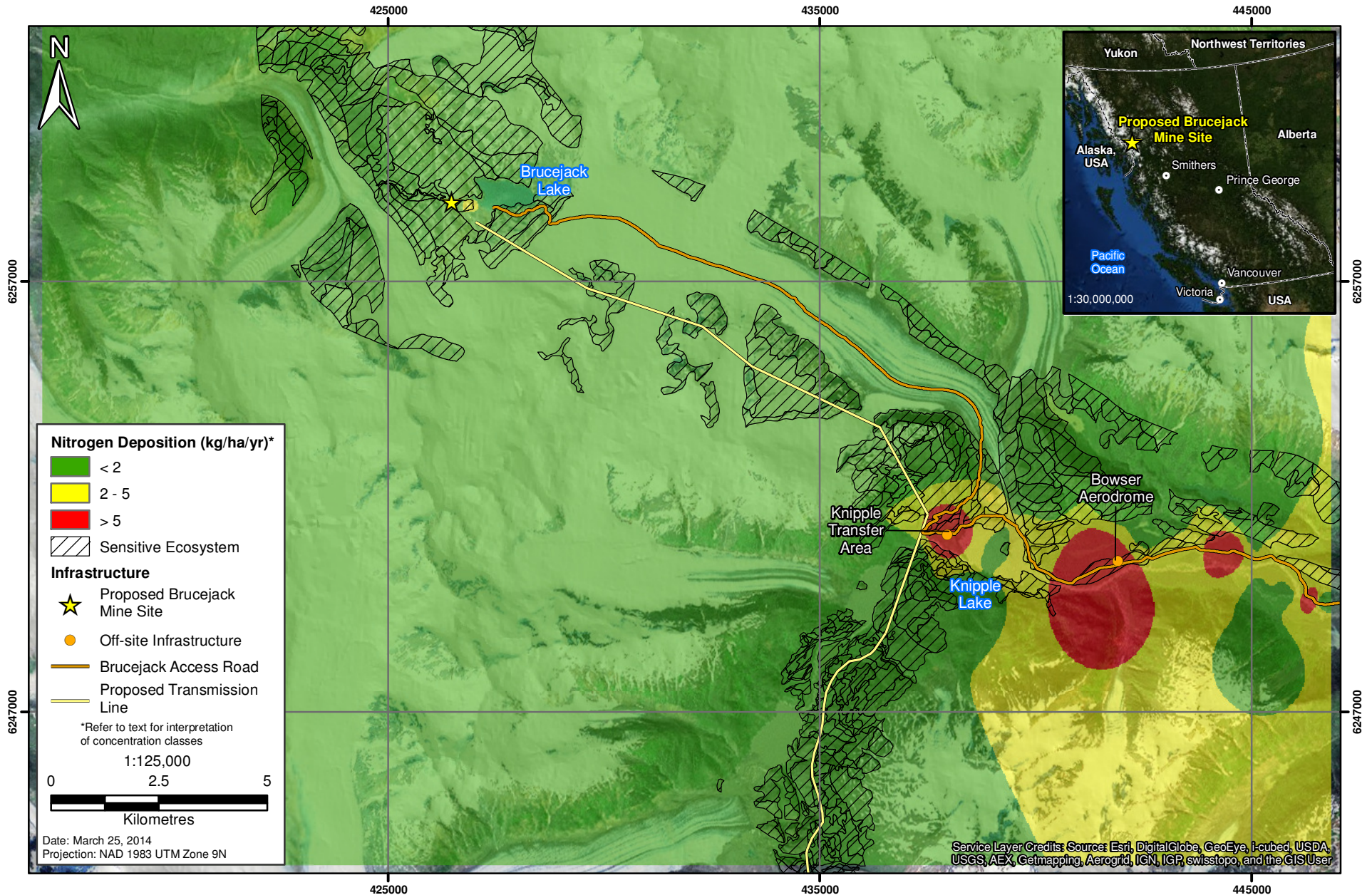


Figure 16.4-2

Predicted Annual Rates of Phosphorus Deposition in the Vicinity of the Proposed Project

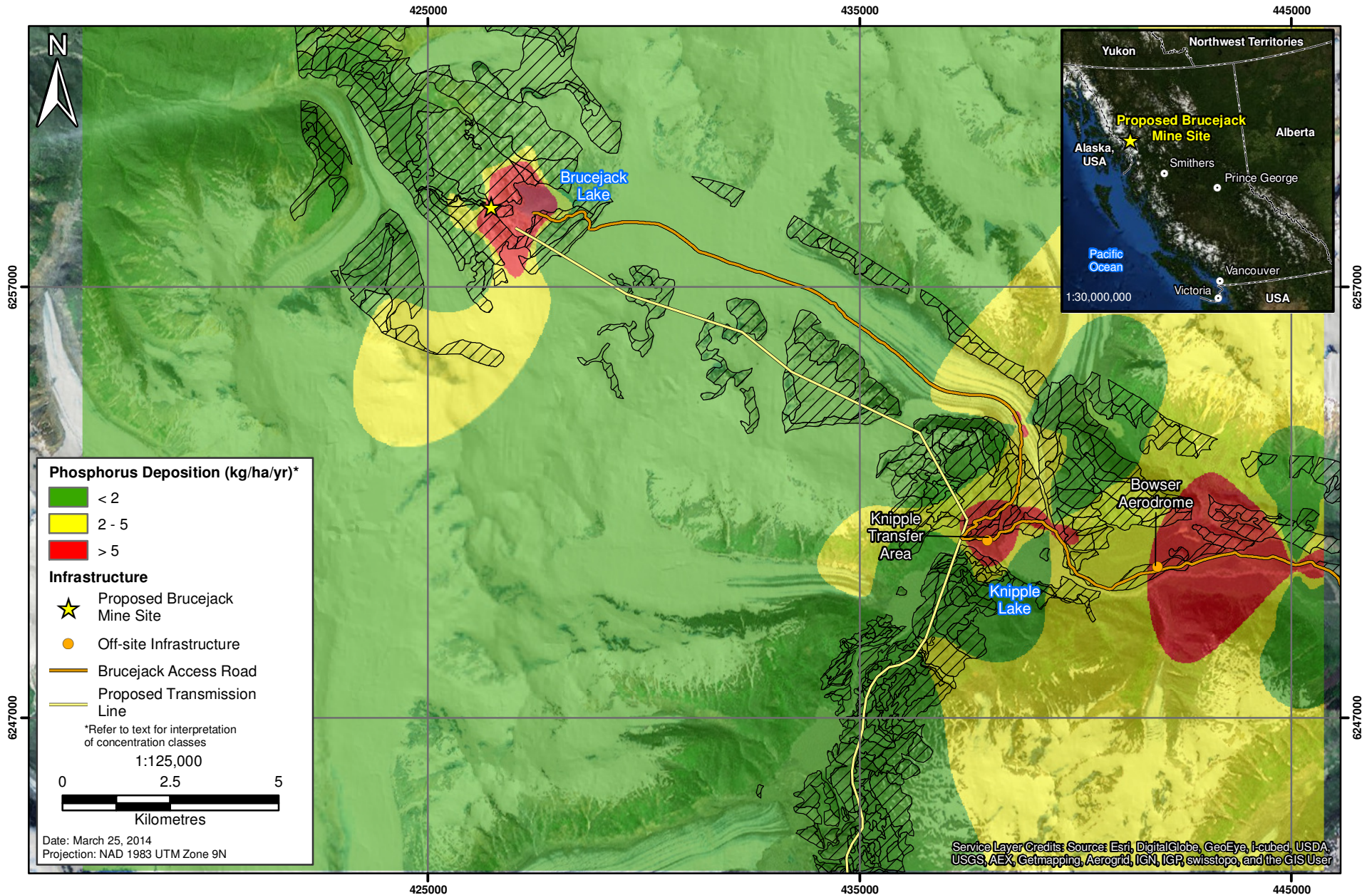
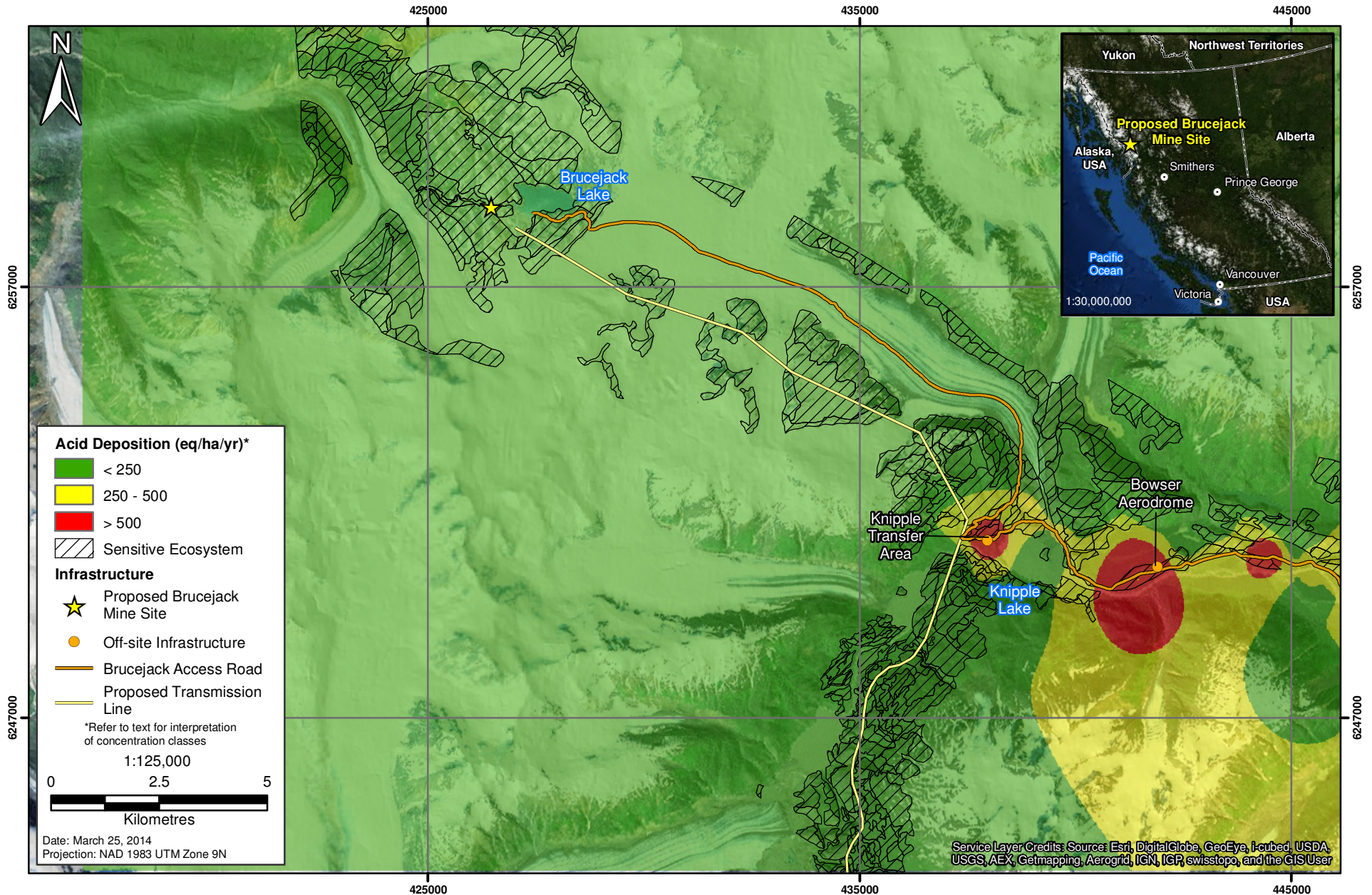


Figure 16.4-3

Predicted Annual Rates of Acid Deposition in the Vicinity of the Proposed Project



With the exception of the *Mountain Hemlock-Subalpine Fir-Blueberry* and the *Subalpine Fir-Lodgepole Pine-Cladonia* assemblages, only a relatively small proportion of sensitive ecosystems will be affected by the rates of deposition exceeding 250 eq/ha/year.

Introduction and/or Spread of Invasive Plants

There is a low risk of invasive plant introduction and spread along the Brucejack Access Road. However, construction and development activities associated with the Project increase the potential of introducing invasive plants into local environments by creating favourable habitat through ground disturbance (Polster 2005). Features fundamental to the construction process, namely transportation corridors as well as the vehicles and machinery travelling along such corridors, provide access and dispersal mechanisms. Invasive plants are often found along road verges and within areas that have sustained some level of disturbance. Vehicles of any size (e.g., heavy machinery to all-terrain vehicles) travelling along the Access Road could inadvertently transport plant propagules in tires, the undercarriage, or in mud on the vehicle to previously unaffected areas.

Invasive plants can aggressively compete with and replace native vegetation when introduced into natural settings (Haber 1997). Invasive plant species can influence ecosystem diversity, structure, and function through invasion and hybridization. Invasive plants can alter the structure of a natural ecosystem and ultimately change the way in which the site is utilized by wildlife, insects, and micro-organisms. Changes to nutrient cycling, hydrology, erosion, and fire regimes may also occur as a result of invasive plants (Canadian Food Inspection Agency 2008).

16.5 EFFECTS ASSESSMENT AND MITIGATION FOR TERRESTRIAL ECOLOGY

The terrestrial ecology assessment identifies the potential effects on terrestrial ecology receptor VCs taking into consideration the interconnections that occurs across the landscape, information from key stakeholders, including Aboriginal and/or local communities, and the guiding principles outlined in the CIS LRMP (BC ILMB 2000) and the Nass South SRMP (BC MFLNRO 2012)). The methodology and results of the assessment are described in the sections below.

16.5.1 Risk Model for Terrestrial Ecology Effects

The key potential Project-related effects on terrestrial ecology receptor VCs was assessed through a risk model, which takes into consideration the magnitude, duration, frequency, geographic extent, reversibility, and resiliency of the terrestrial ecology receptor VCs within an ecological context. A similar approach has been employed in various fields such as wildfire, flood, and ecological risk management (Sayers, Hall, and Meadowcroft 2002; Blackwell et al. 2004). The risk model identifies the probability (i.e., the likelihood that a Project effect will interact with a terrestrial ecology receptor VC) and the consequence (i.e., the relative importance of the ecosystem function) of that interaction (Figure 16.5-1).

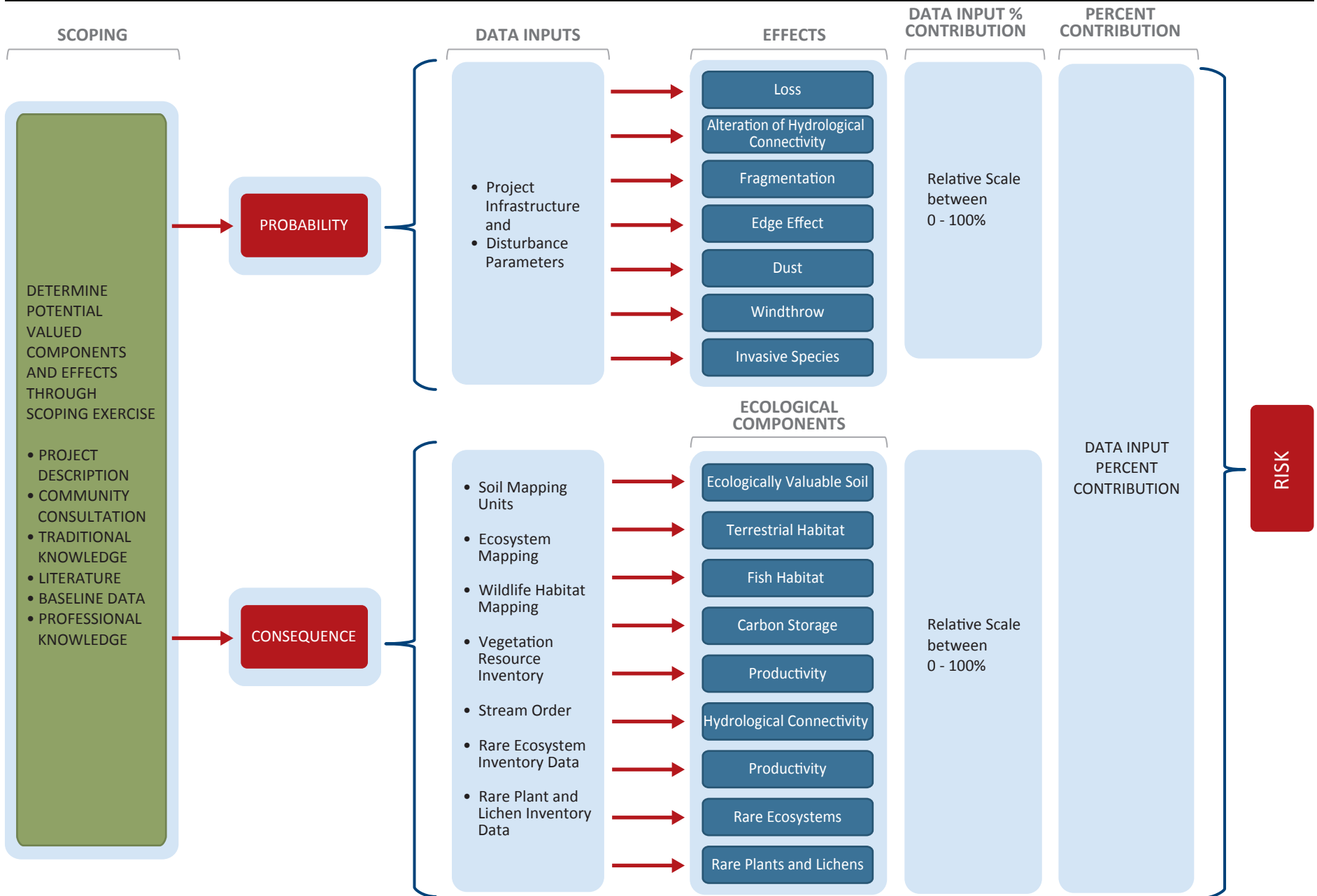
16.5.2 Determination of Probability of an Effect

The probability that a Project activity (e.g., mine construction, road use, and transmission tower installation) will result in an effect on an ecosystem function was determined through reviews of relevant literature, proposed Project activities, baseline information, and/or expert opinion.

Based on this review, seven potential effects were identified: high impact surface disturbance, dust effects, edge effects, introduction and/or spread of invasive plant species, windthrow, fragmentation, and alteration of hydrological connectivity. Each potential effect was assigned a magnitude rating based on empirical data or expert knowledge regarding the type, extent, and duration of the potential effect.

Figure 16.5-1

Probability and Consequence Model used to Evaluate Project Effects on Terrestrial Ecology Receptor Valued Components



For example, results of atmospheric modelling were used to estimate rates of eutrophication and acidification resulting from the deposition of nitrogen, phosphorus (in the form of dust) and acid. Transects perpendicular to the road surface in areas away from the influence of any Project infrastructure characterized dust and acid deposition due to road traffic; these transects were assumed to be representative of the contribution of road traffic to dust and acid deposition along the entire road outside of the atmospheric modelling domain. The results indicated that there was no statistically significant difference between the background levels of dust and acid deposition related to the Project beyond 100m from the road. This information was used to determine the probability ratings for dust effect on ecosystem function (Table 16.5-1a). The probability ratings were further characterized through identification of an effect contribution. The effect contribution is the relative likelihood that this effect (i.e., fugitive dust) will result in an effect to ecosystem function.

Table 16.5-1a. Example of Probability Rating for Fugitive Dust Effects

| Effects | Measured Criteria for Ecological Effects | Rating Weight for Effect | Overall Contribution of the Effect (%) |
|----------------|--|--------------------------|--|
| Eutrophication | Nitrogen Deposition Rate: | | 20% |
| | < 2 kg/ha/yr | 10 | |
| | 2 - 5 kg/ha/yr | 5 | |
| | > 5 kg/ha/yr | 1 | |
| | Phosphorus Deposition Rate: | | |
| | < 2 kg/ha/yr | 10 | |
| | 2 - 5 kg/ha/yr | 5 | |
| Acidification | Acid Deposition Rate: | | |
| | < 250 eq/ha/yr | 10 | |
| | 250 - 500 eq/ha/yr | 5 | |
| | > 500 eq/ha/yr | 1 | |

Figure 16.5-2a to 16.5-2c illustrates the probability rating of all potential effects within the Brucejack Mine Site, Brucejack Access Road, and Brucejack Transmission Line sub-areas according to the current Project design, regardless of the consequence.

16.5.3 Determination of Consequence of an Effect

The consequence of a Project effect interacting with an ecosystem function or value was also determined through reviews of relevant literature, proposed Project activities, baseline information, and professional judgement. Ecosystems were categorized into alpine, parkland, forested, and riparian ecosystems based on the BEC unit within which they occur. For example, ecosystems within the CMAunp were categorized as alpine ecosystems and ecosystems within the ESSFwv were categorized as forested ecosystems. The consequence (i.e., relative importance) of all vegetated ecosystems were assessed and weighted in relation to the following attributes:

- ecologically valuable soil;
- forest productivity;
- carbon storage;

Figure 16.5-2a
Probability Rating Map Brucejack Mine Site Sub-area

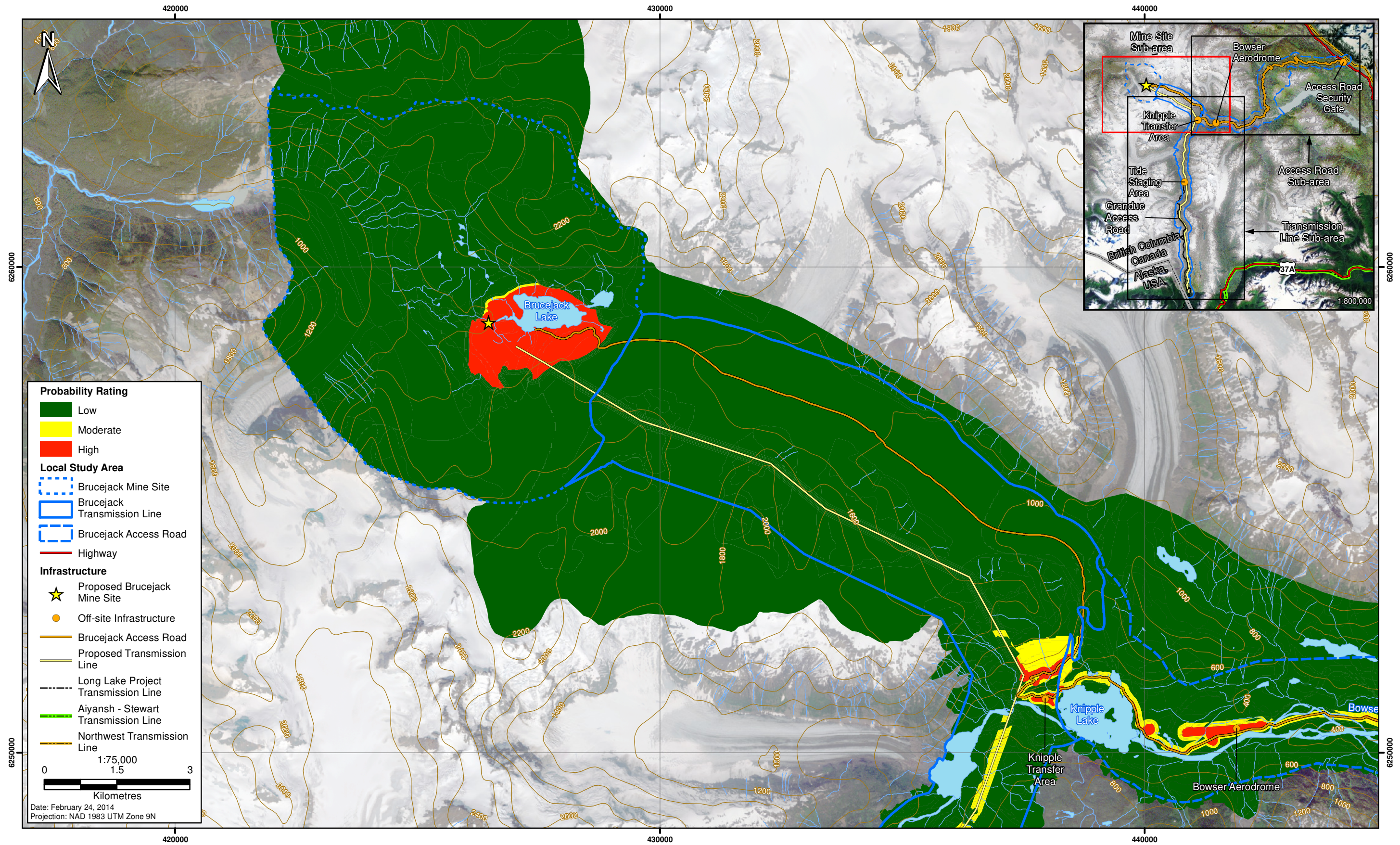


Figure 16.5-2b
Probability Rating Map Brucejack Access Road Sub-area

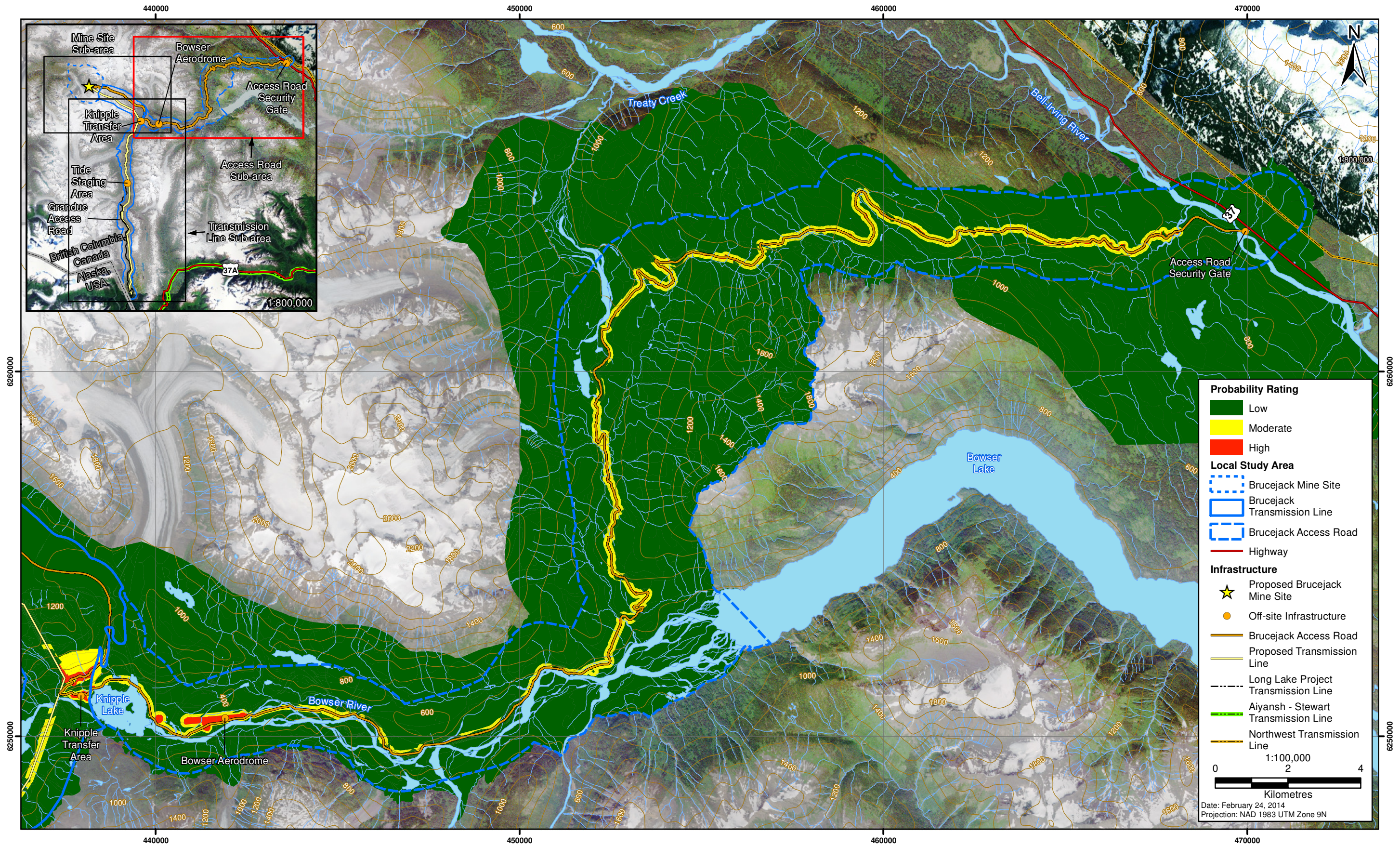
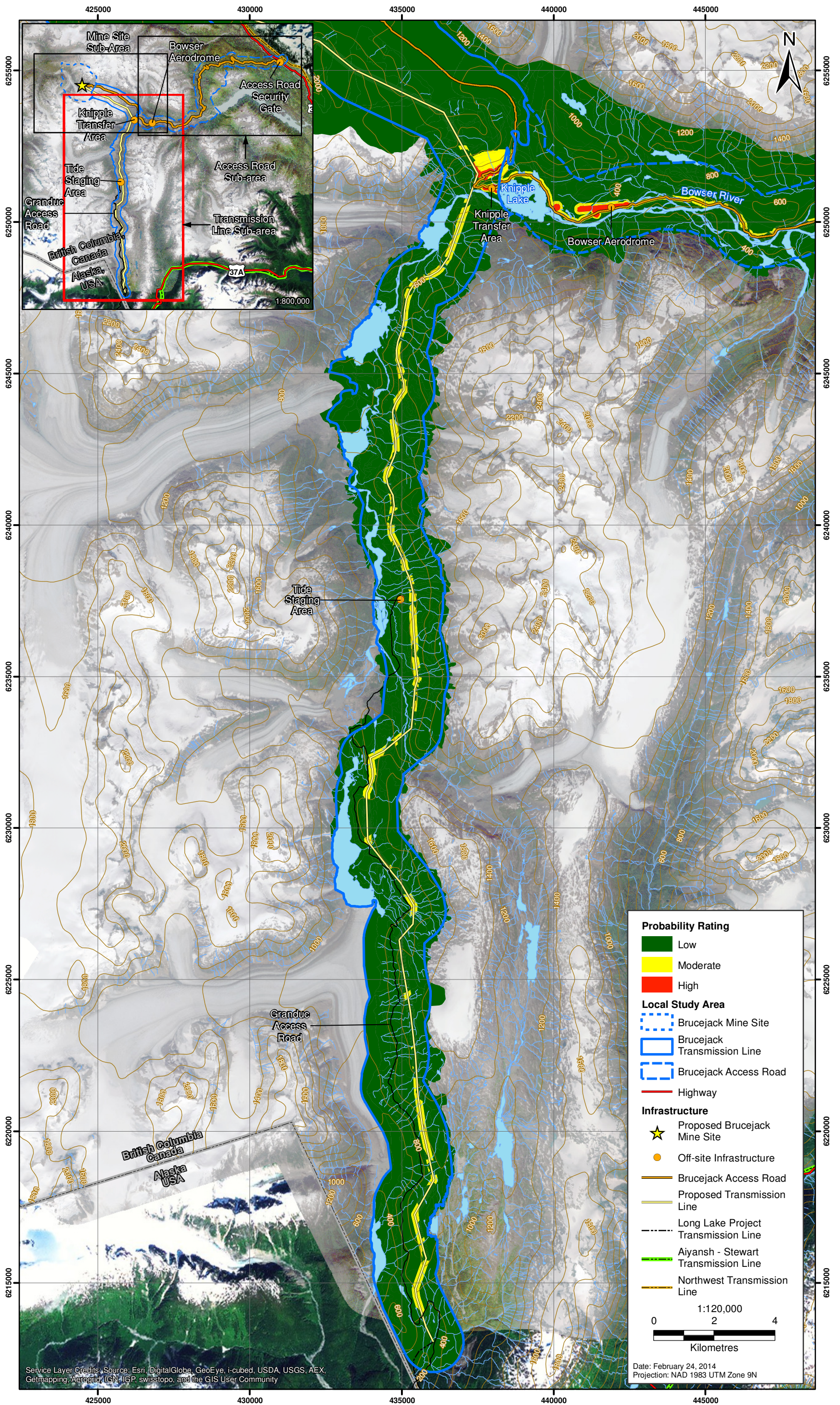


Figure 16.5-2c

Probability Rating Map Brucejack Transmission Line Sub-area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- critical habitat for select wildlife species;
- ecologically valuable habitat for fish species;
- hydrological connectivity;
- rare ecosystems;⁴ and
- rare plants or lichens⁴ (confirmed populations).

The attributes listed above, although not exhaustive, represent characteristics tempered by social considerations that may help predict how an ecosystem functions and how readily an ecosystem is likely to respond to and recover from anthropogenic disturbances or other environmental stressors. The elements of each attribute were weighted based on their relative contribution to the attribute as a whole. For example, ecologically valuable soils were rated as high, moderate, low, and nil according to their relative degree of sustainable biomass productivity within their respective BEC subzones. This is interpreted from their soil development and parent material characteristics (i.e., soils rated as high represent sites within stable environments that have deeper effective root zones, are well drained, and exhibit soil textures and organic matter content that allow for higher nutrient and moisture holding capacity; Table 16.5-1b).

Table 16.5-1b. Example of Consequence Rating for the Function of Ecologically Valuable Soils

| Attribute | Description of Typical Project Soils | Attribute Contribution | Function/Value Contribution |
|-----------------------------|--|------------------------|-----------------------------|
| Ecologically Valuable Soils | <ul style="list-style-type: none"> • Brunisolic and Podzolic soils commonly developed in morainal blankets. • Wetland organic and peaty soils - rated high because of their high organic matter content and nutrient holding capacity. | High (10) | 40% |
| | <ul style="list-style-type: none"> • Gleysolic soils on a variety of parent materials; or better developed and better drained soils on less suitable parent materials (typically excessive coarse fragment content) such as colluvium “C,” fluvial “F,” and glacio-fluvial “G” materials. | Moderate (7) | |
| | <ul style="list-style-type: none"> • Regosolic soils; especially those in areas of active terrain processes (high-energy flooding and avalanche activity) where soil development is interrupted by frequent disturbance and/or biomass may be removed; shallow soils developed in and around bedrock outcrops (weathered bedrock “D” parent materials). | Low (3) | |
| | <ul style="list-style-type: none"> • Non-soils (exposed bedrock, water, glaciers - ice, permanent snow, soils disturbed by anthropogenic activities/materials) | Nil (1) | |

Attributes were further characterized through identification of a function/value contribution. The function/value contribution is the relative contribution of that attribute to the overall maintenance, resilience, or function of the ecosystem. For example, ecologically valuable soils are assigned a 40% relative contribution to the overall function of an ecosystem in this area.

⁴ Polygons/raster cells with known occurrences of listed ecosystems, plants or lichens of conservation interest were assigned a consequence rating of 10, the highest value possible, to ensure that these ecosystems were distinguishable from other values at risk.

The consequences of a Project effect interacting with culturally/economically important plants were assessed independent of the model and are discussed in Section 16.5.5.6.

Figure 16.5-3a to 16.5-3c illustrates the consequence rating of the ecosystem functions within the Brucejack Mine Site, Brucejack Access Road, and Brucejack Transmission Line sub-areas.

16.5.4 Determination of Risk of an Effect

The final output of the risk model is a spatial characterization of risk based on probability and consequence ratings for individual terrestrial ecology receptor VCs. The final risk determination of this model is used to evaluate the type, distribution, likelihood and relative importance of each effect on a terrestrial ecology receptor VC, within each defined sub-area. The probability and consequence criteria for each attribute are summarized in Tables 16.5-2a and 16.5-2b. The results of this risk assessment are illustrated in Figure 16.5-4a, 16.5-4b, and 16.5-4c, and are discussed in detail in Sections 16.5.2 to 16.5.3.

16.5.5 Key Effects on Terrestrial Ecology

Ecosystems are complex interactions of geomorphic, bio-geochemical, and ecological processes that result in unique soil types, species assemblages, and community structure and functions. Loss or alteration of ecosystem processes has implications regarding a site's ability to provide ecosystem services such as wildlife habitat, forest productivity, and carbon storage. The magnitude of loss or alteration of ecological process is largely dependent on the type, extent, and duration of the effects, as well as on the resiliency of the affected site.

The following sections summarize the final risk of the potential loss or alteration of ecosystem function and extent for Alpine, Parkland, Forested, and Riparian ecosystems within the Brucejack Mine Site, Brucejack Access Road, and Brucejack Transmission Line sub-areas. Loss or alteration of rare ecosystems, culturally important plant species, and rare plants and lichens were assessed independent from the model and are discussed in Sections 16.5.2.5 to 16.5.2.7.

16.5.5.1 Identifying Key Effects on Alpine Ecosystems

A loss of alpine ecosystem function and extent is expected to occur during the Construction and Operation phases at the Brucejack Mine Site and Brucejack Transmission Line, but not along the Brucejack Access Road during any Project phase. Alteration of ecosystem function and extent is expected due to surface clearing activities and Mine Site operation, and potential introduction of invasive plants along the Brucejack Transmission Line.

Brucejack Mine Site Sub-area

According to the results of the model, the Project effects of surface clearing represent a high risk to 24 ha, a moderate risk to 6 ha, and a low risk to 364 ha. There is no risk to 1,470 ha of alpine ecosystems within the Brucejack Mine Site sub-area (Table 16.5-3a). The high risk rating is related to the rare plant habitat located immediately northwest of Brucejack Lake. The potential effects on this area and associated habitat are discussed further in the rare plants and lichens section (Section 16.5.1.4). The moderate risk rating is largely attributable to effects resulting from the clearing activities during general operations and/or dust deposition from vehicles as well as the fact that the ecosystems at the Mine Site have low resiliency and an overall low to moderate function.

Figure 16.5-3a
Consequence Rating Map Brucejack Mine Site Sub-area

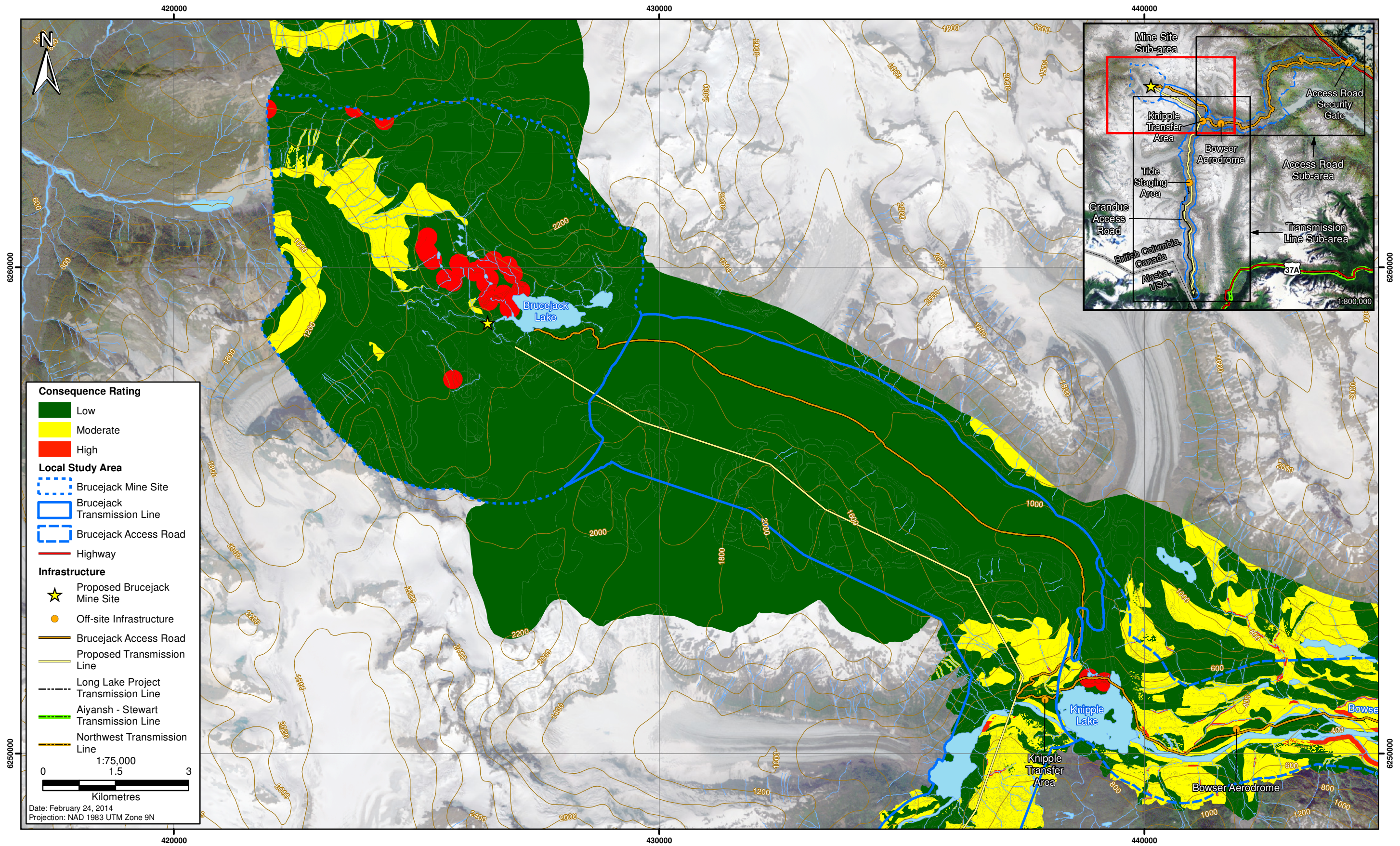


Figure 16.5-3b
Consequence Rating Map Brucejack Access Road Sub-area

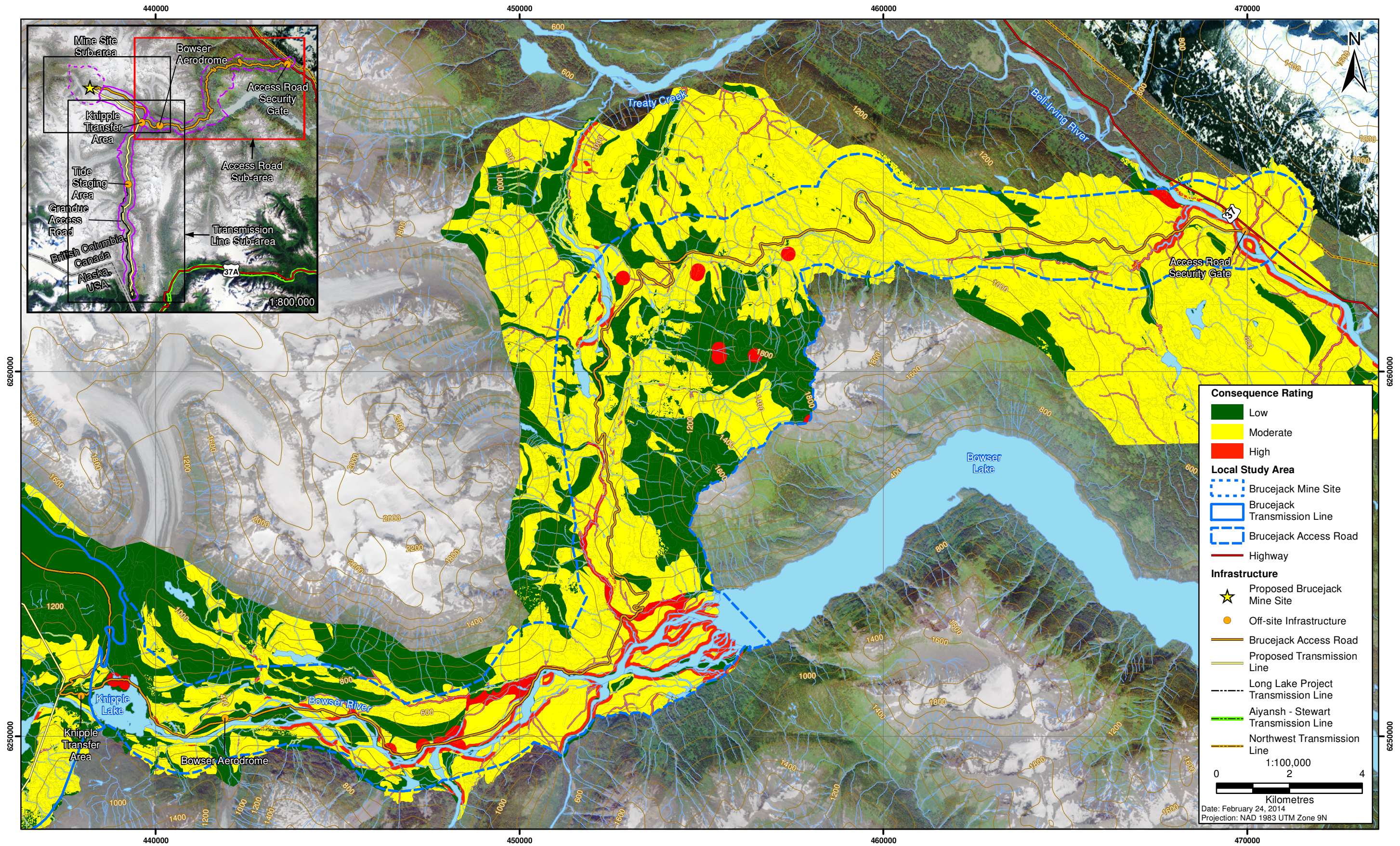
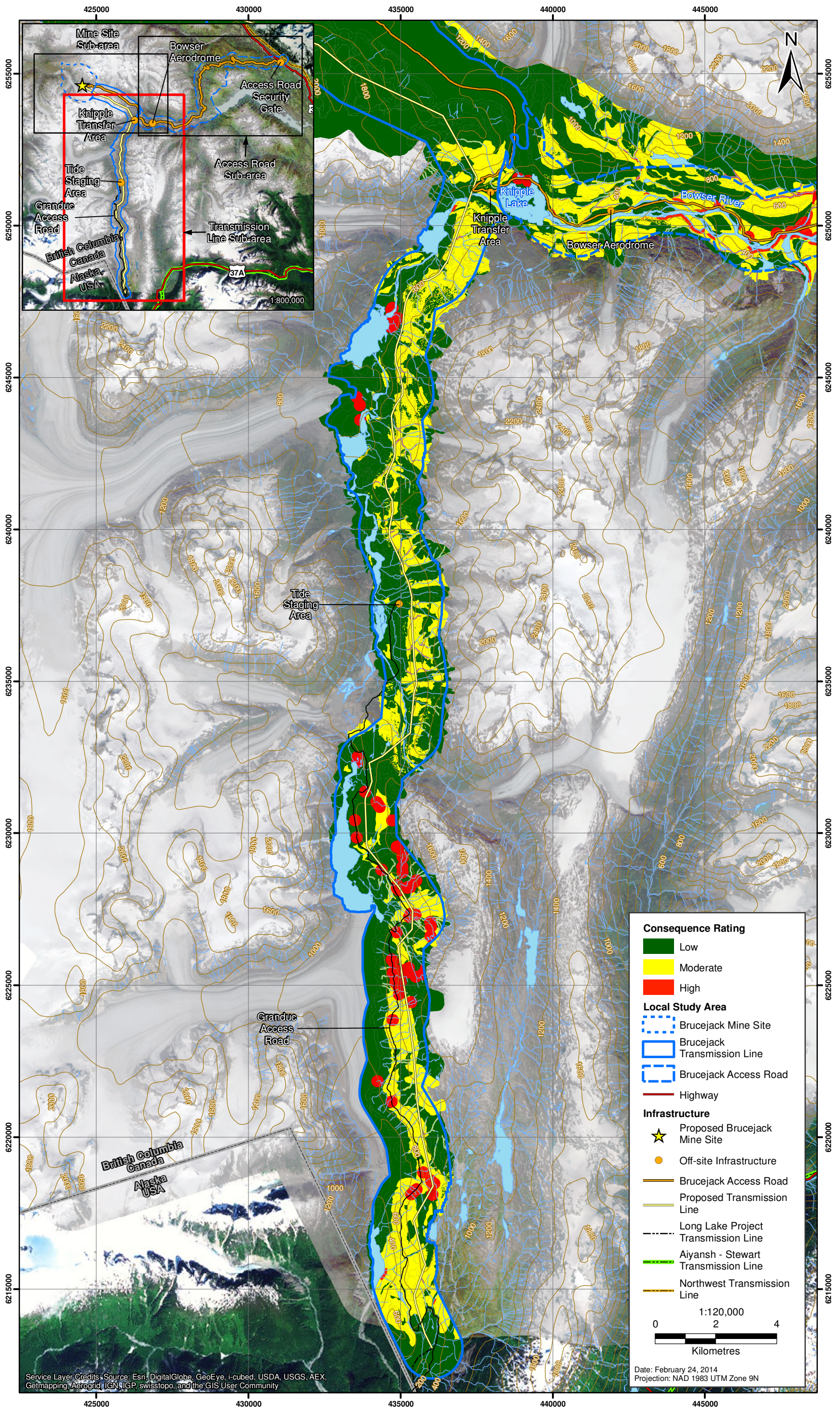


Figure 16.5-3c

Consequence Rating Map Brucejack Transmission Line Sub-area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Table 16.5-2a. Probability Ratings for Potential Project Effects

| Data Resources for Each Ecological Attribute | Effects | Measured Criteria for Ecological Effects | Rating Weight for Effect | Overall Contribution of the Effect (%) | |
|--|------------------|--|--------------------------|---|-----|
| Infrastructure | Lost Area | Areas under Infrastructure | 10 | Presence automatically overrides values calculated using ecological attributes identified above at 100% probability | |
| Atmospheric Modelling | Eutrophication | Nitrogen Deposition Rate: < 2 kg/ha/yr 2 - 5 kg/ha/yr > 5 kg/ha/yr | 10 5 1 | 20% | |
| | Acidification | Phosphorus Deposition Rate: < 2 kg/ha/yr 2 - 5 kg/ha/yr > 5 kg/ha/yr | 10 5 1 | | |
| | | Acid Deposition Rate: < 250 eq/ha/yr 250 - 500 eq/ha/yr > 500 eq/ha/yr | 10 5 1 | | |
| Terrestrial Ecosystem Mapping | Edge Effects | TEM Polygon Adjacent to Project TEM Polygon not Adjacent Project | 10 0 | | 30% |
| Terrestrial Ecosystem Mapping | Invasive Species | TEM Polygon within 100 m of Linear Feature TEM Polygon Adjacent to Infrastructure TEM Polygon not Adjacent to Infrastructure or within 100 m of a Linear Feature | 10 4 0 | | 20% |
| Terrestrial Ecosystem Mapping | Windthrow | Forested TEM Polygon within 20 m of Cleared Area Forested TEM Polygon within 20 - 70 m of Cleared Area Forested TEM Polygon > 70 from Cleared Area | 10 3 0 | | 10% |

(continued)

Table 16.5-2a. Probability Ratings for Potential Project Effects (completed)

| Data Resources for Each Ecological Attribute | Effects | Measured Criteria for Ecological Effects | Rating Weight for Effect | Overall Contribution of the Effect (%) |
|--|---------------------------|---|--------------------------|--|
| Terrestrial Ecosystem Mapping | Fragmentation | Forested (i.e., Structural Stage 6 or 7) TEM Polygon Fragmented by Infrastructure | 10 | 10% |
| | | Structural Stage 4 or 5 TEM Polygon Fragmented by Infrastructure | 5 | |
| | | All Other Polygons | 0 | |
| Terrestrial Ecosystem Mapping | Hydrological Connectivity | Areas Within 50 m of Cleared Area | 10 | 10% |
| | | Areas 50 - 100 m of Cleared Area | 5 | |
| | | Areas > 100 m from Cleared Area | 0 | |

Table 16.5-2b. Consequence Ratings for Terrestrial Ecosystem Function

| Data Resources for Each Ecological Attribute | Ecological Attribute | Measured Criteria for Ecological Attributes | Rating Weight for Ecological Attribute | Overall Percent Contribution of the Ecological Attribute |
|--|----------------------------|--|--|--|
| Soil Mapping Units (Rescan 2013) | Ecologically Valuable Soil | Brunisolic and Podzolic Soils | 10 | 40% |
| | | Wetland organic and Peaty Soils | | |
| | | Gleysolic Soils on a variety of parent materials; or better developed and better drained soils on less suitable parent materials (typically excessive coarse fragment content) such as colluvium "C," fluvial "F," and glacio-fluvial "G" materials. | 7 | |
| | | Regosolic soils; especially those in areas of active terrain processes (high-energy flooding and avalanche activity) where soil development is interrupted by frequent disturbance and/or biomass may be removed; shallow soils developed in and around bedrock outcrops (weathered bedrock "D" parent materials). | 3 | |
| | | Non-soils (exposed bedrock, water, glaciers - ice, permanent snow, soils disturbed by anthropogenic activities/materials) | 1 | |

(continued)

Table 16.5-2b. Consequence Ratings for Terrestrial Ecosystem Function (continued)

| Data Resources for Each Ecological Attribute | Ecological Attribute | Measured Criteria for Ecological Attributes | Rating Weight for Ecological Attribute | Overall Percent Contribution of the Ecological Attribute |
|---|--|--|--|--|
| Wildlife Habitat Suitability Mapping (Rescan 2012) | Terrestrial Wildlife Habitat | Mountain Goat Critical Habitat (Winter)-High | 10 | 30% |
| | | Mountain Goat Critical Habitat (Winter)-Medium | 7 | |
| | | Mountain Goat Critical Habitat (Winter)-Low | 3 | |
| | | Marten Critical Habitat (Winter)-High | 10 | |
| | | Marten Critical Habitat (Winter)-Medium | 7 | |
| | | Marten Critical Habitat (Winter)-Low | 3 | |
| BC TRIM Slope gradient no greater than 22% Fish Surveys and Barriers (BJP-06-026) | Fish-Associated Habitat | Large Streams - Confirmed Fish Presence | 10 | |
| | | Large Streams - Potential Fish Presence | 7 | |
| | | Large Streams - No Fish Present | 0 | |
| | | Small Streams - Confirmed Fish Presence | 10 | |
| | | Small Streams - Potential Fish Presence | 7 | |
| | | Small to Mid Streams - No Fish Present | 0 | |
| Vegetation Resource Inventory Dataset to determine bark, foliage, branch and whole stem above ground biomass (ABI) Use factor of 0.2 x above ground biomass to determine below ground biomass (BGB) Total C = (AGB+BGB) * 0.51 where 0.51 is the biomass conversion factor for northern coniferous forests | Biochemistry (Carbon Storage and Productivity) | >275 (old forest) | 10 | 20% |
| | | 100-275 (mature forest) | 7 | |
| | | <100 (young forest) | 5 | |
| | | Null (non forested) | 1 | |
| Site Index/Biogeoclimatic Ecosystem Classification | Productivity | >17 (high) | 10 | |
| | | 12-16 (med) | 6 | |
| | | <12 (low) | 3 | |
| | | Null (non forested) | 1 | |

(continued)

Table 16.5-2b. Consequence Ratings for Terrestrial Ecosystem Function (completed)

| Data Resources for Each Ecological Attribute | Ecological Attribute | Measured Criteria for Ecological Attributes | Rating Weight for Ecological Attribute | Overall Percent Contribution of the Ecological Attribute |
|--|---|--|--|---|
| BC Freshwater Atlas | Hydrological Connectivity | Stream Order 7+ (100 m buffer) Stream Order 5-6 (50 m buffer) Stream Order 3-4 (30 m buffer) Stream Order 1-2 (20 m buffer) | 10 8 7 5 | 10% |
| Terrestrial Ecosystems Mapping and Field Survey Data | Red-listed Ecosystems Blue-listed Ecosystems | Rare Ecosystems mapped or identified during field surveys | 10 | Presence automatically overrides values calculated using ecological attributes identified above at 100% consequence |
| Rare Plant and Lichen Species Field Surveys | Rare Species | 200 m buffer around any known rare species location | 10 | Presence automatically overrides values calculated using ecological attributes identified above at 100% consequence |
| | | | | 100% |

Figure 16.5-4a
Risk Rating for the Brucejack Mine Site Sub-area

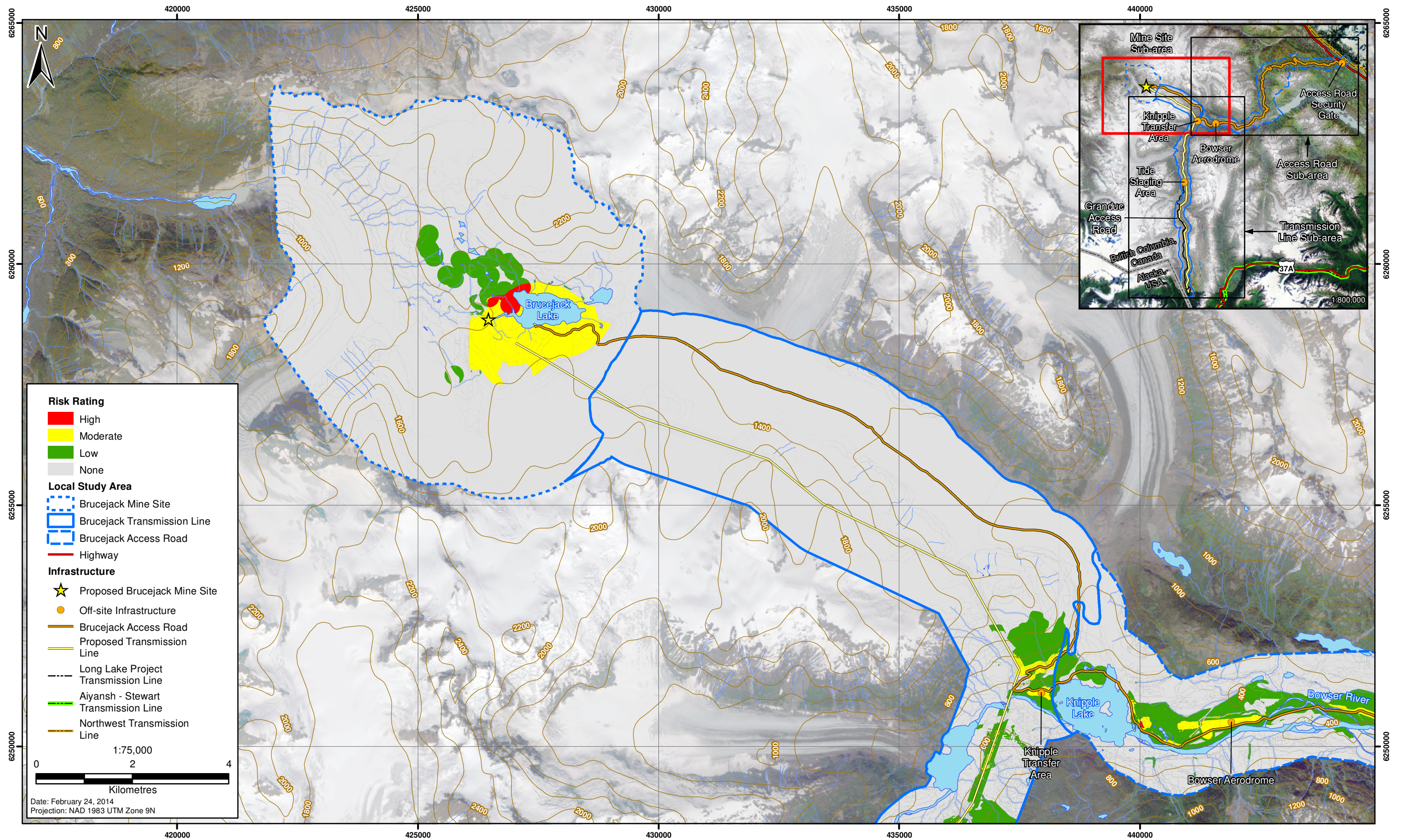


Figure 16.5-4b
Risk Rating for the Brucejack Access Road Sub-area

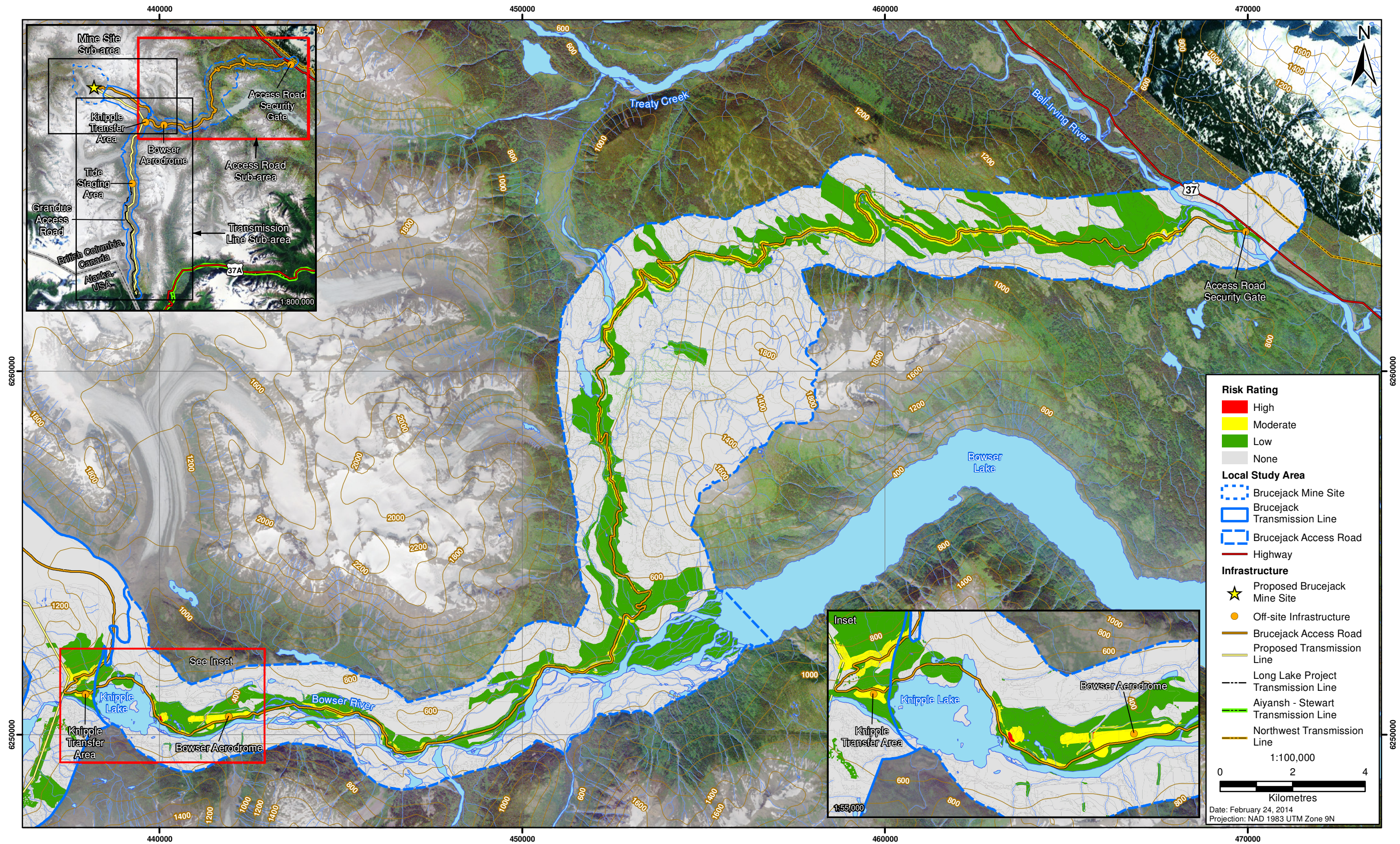


Figure 16.5-4c

Risk Rating for the Brucejack Transmission Line

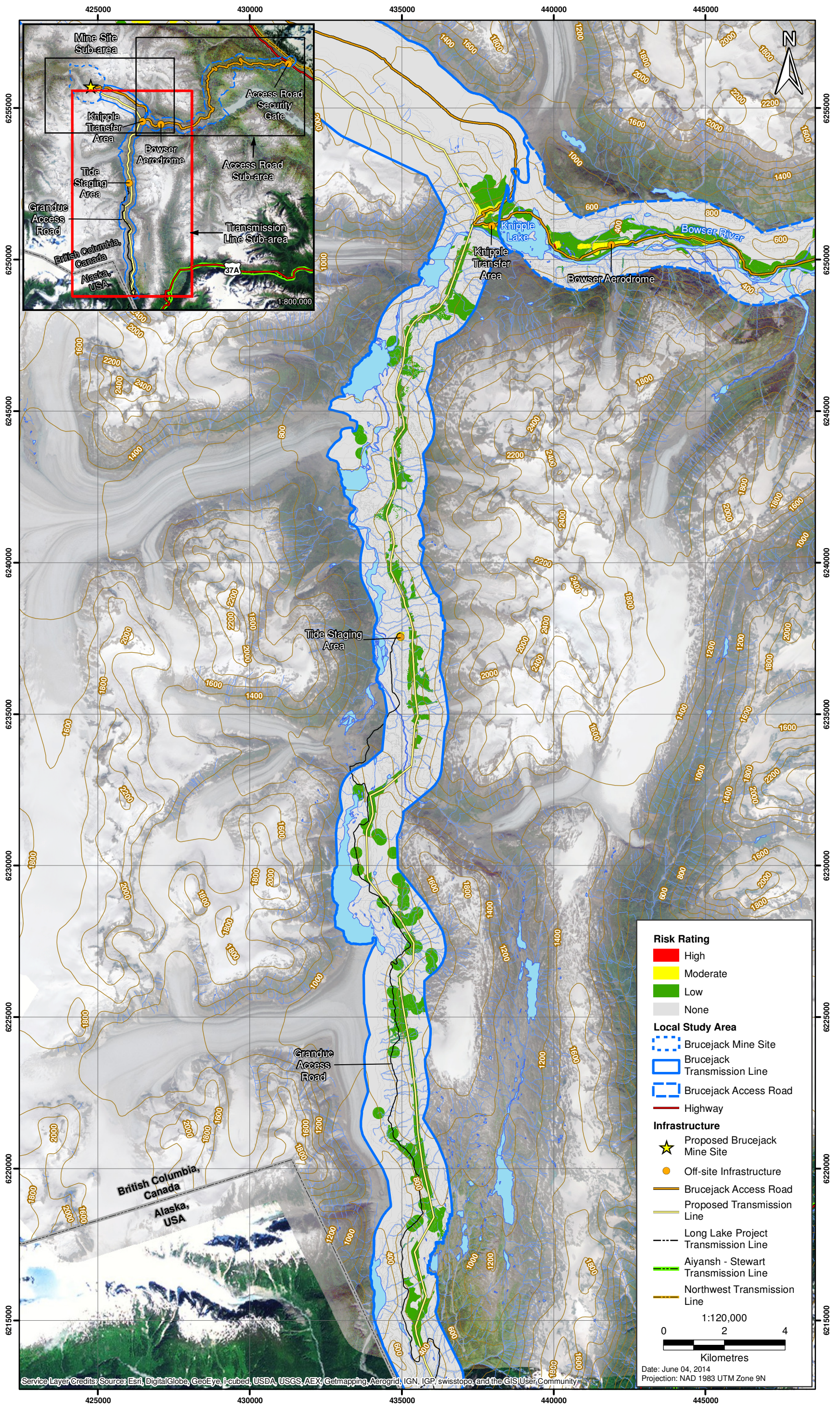


Table 16.5-3a. Risk to Alpine Ecosystems within the Brucejack Mine Site Sub-area

| Sub-component | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|--------------------|---------------------------------------|--------------|------------|---------------|-----------|--------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Alpine Ecosystems | Mountain-heather - Partridgefoot (MP) | 79 | 52 | 2 | 6 | 138 |
| | AM-Alpine Meadow (AM) | 116 | 2 | <1 | - | 118 |
| | Cliff (CL) | 89 | 21 | - | - | 110 |
| | Fescue Lichen (FC) | 121 | 50 | 1 | 7 | 179 |
| | Rock-Lichen (RO) | 735 | 233 | 3 | 12 | 984 |
| | Talus (TA) | 330 | 6 | - | - | 336 |
| Grand Total | | 1,470 | 364 | 6 | 24 | 1,865 |

The majority of the ecosystems at the Brucejack Mine Site have shallow, poorly developed soils, and as a result are relatively unproductive (from a biomass accumulation perspective). Nevertheless, alpine ecosystems are easily degraded by disturbance (McPhee et al. 2000), including use of Brucejack Mine Site haul roads, compaction due to vehicle and foot traffic, etc. Once degraded, these ecosystems may not recover to pre-disturbance levels even in the long term (Frank and del Moral 1986; Forbes, Ebersole, and Strandberg 2001; Mingyu et al. 2009). The low-risk ecosystems are those that could be affected by the introduction and spread of invasive plants due to Project activities during any phase of the Project. Due to the extreme climatic conditions at the Brucejack Mine Site, the introduction and spread of invasive species is considered unlikely. No effects are expected for the remaining ecosystems within the Brucejack Mine Site sub-area.

Brucejack Access Road Sub-area

Of the 491 ha of alpine ecosystems assessed along the Brucejack Access Road, none will be lost or altered due to Project activities (Table 16.5-3b).

Table 16.5-3b. Risk to Alpine Ecosystems within the Brucejack Access Road Sub-area

| Receptor VC | Ecosystem Description | Risk Rating | | | | Total (ha) |
|--------------------|---------------------------------------|-------------|----------|---------------|-----------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Alpine Ecosystems | Mountain-heather - Partridgefoot (MP) | 69 | - | - | - | 69 |
| | AM-Alpine Meadow (AM) | 136 | - | - | - | 136 |
| | Talus (TA) | 285 | - | - | - | 285 |
| Grand Total | | 491 | - | - | - | 491 |

Brucejack Transmission Line Sub-area

The Project effects of loss and alteration of ecosystem function and/or extent due to surface clearing for tower installation and potential invasive plant introduction represents a low risk to 51 ha directly over the glacier, which has several areas of exposed Rock-Lichen (Table 16.5-3c). Installation of towers may require grubbing of the surface, and could result in a loss of alpine vegetation depending on the location of the tower placement. Potential introduction through the deposition of invasive plant propagules is possible along this portion of the route due to the movement of materials and machinery from the Knipple Transfer Area to the Brucejack Mine Site but is very unlikely due to the lack of protected areas for seed establishment, short growing seasons, and austere physical environment for seed development.

Table 16.5-3c. Risk to Alpine Ecosystems within the Brucejack Transmission Line Sub-area

| Receptor VC | Ecosystem Description | Risk Rating | | | | Total (ha) |
|--------------------|---------------------------------------|-------------|-----------|---------------|-----------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Alpine Ecosystem | Mountain-heather - Partridgefoot (MP) | 231 | 37 | 1 | - | 269 |
| | Krumholz (KH) | 32 | 7 | <1 | - | 39 |
| | Rock-Lichen (RO) | 300 | 8 | - | - | 308 |
| | Talus (TA) | 27 | <1 | - | - | 27 |
| Grand Total | | 590 | 51 | 1 | - | 643 |

Clearing activities along the lower portion of the Brucejack Transmission Line, northwest of Premier Mine, represent a moderate risk to the function and extent of 1 ha of Mountain-heather - Partridgefoot alpine ecosystem. No Project effects pose a high risk to alpine ecosystems and there is no risk to 590 ha of alpine ecosystems.

16.5.5.2 Identifying Key Effects on Parkland Ecosystems

Parkland ecosystems within the Brucejack Mine Site and Access Road sub-areas will not be affected by Project activities during any phase. Loss and alteration of parkland ecosystem function and extent is expected to occur during construction of the Brucejack Transmission Line (i.e., through clearing activities).

Brucejack Mine Site Sub Area

Parkland ecosystems, including alpine meadows, krumholz, rock-lichen, and talus ecosystems will not be affected by the Project (Table 16.5-4a).

Table 16.5-4a. Risk to Parkland Ecosystems within the Brucejack Mine Site Sub-area

| Receptor VC | Ecosystem Description | Risk Rating | | | | Total (ha) |
|---------------------|-----------------------|-------------|----------|---------------|-----------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Parkland Ecosystems | Alpine Meadow (AM) | 55 | - | - | - | 55 |
| | Krumholz (KH) | 125 | - | - | - | 125 |
| | Rock-Lichen (RO) | 82 | - | - | - | 82 |
| | Talus (TA) | 92 | - | - | - | 92 |
| Grand Total | | 354 | - | - | - | 354 |

Brucejack Access Road Sub-area

Parkland, including heath, alpine meadows, krumholz, tree islands, rock-lichen, Sitka alder thickets, and talus ecosystems will not be affected by the Project within the Brucejack Access Road sub-area (Table 16.5-4b).

Brucejack Transmission Line Sub-area

Loss and alteration of parkland ecosystem function and extent may occur during construction of the Brucejack Transmission Line (i.e., through clearing activities). Project activities along the Brucejack Transmission Line represent a high risk to 11 ha, moderate risk to 27 ha, a low risk to 186 ha, and no risk to 2,225 ha (Table 16.5-4c). Most of the effects are attributable to fragmentation, edge effects, and changes to hydrological connectivity due to vegetation clearing along the route in krumholz

ecosystems. In actuality, the effect to the parkland ecosystem may be less if vegetation clearing activities can be avoided. There is also low risk of invasive plant introduction and spread.

Table 16.5-4b. Risk to Parkland Ecosystems within the Brucejack Access Road Sub-area

| Receptor VC | Ecosystem Description | Risk Rating | | | | Total (ha) |
|---------------------|---------------------------------------|-------------|----------|---------------|-----------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Parkland Ecosystems | Mountain-heather - Partridgefoot (MP) | 67 | - | - | - | 67 |
| | Alpine Meadow (AM) | 142 | - | - | - | 142 |
| | Krumholz (KH) | 84 | - | - | - | 84 |
| | Parkland Forest/Krummholz (PK) | 30 | - | - | - | 30 |
| | Rock-Lichen (RO) | <1 | - | - | - | <1 |
| | Sitka Alder Thicket (51) | 45 | - | - | - | 45 |
| | Talus (TA) | 123 | - | - | - | 123 |
| Grand Total | | 490 | - | - | - | 490 |

Table 16.5-4c. Risk to Parkland Ecosystems within the Transmission Line Sub-area

| Receptor VC | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|---------------------|---------------------------------------|--------------|------------|---------------|-----------|--------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Parkland Ecosystems | Mountain-heather - Partridgefoot (MP) | 587 | 39 | 4 | 2 | 632 |
| | Alder Thicket (AT) | 6 | - | - | - | 6 |
| | Alpine Meadow (AM) | 131 | 5 | <1 | <1 | 137 |
| | Krumholz (KH) | 613 | 33 | 7 | 3 | 655 |
| | Mountain Alder Thicket (52/F102) | 35 | 1 | <1 | - | 36 |
| | Parkland Forest/Krummholz (PK) | 369 | 102 | 16 | 7 | 494 |
| | Rock-Lichen (RO) | 375 | 3 | <1 | - | 378 |
| | Talus (TA) | 110 | 2 | - | - | 112 |
| Grand Total | | 2,225 | 186 | 27 | 11 | 2,450 |

16.5.5.3 Identifying Key Effects on Forested Ecosystems

Forested ecosystems will not be affected within the Brucejack Mine Site sub-area during any phase of the Project. Loss and alteration of forested ecosystems is expected within the Brucejack Access Road sub-area and the Brucejack Transmission Line sub-area on a limited scale due to one or more of the following effects: 1) loss or alteration of ecologically valuable soils, 2) fragmentation, 3) windthrow, 4) edge effects, 5) invasive plant introduction, and 6) changes to hydrology.

Brucejack Mine Site Sub-area

Of the 390 ha of forested ecosystems within the Brucejack Mine Site sub-area, none are expected to be affected by Project activities or effects (Table 16.5-5a).

Table 16.5-5a. Risk to Forested Ecosystems within the Brucejack Mine Site Sub-area

| Receptor VC | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|---------------------|--------------------------|-------------|----------|---------------|-----------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Forested Ecosystems | 01-HmBa - Blueberry | 134 | - | - | - | 134 |
| | Krumholz (KH) | 99 | - | - | - | 99 |
| | Rock-Lichen (RO) | 50 | - | - | - | 50 |
| | Sitka Alder Thicket (51) | 37 | - | - | - | 37 |
| | Talus (TA) | 69 | - | - | - | 69 |
| Grand Total | | 390 | - | - | - | 390 |

Brucejack Access Road Sub-area

The Project effects of fragmentation, windthrow, edge effects, invasive plant introduction, and changes to hydrology collectively represent a high risk to 1 ha, a moderate risk to 271 ha, and a low risk to 2,437 ha. There is no risk to 6,976 ha of forested ecosystems within the Brucejack Access Road sub-area (Table 16.5-5b). The potential implication on ecosystem function and extent are discussed below.

Table 16.5-5b. Risk to Forested Ecosystems within the Brucejack Access Road Site Sub-area

| Receptor VC | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|---------------------|----------------------------------|--------------|--------------|---------------|-----------|--------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Forested Ecosystems | 01-BIHm - Azalea | 1,148 | 367 | 70 | <1 | 1,585 |
| | 01-HmBa - Blueberry | <1 | 1 | 1 | - | 2 |
| | 01-HwBL - Devil's club | 1,121 | 453 | 26 | <1 | 1,600 |
| | 02-BIPl - Cladonia | 77 | 21 | 1 | - | 98 |
| | 02-Hw - Step moss | 261 | 51 | 2 | <1 | 314 |
| | 03-BIHm - Feathermoss | 345 | 30 | 5 | 1 | 381 |
| | 03-Sx - Devil's club | 626 | 255 | 24 | <1 | 895 |
| | 04-BIHm - Heron's-bill | 31 | - | - | - | 31 |
| | 05-BaHm - Twistedstalk | <1 | <1 | - | - | <1 |
| | 05-BI - Oak fern - Heron's-bill | 491 | 197 | 49 | <1 | 737 |
| | 06-BI - Devil's club - Lady fern | 536 | 535 | 75 | <1 | 1,146 |
| | 07-BI - Valerian - Sickie moss | 87 | 184 | 3 | - | 274 |
| | 08-BI - Horsetail - Glow moss | 75 | 7 | <1 | - | 81 |
| | Alder Thicket (AT) | 2 | - | - | - | 2 |
| | Alpine Meadow (AM) | 38 | - | - | - | 38 |
| | Fescue Lichen-(FC) | 4 | - | - | - | 4 |
| | Mountain Alder Thicket (52/FI02) | 45 | 101 | <1 | - | 147 |
| | Rock-Lichen (RO) | 322 | 33 | <1 | <1 | 355 |
| | Sitka Alder Thicket (51) | 1,657 | 203 | 15 | <0 | 1,874 |
| | Talus (TA) | 109 | - | - | - | 109 |
| Grand Total | | 6,976 | 2,437 | 271 | 1 | 9,685 |

Brucejack Transmission Line Sub-area

Project effects represent a high risk to 2 ha, a moderate risk to 95 ha, and a low risk to 768 ha of forested ecosystems within the Brucejack Transmission Line sub-area (Table 16.5-5c). Approximately 3,293 ha will not be affected by Project infrastructure or activities. Most of the effects are related to vegetation clearing at the southern end of the Brucejack Transmission Line, which runs through a series of forested ecosystems. The removal of vegetation along this section is expected to result in habitat fragmentation, edge effects and windthrow. Surface water runoff may increase in some areas along the Brucejack Transmission Line but is considered negligible.

Table 16.5-5c. Risk to Forested Ecosystems within the Brucejack Transmission Line Sub-area

| Receptor VC | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|-------------------------|---------------------------------------|-------------|-----------|---------------|--------------|------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Forested Ecosystems | Mountain-heather - Partridgefoot (MP) | 50 | 1 | - | - | 51 |
| | 01-HmBa - Blueberry | 869 | 499 | 62 | <1 | 1,430 |
| | 02-HmBa - Mountain-heather | 343 | 92 | 6 | - | 441 |
| | 05-BaHm - Twistedstalk | 153 | 49 | 8 | <1 | 210 |
| | 06-BI - Devil's club - Lady fern | <1 | 13 | 8 | - | 21 |
| | 06-HmYc - Deer cabbage | 10 | 6 | <1 | - | 16 |
| | 07-YcHm - Hellebore | 44 | 10 | <1 | - | 54 |
| Non-Forested Ecosystems | Alder Thicket (AT) | 462 | 7 | - | - | 469 |
| | Alpine Meadow (AM) | 51 | 4 | 1 | <1 | 56 |
| | Dryas Herb (DH) | 174 | 1 | - | - | 176 |
| | Krumholz (KH) | 134 | 10 | 1 | - | 144 |
| | Rock-Lichen (RO) | 614 | 12 | 1 | 1 | 627 |
| | Sitka Alder Thicket (51) | 287 | 62 | 8 | <1 | 357 |
| | Talus (TA) | 101 | 3 | <1 | - | 104 |
| Grand Total | 3,293 | 768 | 95 | 2 | 4,158 | |

16.5.5.4 Identifying Key Effects on Floodplain Ecosystems

Floodplain ecosystems will not be affected within the Brucejack Mine Site sub-area or within the Brucejack Transmission sub-area during any phase of the Project. Some alteration of floodplain ecosystem function and extent is expected to occur along the Brucejack Access Road during Operation and along the Brucejack Transmission Line during Construction.

Brucejack Access Road Sub-area

Project effects represent a high risk to approximately 2 ha, a moderate risk to 60 ha, and a low risk to 1,379 ha within the Brucejack Access Road sub-area (Table 16.5-6). There is no risk to 1,327 ha. Direct effects to floodplain ecosystems will occur at the aerodrome during surface clearing activities and indirect effects resulting from fragmentation, dust deposition, and changes to hydrology.

The proposed aerodrome is located primarily on a recent, lower bench of the Bowser River floodplain, slightly east of Knipple Lake. This site is dominated by early seral species, including cottonwood (*Populus balsamifera*) and Drummond's mountain avens as well as sitka alder (*Alnus crispa*), soopolallie (*S. canadensis*), and willow species (*Salix* spp.). The existing exploration access road and an old airstrip are evidence of past development in the area. Surface clearing activities are expected to result in

alteration of floodplain ecosystem extent. No measurable effects to function are expected from clearing activities. The high bench floodplain deposits associated with the aerodrome have characteristics that lend them to resistance to disturbance. Little soil development has taken place in the coarse substrate. Little fine soil material is present, meaning that erosion and compaction risk is minimal.

Table 16.5-6. Risk to Floodplain Ecosystems within the Brucejack Access Road Sub-area

| Receptor VC | Ecosystem Descriptor | Risk Rating | | | | Total (ha) |
|-----------------------|--|--------------|--------------|---------------|-----------|--------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Floodplain Ecosystems | Willow Thicket (WT) | 68 | 4 | - | - | 72 |
| | 04-Sx - Devil's club - Dogwood-active floodplain | 396 | 169 | 27 | <1 | 592 |
| | 05-Act - Red-osier dogwood-active floodplain | 634 | 822 | 16 | 1 | 1,473 |
| | Gravel Bar (GB) | 51 | 231 | <1 | - | 283 |
| | Middle Bench Floodplain (Fm) | 33 | 40 | 5 | 1 | 79 |
| | Undescribed floodplain (FP) | 145 | 113 | 11 | <1 | 269 |
| Grand Total | | 1,327 | 1,379 | 60 | 2 | 2,768 |

The predicted levels of nutrient addition sustained throughout the Project life may potentially affect floristic composition and diversity of sensitive ecosystems and affect abundance of rare vegetation species in the vicinity of the Bowser Aerodrome. The introduction of invasive plants from outside sources could occur anywhere along the Brucejack Access Road during any phase of the Project. Currently, however, there are no known invasive plants along the Brucejack Access Road and thus the risk is considered low.

16.5.5.5 Identifying Key Effects on Rare Ecosystems

There are no anticipated losses of rare ecosystems based on the current Project design in any of the three sub-areas. Additionally, no indirect effects to rare ecosystems within the Brucejack Mine Site or Brucejack Transmission Line sub-area are expected. Two rare ecosystems—the mountain alder - red-osier dogwood - lady fern (ICHvc 52) and the black cottonwood - subalpine fir - devil's club (ICHvc Fm03)—may be indirectly affected by fragmentation, edge effects, changes in hydrology, dust deposition, and windthrow as a result of the ongoing use of the Brucejack Access Road.

The distributions of rare ecosystems within the Brucejack Access Road sub-area, as well as the amount of rare ecosystems that could be altered, are summarized in Table 16.5-7.

Table 16.5-7. Risk to Rare Ecosystems within the Brucejack Access Road Sub-area

| Sub-area | Rare Ecosystem Descriptor | Rare Ecosystems Predicted (ha) | Total Rare Ecosystems Altered (ha) | Percentage of Rare Ecosystems Altered (%) |
|-----------------------|--|--------------------------------|------------------------------------|---|
| Brucejack Access Road | Mountain alder - Red-osier dogwood - Lady fern (ICHvc 52) | 1,168 | 16 | 1 |
| | Black cottonwood - Subalpine fir - Devil's club; Black cottonwood/Spruce (hybrid) - Red-osier dogwood (ICHvc Fm03) | 32 | 4 | 13 |
| Grand Total | | 1,492 | 20 | - |

16.5.5.6 *Key Effects on Culturally/Economically Important Plant Habitat*

Three species—soapberry, devil’s club and pine mushroom—were selected to characterize the potential direct effects of the Project on culturally/economically important plants within the LSA. These species were selected based on information provided by the Skii km Lax Ha (Appendix A of Rescan 2013a) and from economic reports and public documents on harvestable plants in the north (Sharmin, Holly Ridenour, and Philpot 1998; Berch and Cocksedge 2003). According to information provided by the Skii km Lax Ha, soapberries are the most important plant in terms of berry consumption and devil’s club is intensively utilized for medicinal purposes (Rescan 2013a). According to public reports, pine mushroom is identified as the most economically important wild mushroom harvested in BC (Wiensczyk and Berch 2001).

The known ecological characteristics of soapberry, devil’s club, and pine mushroom habitat were used to determine the potential distribution of likely habitat throughout the LSA (summarized in Section 16.3.5.1). The results of this study were compared with the planned Project infrastructure, and predicted potential direct effects on soapberry, devil’s club, and pine mushroom were determined. In total, it is estimated that 74 ha (1.5%) of pine mushroom habitat, 84 ha (1.3%) of soapberry habitat, and 137 ha (1.6%) of devil’s club habitat could be directly affected by Project activities. The effects to culturally/economically important plant habitat by sub-area are summarized in Table 16.5-8.

16.5.5.7 *Key Effects on Rare Plants and Lichens and their Habitat*

The known locations of rare plants were assigned a 200-m buffer to broadly define their associated habitat. These locations and associated habitat were then compared with the location and extent of potential Project-related effects in order to determine if there will be any direct or indirect effects to rare plant and lichen habitat (Figure 16.5-5).

According to the current Project design, no rare plants are expected to be removed as a result of the Brucejack Gold Mine Project. However, there are a number of rare plants and lichens in close proximity to the proposed development which could be altered by dust deposition, fragmentation, changes in hydrological connectivity or impacts from vehicular or foot traffic during any phase of the Project. There are 25 lichens (including red and blue listed species with NatureServe ranks ranging from a SARA list candidate to apparently secure), 2 mosses (including a red listed species with a NatureServe rank of critically imperiled to imperiled) and 7 vascular plants (including blue listed species with NatureServe ranks ranging from imperiled to vulnerable) that may be impacted by Project activities (Table 16.5-9).

Deposition at the Brucejack Mine Site and along the Brucejack Access Road may impact rare vegetation species, particularly lichens. The predicted levels of dust deposition are highest at the mine site where model results indicate that 11 vegetation species will be exposed to deposition amounts exceeding the critical load for phosphorous. Along the Brucejack Access Road, dust deposition is highest close to the road and decreases exponentially with increasing distance from the road. While the critical load was not exceeded for any elements along the road there may be effects to lichens due to their inherent sensitivity to some elements. Cited in Auerbach, Walker, and Walker (1997), Rao (1982) identifies nonvascular taxa as especially vulnerable to dust disturbance due to structural characteristics rendering them more susceptible to the effects of atmospheric pollutants. Described by Berryman, Straker, and Straker (2009), in studies near remote mining operations, lichens are one of the most sensitive ecosystem components and can serve as “early-warning” indicators in air quality and effects monitoring programs.

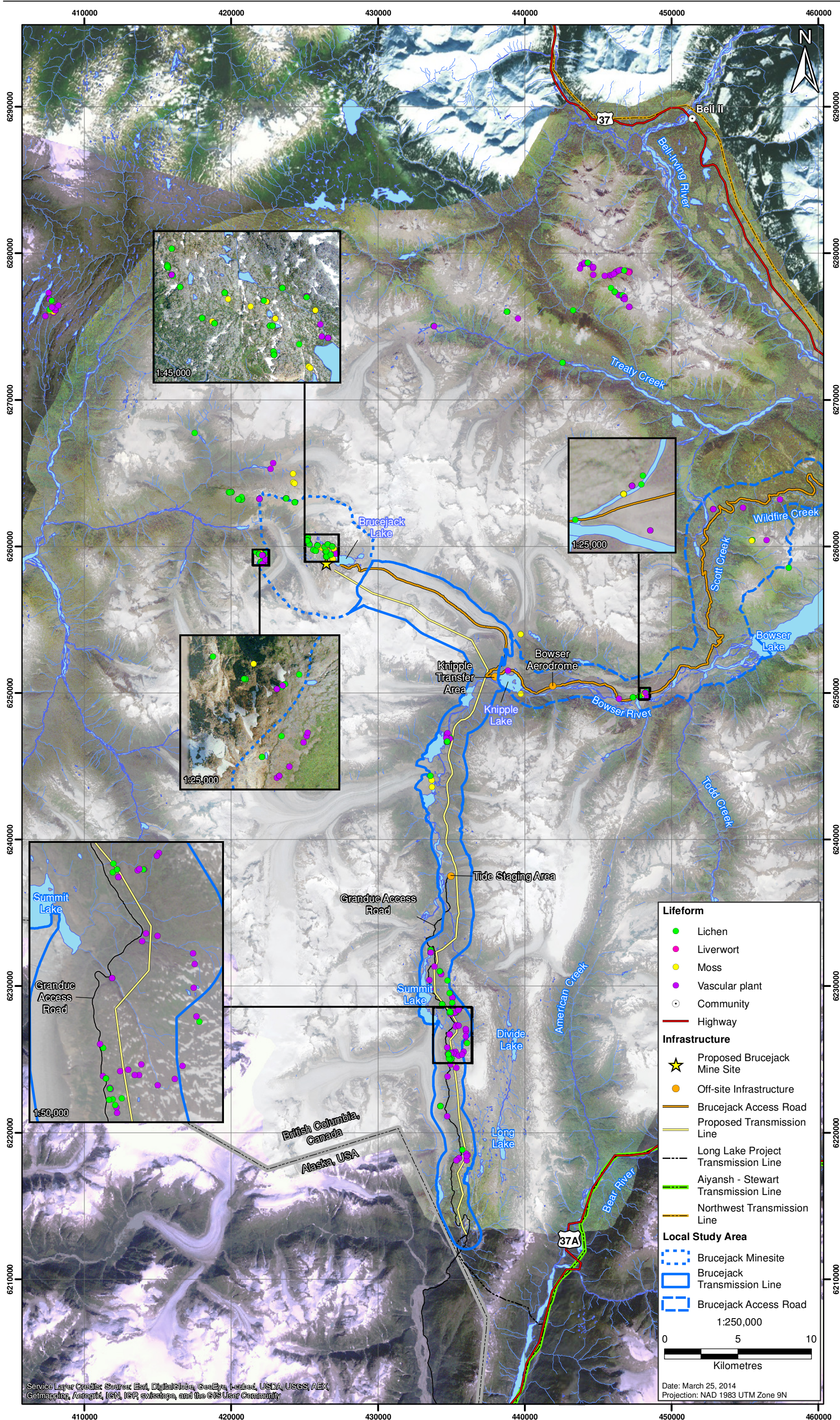
Lichens lack the ability to control the exchange of water, nutrients, gases, and particles with the external environment and are not influenced by natural elements in soils, due to the lack of roots and a vascular system. As a result, sampling and monitoring of lichen tissue enables differentiation between natural soil-borne and anthropogenic airborne element enrichment (Berryman, Straker, and Straker 2009).

Table 16.5-8. Loss of Culturally/Economically Important Plant Habitat within Each of the Sub-areas

| Sub-area | Likelihood of Habitat | Soapberry | | | Devil's Club | | | Pine Mushroom | | |
|------------------------------------|-----------------------|------------------------|-------------------|----------------------------------|------------------------|-------------------|----------------------------------|------------------------|-------------------|----------------------------------|
| | | Predicted Habitat (ha) | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area | Predicted Habitat (ha) | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area | Predicted Habitat (ha) | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area |
| Brucejack Mine Site | High | 0 | 0 | - | 0 | 0 | - | 0 | 0 | - |
| | Medium | 10 | 0 | - | 58 | 0 | - | 0 | 0 | - |
| | Low | 24 | 1 | - | 0 | 0 | - | 0 | 0 | - |
| Brucejack Access Road | High | 241 | 2 | 1 | 4,469 | 67 | 2 | 751 | 6 | >1 |
| | Medium | 3,523 | 71 | 2 | 2,944 | 30 | 1 | 1,218 | 7 | >1 |
| | Low | 613 | 9 | 1 | 13 | 0 | 0 | 3,112 | 61 | 2 |
| Brucejack Transmission Line | High | 555 | 0 | 0 | 0 | 0 | - | 0 | 0 | - |
| | Medium | 971 | 0 | 0 | 1,152 | 40 | 3 | 0 | 0 | - |
| | Low | 357 | 1 | 0 | 35 | 0 | 0 | 0 | 0 | - |
| Grand Total (all sub-areas) | | 6,294 | 84 | 1.0¹ | 8,671 | 137 | 2¹ | 5,081 | 74 | 2¹ |



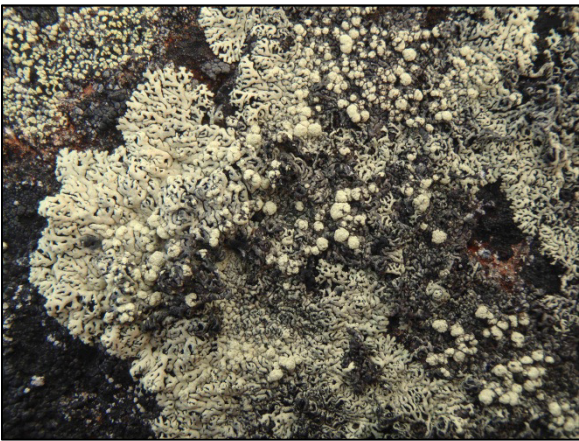
¹ Areas are approximate as numbers have been rounded to the nearest decimal.

Figure 16.5-5
Rare Plant and Lichen Observations in the Brucejack Local and Regional Study Areas






Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar (USA), USGS, AeroGRID, IGN, IGP, swisstopo, and the GIS User Community

Table 16.5-9. Rare Plant or Lichen Species Potentially Altered by the Brucejack Gold Mine Project Activities by Sub-area

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Umbilicaria lambii</i></p> <p>vulnerable (S3); blue-listed</p> |  | ✓ | | |
| <p><i>Allantoparmelia almquisti</i></p> <p>vulnerable (S3); blue-listed</p> |  | ✓ | | |
| <p><i>Arctoparmelia incurve</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |




(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|--|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Bryocaulon hyperboreum</i></p> <p>Not ranked; previously undocumented in BC</p> |  | ✓ | | |
| <p><i>Sphaerophorus fragilis</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |
| <p><i>Bryoria nitidula</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |

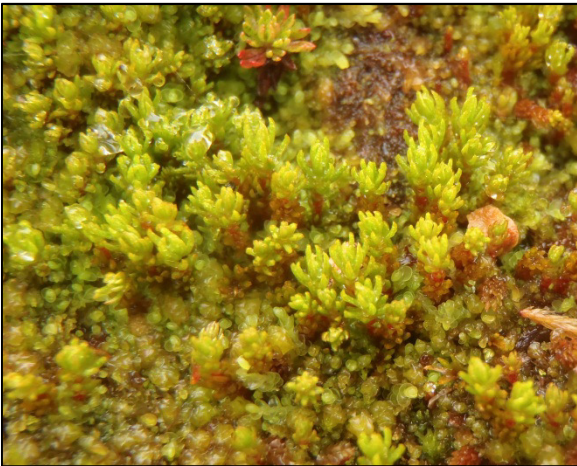


(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|--|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Cetraria nigricans</i></p> <p>vulnerable (S3); blue-listed</p> |  | ✓ | | |
| <p><i>Cladonia subfurcata</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |
| <p><i>Cladonia pseudalcicornis</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |




(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Psilopilum cavifolium</i></p> <p>critically imperiled to imperiled (S1S2); red-listed</p> |  | ✓ | | |
| <p><i>Epilobium hornemannii</i> ssp. <i>Behringianum</i></p> <p>imperiled to vulnerable (S2S3); blue-listed</p> |  | ✓ | | |
| <p><i>Placynthium asperellum</i></p> <p>Vulnerable (S3?); blue-listed</p> |  | | ✓ | |




(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Cladonia singularis</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | ✓ | |
| <p><i>Dermatocarpon leptophyllodes</i></p> <p>imperilled to apparently secure (S2S4); blue-listed</p> |  | | ✓ | |
| <p><i>Cladonia coccifera</i></p> <p>critically imperilled (S1); red-listed</p> |  | | ✓ | |

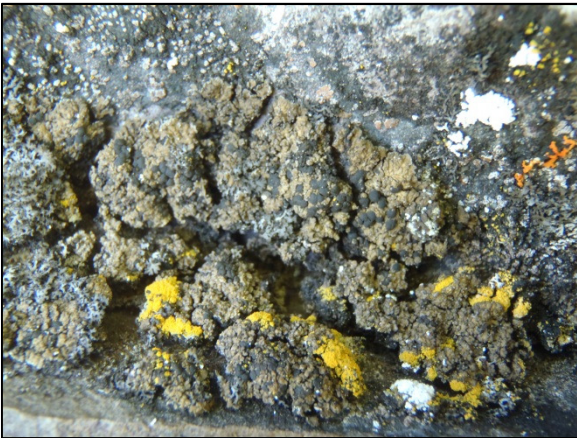


(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Fuscopannaria cheiroloba</i></p> <p>Not ranked; documented in very few locations</p> |  | | ✓ | |
| <p><i>Collema cristatum</i> var. <i>marginale</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | ✓ | |
| <p><i>Collema</i> sp. nov.</p> <p>Not ranked; species new to science</p> |  | | ✓ | |




(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|--|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Vahliella leucophaea</i></p> <p>Not ranked; previously undocumented in BC</p> |  | | ✓ | |
| <p><i>Collema crispum</i></p> <p>critically imperilled (S1); red-listed</p> |  | | ✓ | |
| <p><i>Lempholemma intricatum</i></p> <p>critically imperilled to imperilled (S1S2); red-listed</p> |  | | ✓ | |



(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Leptogium cyanescens</i></p> <p>critically imperilled (S1); red-listed</p> |  | | ✓ | |
| <p><i>Stereocaulon botryosum</i></p> <p>imperilled (S2); red-listed</p> |  | | ✓ | |
| <p><i>Miehlichhoferia elongata</i></p> <p>Not ranked; previously undocumented in BC¹</p> |  | | ✓ | |




(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|--|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Carex rostrata x utriculata</i></p> <p>imperilled to vulnerable (S2S3); blue-listed)</p> |  | | ✓ | ✓ |
| <p><i>Draba glabella</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | ✓ | |



(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Draba</i> sp. nov.</p> <p>Not ranked; previously undocumented in BC</p> |  | | ✓ | |
| <p><i>Stereocaulon botryosum</i></p> <p>imperilled (S2); red-Listed</p> |  | | ✓ | |
| <p><i>Vestergrenopsis elaeina</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | | ✓ |



(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (continued)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|--|--|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Peltigera gowardii</i> (<i>Hydrothyria venosa</i>)</p> <p>critically imperiled to imperiled (S1S2); red-listed; candidate for SARA listing (2011, decision expected in 2014)</p> |  | | | ✓ |
| <p><i>Gymnocarpium jessoense</i> ssp. <i>parvulum</i></p> <p>vulnerable (S3); blue-listed</p> |  | | | ✓ |

(continued)

Table 16.5-9. Rare Plant or Lichen Species Altered by the Brucejack Gold Mine Project Activities by Sub-area (completed)

| Species and Conservation Rank | Species Photo | Project Sub-area (ha) | | |
|---|---|-----------------------|----------------------|----------------------------|
| | | Mine Site Sub-area | Access Road Sub-area | Transmission Line Sub-area |
| <p><i>Botrychium crenulatum</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | | ✓ |
| <p><i>Carex enanderi</i></p> <p>imperilled to vulnerable (S2S3); blue-listed</p> |  | | | ✓ |

¹ Not ranked, but the present population is apparently the only one documented thus far from British Columbia; said in literature to be globally rare, though this is not reflected by the Natureserve rank of G4 (Natureserve 2012).

Furthermore, the predicted levels of nutrient addition sustained throughout the Project life may affect floristic composition and abundance of rare vegetation species in the vicinity of the Bowser Aerodrome. The predicted levels of eutrophication may affect several sensitive ecosystems located near the Bowser aerodrome that contain very poor to poor nutrient regimes. The rare species associated with these ecosystems include a number of red and blue-listed lichens (e.g., *Allantoparmelia almquistii*, *Arctoparmelia incurva*, *Bryoria nitidula*, *Cetraria delisei*, *Cetraria nigricans*, *Cladonia coccifera*, *Cladonia pseudalcicornis*, *Stereocaulon botryosum*), mosses (e.g., *Plagiobryum demissum*, *Pohlia cardotii*, *Psilopilum cavifolium*) and vascular plants (e.g., *Antennaria howellii* × *alpine*, *Carex rostrata* × *utriculata*, *Draba glabella*, *Ranunculus occidentalis*-var. *hexasepalus*, *Woodsia alpina*; Appendix 9-1 of Rescan 2013b).

Brucejack Mine Site Sub-area

Within the Mine Site sub-area, there are nine lichens, 1 vascular plant, and 1 moss that may be affected by dust deposition. Each of these species will be exposed to dust deposition that exceeds the critical load of 5 kg/ha/year for phosphorous on soils (Table 16.5-10).

Brucejack Access Road Sub-area

The use of the Brucejack Access Road may result in effects on 12 lichens, one moss and four vascular plant populations through eutrophication or acidification of soils or due to fragmentation, edge effects, changes to hydrology, and windthrow during Operation. The list of species potentially affected along the Access Road and the distance from the Access Road is summarized in Table 16.5-11.

Brucejack Transmission Line Sub-area

According to the current Project design, the Brucejack Transmission Line could impact one red-listed species—hydrothyria lichen *Peltigera gowardii* (*Hydrothyria venosa* J.L. Russell), which is also a SARA list candidate—and four blue listed species: Asian oak fern (*Gymnocarpium jessoense* ssp. *parvulum*), Enander's sedge (*Carex enanderi*), dainty moonwort (*Botrychium crenulatum*), and vestergrenopsis lichen (*Vestergrenopsis elaeina*; Table 16.5-12). However, rare plants and lichens are not expected to be affected along the Brucejack Transmission Line as towers construction and clearing efforts will be sited away from known rare plant locations.

Table 16.5-10. Summary Results of Potential Phosphorous Deposition on Rare Plants and Lichens from the Brucejack Mine Site Sub-area

| Species and Life Form | BC CDC Rank | NatureServe S Rank | Phosphorous Deposition (kg/ha/yr) ¹ |
|---|-------------|---|--|
| Lichens | | | |
| <i>Umbilicaria lambii</i> | blue | S3 | 20.9 |
| <i>Allantoparmelia almquistii</i> | blue | S3 | 8.9 |
| <i>Arctoparmelia incurva</i> | blue | S2S3 | 8.9 |
| <i>Bryocaulon hyperboreum</i> | na | unranked; previously undocumented in BC | 8.9 |
| <i>Sphaerophorus fragilis</i> | blue | S2S3 | 8.9 |
| <i>Bryoria nitidula</i> | blue | S2S3 | 8.9 |
| <i>Cetraria nigricans</i> | blue | S3 | 8.5 |
| <i>Cladonia subfurcata</i> | blue | S2S3 | 8.5 |
| <i>Cladonia pseudalcicornis</i> | blue | S2S3 | 8.5 and 5.6 |
| Moss | | | |
| <i>Psilopilum cavifolium</i> | red | S1S2 | 5.6 |
| Vascular Plants | | | |
| <i>Epilobium hornemannii</i> spp. <i>behringianum</i> | blue | S2S3 | 5.6 |

¹ Threshold value =5 kg/ha/yr (WHO 2000).

Table 16.5-11. Summary of Rare Plant or Lichen Species that May Be Affected by the Use of the Brucejack Access Road Sub-area

| Species and Life Form | BC CDC Rank | NatureServe S Rank | Distance from the Access Road Centre Line (m) |
|---|---|--|---|
| Lichens | | | |
| <i>Placynthium asperellum</i> | blue | S3 | 83 |
| <i>Cladonia singularis</i> | blue | S3 | 8 |
| <i>Dermatocarpon leptophyllodes</i> | blue | S2S4 | 7 |
| <i>Cladonia coccifera</i> | red-listed | S1 | 83 |
| <i>Fuscopannaria cheiroloba</i> | na | unranked; documented in very few locations | 171 |
| <i>Collema crispum</i> var. <i>marginale</i> | blue | S2S3 | 122 |
| <i>Collema</i> sp. nov. | species new to science | unranked | 117 |
| <i>Vahliella leucophaea</i> | unranked; previously undocumented in BC | unranked | 122 |
| <i>Collema crispum</i> | red | S1 | 83 |
| <i>Lempholemma intricatum</i> | red | S1S2 | 83 |
| <i>Leptogium cyanescens</i> | red | S1 | 83 |
| <i>Stereocaulon botryosum</i> | red | S2 | 8 |
| Moss | | | |
| <i>Miehlichhoferia elongata</i> | na | unranked; previously undocumented in BC | 79 |
| Vascular Plants | | | |
| <i>Epilobium hornemannii</i> ssp. <i>Behringianum</i> | blue | S2S3 | 12 |
| <i>Carex rostrata</i> x <i>utriculata</i> | blue | S2S3 | 1 |
| <i>Draba glabella</i> | blue | S2S3 | 122 |
| <i>Draba</i> sp. nov. | na | unranked; previously undocumented in BC | 122 |

Table 16.5-12. Summary of Rare Plant or Lichen Species that May Be Affected by the Construction of the Brucejack Transmission Line

| Location | Species | BC CDC Rank | NatureServe Rank |
|-----------------------------|---|---------------------|------------------|
| Brucejack Transmission Line | <i>Peltigera gowardii</i> (<i>Hydrothyria venosa</i>) | red: SARA Candidate | S1S2 |
| | <i>Botrychium crenulatum</i> , <i>Carex enanderi</i> , <i>Carex rostrata</i> x <i>utriculata</i> , <i>Vestergrenopsis elaeina</i> | blue | S2S3 |
| | <i>Gymnocarpium jessoense</i> ssp. <i>parvulum</i> | blue | S3 |

16.5.6 Summary of Key Effects on Terrestrial Ecology

In summary, of the possible key effects on the terrestrial ecology receptor VCs, Project-related activities pose a high risk to 41 ha, a moderate risk to 467 ha, and a low risk to 5,316 ha of the total LSA of 25,564 ha. Approximately 19,575 ha of ecosystems will not be affected by Project activities (Table 16.5-13).

Table 16.5-13. Summary of Key Effects on Terrestrial Ecology VCs by Risk

| Receptor Valued Component | Sub-area | Risk Rating | | | | Total (ha) |
|---------------------------|-----------------------------|---------------|--------------|---------------|-----------|---------------|
| | | None (ha) | Low (ha) | Moderate (ha) | High (ha) | |
| Alpine | Brucejack Mine Site | 1,665 | 421 | 6 | 24 | 2,116 |
| | Brucejack Access Road | 610 | - | - | - | 610 |
| | Brucejack Transmission Line | 858 | 59 | 1 | - | 919 |
| Alpine Total | | 3,133 | 480 | 7 | 24 | 3,645 |
| Parkland | Brucejack Mine Site | 524 | - | - | - | 524 |
| | Brucejack Access Road | 493 | - | - | - | 493 |
| | Brucejack Transmission Line | 2,662 | 186 | 27 | 11 | 2,887 |
| Parkland Total | | 3,678 | 186 | 27 | 11 | 3,903 |
| Forested | Brucejack Mine Site | 555 | - | - | - | 555 |
| | Brucejack Access Road | 7,096 | 2,468 | 273 | 1 | 9,838 |
| | Brucejack Transmission Line | 3,745 | 803 | 100 | 2 | 4,649 |
| Forested Total | | 11,396 | 3,271 | 372 | 3 | 15,042 |
| Floodplain | Brucejack Access Road | 1,327 | 1,379 | 60 | 2 | 2,768 |
| | Brucejack Transmission Line | 41 | <1 | - | - | 41 |
| Floodplain Total | | 1,368 | 1,379 | 60 | 2 | 2,809 |
| Grand Total | | 19,575 | 5,316 | 467 | 41 | 25,399 |

There are no anticipated losses of rare ecosystems based on the current Project design in any of the three sub-areas. There is also no anticipated alteration of rare ecosystems within the Brucejack Mine Site or Brucejack Transmission Line sub-areas. Rare ecosystems may be indirectly affected by fragmentation, edge effects, changes in hydrology, fugitive dust, and/or windthrow along the Brucejack Access Road. The type and extent of rare ecosystems within the Brucejack Access Road sub-area that may be affected by Project activities are summarized in Table 16.5-14.

Table 16.5-14. Rare Ecosystems Potentially Altered within the Brucejack Access Road Sub-area

| Rare Ecosystem Descriptor | Rare Ecosystems Predicted (ha) | Total Rare Ecosystems Altered (ha) | Percentage of Rare Ecosystems Altered (%) |
|--|--------------------------------|------------------------------------|---|
| Mountain alder - Red-osier dogwood - Lady fern (ICHvc 52) | 1,168 | 16 | 1 |
| Black cottonwood - Subalpine fir - Devil's club; Black cottonwood/Spruce (hybrid) - Red-osier dogwood (ICHvc Fm03) | 32 | 4 | 13 |
| Grand Total | 1,492 | 20 | - |

According to the current Project design, it is estimated that 84 ha (1.3%) of the soapberry habitat within the LSA may be impacted by Project activities, the majority of which would occur along the Access Road. An estimated 137 ha (1.6%) of devil's club habitat may be affected along the Brucejack Transmission Line, depending on the final alignment, and along the Access Road. Approximately 74 ha

(1.5%) of the total pine mushroom habitat could be directly affected by Project activities along the Access Road (Table 16.5-15).

Table 16.5-15. Loss of Culturally/Economically Important Plant Habitat within each of the Sub-areas

| LSA Sub-area | Likelihood of Habitat | Soapberry | | Devil’s Club | | Pine Mushroom | |
|------------------------------------|-----------------------|-------------------|----------------------------------|-------------------|----------------------------------|-------------------|----------------------------------|
| | | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area | Habitat Lost (ha) | Habitat Lost (%) of the Sub-area |
| Brucejack Mine Site | High | 0 | - | 0 | - | 0 | - |
| | Medium | 0 | - | 0 | - | 0 | - |
| | Low | 1 | - | 0 | - | 0 | - |
| Brucejack Access Road | High | 2 | 1 | 67 | 2 | 6 | >1 |
| | Medium | 71 | 2 | 30 | 1 | 7 | >1 |
| | Low | 9 | 1 | 0 | 0 | 61 | 2 |
| Brucejack Transmission Line | High | 0 | 0 | 0 | - | 0 | - |
| | Medium | 0 | 0 | 40 | 3 | 0 | - |
| | Low | 1 | 0 | 0 | 0 | 0 | - |
| Grand Total (all sub-areas) | | 84 | 1¹ | 137 | 2¹ | 74 | 2¹ |

¹ Areas are approximate as numbers have been rounded to the nearest decimal.

There are 25 lichens (including red and blue listed species with NatureServe ranks ranging from a SARA list candidate to apparently secure), 2 mosses (including a red listed species with a NatureServe rank of critically imperiled to imperiled) and 7 vascular plants (including blue listed species with NatureServe ranks ranging from imperilled to vulnerable) that may be impacted by Project activities (Table 16.5-16).

Table 16.5-16. List of Rare Plants and Lichens Associated with Potential Alteration of Habitat by the Brucejack Gold Mine Project

| Location | BC CDC Rank | NatureServe S Rank | Species |
|-----------------------|---|--------------------|---|
| Brucejack Mine Site | red | S1S2 | <i>Psilopilum cavifolium</i> |
| | blue | S2S3 | <i>Arctoparmelia incurva, Bryoria nitidula, Cladonia pseudalcicornis, Cladonia subfurcata, Epilobium hornemannii</i> ssp. <i>Behringianum, Sphaerophorus fragilis</i> |
| | | S3 | <i>Allantoparmelia almquistii, Cetraria nigricans,</i> |
| | Unranked (undocumented in BC or new to science) | na | <i>Bryocaulon hyperboreum</i> |
| Brucejack Access Road | red | S1 | <i>Collema crispum, Leptogium cyanescens, Cladonia coccifera</i> |
| | | S1S2 | <i>Lempholemma intricatum</i> |
| | | S2 | <i>Stereocaulon botryosum</i> |
| | blue | S2S3 | <i>Carex rostrata x utriculata, Cladonia singularis, Collema cristatum var. marginale, Draba glabella</i> |

(continued)

Table 16.5-16. List of Rare Plants and Lichens Associated with Potential Alteration of Habitat by the Brucejack Gold Mine Project (completed)

| Location | BC CDC Rank | NatureServe S Rank | Species |
|--------------------------------------|--|-----------------------|--|
| Brucejack Access Road (cont'd) | blue (cont'd) | S2S4 | <i>Dermatocarpon leptophyllodes</i> |
| | | S3 | <i>Cladonia singularis, Placynthium asperellum</i> |
| | Unranked (undocumented in BC or new to science) | na | <i>Fuscopannaria cheiroloba, Miehllichhoferia elongata, Draba</i> <i>sp. nov., Collema sp. nov., Vahliella leucophaea</i> |
| Brucejack Transmission Line | red: SARA Candidate | S1S2 | <i>Peltigera gowardii (Hydrothyria venosa)</i> |
| | blue | S2S3 | <i>Botrychium crenulatum, Carex enanderi, Carex rostrata x</i> <i>utriculata, Vestergrenopsis elaeina</i> |
| | | S3 | <i>Gymnocarpium jessoense ssp. parvulum</i> |

16.5.7 Mitigation Measures for Terrestrial Ecology

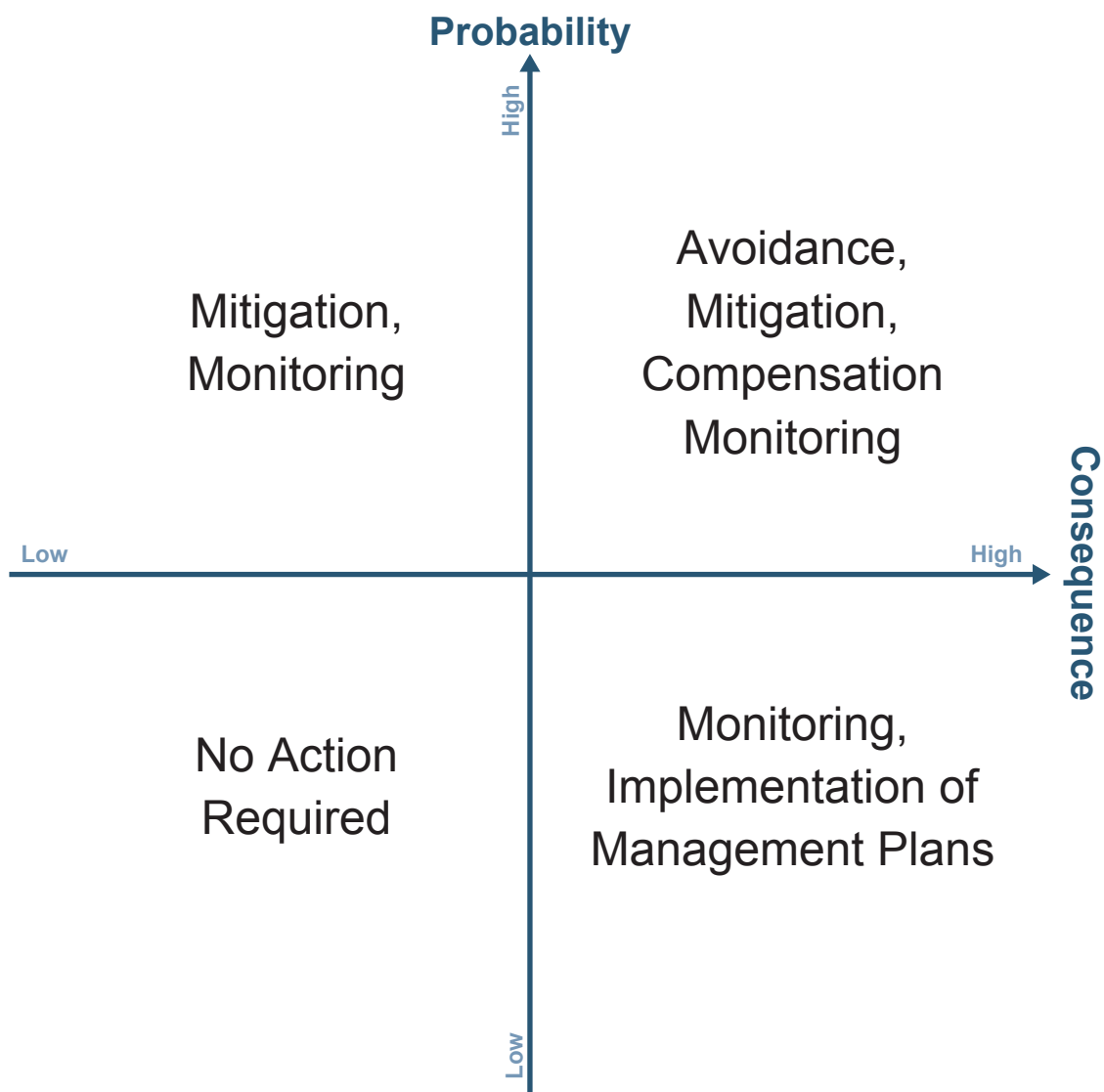
Mitigation and management measures were determined based on results of the risk model, professional judgement, and scientific literature. The results of the risk model serve to inform Project planning, management, and mitigation strategies in order to avoid, minimize, or restore for adverse effects of the Project on terrestrial ecology receptor VCs. Figure 16.5-6 provides a schematic representation of how probability and consequence (i.e., risk) can inform mitigation strategies (i.e., the level of mitigation and management increases/decreases in relation to probability and consequence).

Mitigation and management measures for the terrestrial ecology receptor VCs are described in the Ecosystems Management Plan (Section 29.5), the Invasive Plants Management Plan (Section 29.9), and the Rare Plant and Lichen Management Plan (Section 29.12). The key objectives presented in these plans are summarized below.

16.5.7.1 Ecosystem Management Plan

The management and mitigation measures incorporated in Section 29.4, Ecosystem Management Plan, focus on an ecosystem based approach which includes the following:

- identify ecosystems with low resiliency to disturbance using existing resources such as ecosystem mapping ([Appendix 16-A, Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies](#)), soil mapping units ([Appendix 17-A, Wetland Baseline Study](#)), as-built road design (Cypress Forest Consultants Ltd 2013), and environmental monitoring reports (McElhanney 2011; Cambria Gordon 2013);
- minimize environmental impacts to alpine, parkland, floodplain habitats, wetlands/wetland complexes, lake outlets and floodplains of rivers to the extent possible;
- develop procedures for low-resilience ecosystems (e.g., red- and blue-listed ecosystems, rare plant and lichen habitat, alpine ecosystems and wetlands) such as avoidance strategies, identification of seasonal access restrictions and soil handling measures for sensitive soils;
- minimize all clearing dimensions during construction activities, including the Brucejack Transmission Line site preparation and tower installation, as well as upgrades to the Brucejack Access Road for use during Construction, Operation, and Closure;



- ensure clearing activities are coordinated with other management plans including, but not limited to, the Air Quality Management Plan (Section 29.2), the Soils Management Plan (Section 29.13), the Aquatics Effects Monitoring Plan (Section 29.3), the Wildlife Management and Monitoring Plan (Section 29.21), and the Water Management Plan (Section 29.19);
- minimize soil degradation (i.e., erosion) by adhering to the Soils Management Plan (Section 29.13). Specifically, soil will be salvaged during appropriate weather conditions, transported to stockpiles in a timely manner, and erosion control structures will be established to minimize erosion;
- manage floodplain areas according to the legislated reserve and/or management zone setbacks and work practices established under the *Forests and Range Practices Act* (2002b) unless specifically indicated otherwise;
- reduce impacts to terrestrial ecosystems that depend on hydrological connectivity and flow through management based upon an understanding of hydrology and how it affects ecosystem function. For example, water will not be diverted into areas where soil erosion risk is high, and diversion structures will be engineered so that flow energy is not unsuitably altered;
- ensure all vehicles and machinery travel only on designated road surfaces;
- avoid and/or reduce windthrow according to best management practices through retaining wind-firm trees, feathering edges, topping/pruning of individual trees, and removing windthrow along clearings and road edges;
- avoid where possible, removal of mature and old forest, which provide multiple ecological functions such as diverse wildlife habitat types within close proximity to each other, and carbon storage;
- carry out dust suppression on roads to prevent fugitive dust from impacting ecosystems;
- re-establish vegetation cover promptly to avoid introduction of invasive plants and soil and erosion;
- manage forested areas in accordance with the *Forest and Range Practices Act* (2002b) guidelines in order to meet the stated end land use objectives, as applicable;
- establish communication procedures between on the ground personnel and the Environmental Manager to facilitate timely reporting of any environmental incidents or concerns during all phases of the Project. Construction personnel will be required to communicate any concerns including erosion and sediment production, windthrow, invasive plants, unauthorized access to restricted areas (i.e., rare plant and lichen habitat); and
- provide appropriate education and training for the Environmental Monitor.

16.5.7.2 *Invasive Plant Management Plan*

Management and mitigation measures incorporated in the Invasive Plant Management Plan (Section 29.9, Invasive Plant Management Plan) include the following:

- minimization of soil degradation (i.e., erosion) by adhering to the Soils Management Plan (Section 29.13). Specifically, soil will be salvaged during appropriate weather conditions and transported to stockpiles in a timely manner. Erosion control will be established in a timely manner, the methods of which will be determined by the timing of salvage;
- equipment inspections for target invasive plants at designated Project checkpoint. Project equipment (bulldozers, mine trucks, excavators, etc.) transported from other areas will be thoroughly inspected, target species will be removed (if present), and vehicles will be properly

washed at an appropriate location where the removal of dirt or plant propagules can be effectively achieved without harm to natural ecosystems; and

- detection and eradication of invasive plants, through implementation of an effective early detection system and inventory, control, and monitoring program (detailed in the following sections). The ecological cause (disturbance, favourable light conditions, compacted soil, etc.) and likely succession of the invasive plant population will be used to help select an ecologically appropriate treatment option(s). Treatment options include mechanical, chemical, biological, or a combination of these methods using an ecology-based approach, commonly referred to as integrated pest management.

16.5.7.3 *Rare Plant and Lichen Management Plan*

Management and mitigation measures incorporated into the Rare Plant Management Plan (Section 29.12) include:

- identify known locations of rare plants and rare plant habitat in relation to planned Project activities to ensure that effects to rare plants and lichens are avoided and/or minimized;
- appoint an Environmental Manager to be responsible for the protection of rare plants and their habitat;
- ensure that the Environmental Manager is familiar with the location of rare plants and rare plant habitat so that the avoidance, mitigation and management strategies can effectively be incorporated into Project planning and development activities including drilling, road construction and transmission tower placement;
- avoid and/or minimize wherever possible surface disturbance in areas with known rare plant habitat;
- avoid use of herbicide sprays within 200 m of known rare plant and lichen populations and limit such use to direct application rather than broadcast sprays, except where they may be required for invasive species control;
- create a buffer (exclusion zone) from known rare plant and lichen habitats to avoid direct disturbance and to minimize effects related to fugitive dust transport, weed invasion, vehicular activities, and accidental chemical spills;
- ensure that a qualified environmental monitor is on site (at the clearing location) during vegetation clearing activities;
- where avoidance is not feasible and development is planned within 200 m of plant populations, demarcate the nearby rare plant habitat (i.e., with flagging, temporary fencing or other barriers) to avoid further disturbance to the site;
- prevent dust from impacting rare plants and rare plant habitat through adherence to established buffers where possible and dust control measures during all applicable seasons, using dust abatement applications comprised of water only, with minimal use of magnesium chloride or other chemicals;
- avoid and/or minimize wherever possible alteration and disturbance of the hydrological setting that influences rare plant habitat (e.g., avoid upslope diversion of water); and
- avoid and/or minimize wherever possible construction activities upslope of rare plant habitat.

16.6 RESIDUAL EFFECTS ON TERRESTRIAL ECOLOGY

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from the Project's Construction, Operation, Closure, and Post-closure phases. However, direct and indirect effects cannot be fully mitigated and thus residual effects are anticipated for alpine ecosystems, parkland ecosystems, forested ecosystems, and floodplain ecosystems, plants of cultural/economic importance, and rare plants and lichens. No detectable residual effects are expected for rare ecosystems.

16.6.1 Residual Effects on Alpine Ecosystems

Loss of alpine ecosystems is expected to be a residual effect because there is low confidence that reclamation efforts will restore ecosystem function and extent to a level similar to that of baseline conditions (Frank and del Moral 1986; Forbes 1995; Forbes, Ebersole, and Strandberg 2001; BC Reg. 375/96). The restoration success of each alpine ecosystem is influenced by the scale, frequency, and intensity of the disturbance as well as the severe local edaphic conditions, including low temperatures, water availability, low soil nutrients, and strong winds (Chapin III and Shaver 1985; Forbes, Ebersole, and Strandberg 2001; Urbanska and Chambers 2002). Alpine ecosystems at the Brucejack Mine Site are predominantly dry alpine sites, which according to Forbes, Ebersole, and Strandberg (2001) are the most difficult ecosystems to restore. Due to low rates of pedogenesis, these sites have low fertility (as expressed by nutrient levels and cation exchange capacity), which along with climate, results in limited vegetation growth (R. W. Brown and Johnston 1976). The summary of predicted residual effects on alpine ecosystems and associated mitigation measures is summarized in Table 16.6-1.

Table 16.6-1. Summary of Predicted Potential Residual Effects on Alpine Ecosystems

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect ⁵ | Description of Mitigation Measure(s) | Description of Residual Effect |
|---------------------------|----------------------------------|--|---|--|---|
| Alpine Ecosystems | Construction and Operation | Brucejack Mine Site and Brucejack Transmission Line surface clearing | Surface clearing activities will result in the removal of vegetation and soil; deposition of fugitive dust, acidification, changes in hydrological connectivity | Avoidance; re-vegetation adherence to management procedures for alpine ecosystems; enforcement of travel on designated road surfaces; inspections for target invasive plants;; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents or concerns. | Loss and/or alteration of ecosystem function and extent |

16.6.2 Residual Effects on Parkland Ecosystems

Alteration of parkland ecosystems is expected to be a residual effect because there is low confidence that reclamation efforts will restore ecosystem function and extent to a level similar to that of baseline conditions or other comparable parkland ecosystems. Parkland ecosystems are slow growing and develop in response to variations in micro-topography as well as over-arching influences such as snowpack (i.e., water availability), temperature, exposure, and disturbance. Severe conditions along

⁵ "Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the intermediate component, and the actual change or effect that results.

with the complexity of parkland ecosystems are not conducive to reclamation success. Furthermore, the surficial material depth and texture, slope steepness, aspect, and soil moisture and nutrient regimes may be affected during clearing activities and would thus result in alteration of a site’s potential and subsequent function. The summary of predicted residual effects on parkland ecosystems and associated mitigation measures is summarized in Table 16.6-2.

Table 16.6-2. Summary of Predicted Potential Residual Effects on Parkland Ecosystems

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect | Description of Mitigation Measure(s) | Description of Residual Effect |
|---------------------------|----------------------------------|--|--|--|---|
| Parkland Ecosystems | Construction and Operation | Brucejack Transmission Line Surface clearing and maintenance of the right of way | Surface clearing, changes to hydrological connectivity and fragmentation | Avoidance; re-vegetation adherence to management procedures for parkland ecosystems; ; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents or concerns. | Alteration of ecosystem function and extent |

16.6.3 Residual Effects on Forested Ecosystems

Alteration of forested ecosystem function and extent is expected to be a residual effect because windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. Mitigation measures as outlined in the Invasive Plant Management Plan are considered adequate to avoid the potential introduction and spread of invasive plants and thus are not considered a residual effect. However, the introduction and/or spread of invasive plants during any phase of the Project is possible and establishment of invasive plants depends on the ability to collectively recognize potential problems, availability of potential vectors of introduction (e.g., vehicular traffic along Highway 37) as well as the success of eradication measures. The summary of predicted residual effects on forested ecosystems and associated mitigation measures is summarized in Table 16.6-3.

Table 16.6-3. Summary of Predicted Residual Effects on Forested Ecosystems

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect | Description of Mitigation Measure(s) | Description of Residual Effect |
|---------------------------|----------------------------------|--|--|--|---|
| Forested Ecosystems | Construction and Operation | Brucejack Access Road and Brucejack Transmission Line Road and transmission line maintenance | Surface clearing, changes to hydrology, creation of edges, fragmentation and windthrow, removal of productivity and carbon storage | minimize loss and adaptively manage effects, including, managing for hydrological connectivity; adherence to best management practices for forested ecosystems (e.g., windthrow prevention, riparian area management); dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents or concerns. | Alteration of ecosystem function and extent |

16.6.4 Residual Effects on Floodplain Ecosystems

Loss and alteration of floodplain ecosystem function and extent is expected to be a residual effect because windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. The summary of predicted residual effects on floodplain ecosystems and associated mitigation measures is summarized in Table 16.6-4.

Table 16.6-4. Summary of Predicted Residual Effects on Floodplain Ecosystems

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect | Description of Mitigation Measure(s) | Description of Residual Effect |
|---------------------------|----------------------------------|---|---|---|---|
| Floodplain Ecosystems | Construction and Operation | Brucejack Access Road and Brucejack Transmission Line Road maintenance and surface clearing | Surface clearing, changes to hydrology, creation of edges, fragmentation and windthrow, removal of productivity and carbon storage, deposition of fugitive dust | Minimize loss and adaptively manage effects including, managing for hydrological connectivity; adherence to best management practices for riparian ecosystems; dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees/ contractors; coordination with other management plans; effective internal reporting of environmental incidents or concerns. | Alteration of ecosystem function and extent |

16.6.5 Residual Effects on Culturally or Economically Important Plants

Loss of devil’s club and pine mushroom resources is expected to be a residual effect because surface clearing activities along the Brucejack Transmission Line will remove habitat that supports these species. Surface clearing activities would likely result in the permanent removal of pine mushroom habitat, as pine mushrooms are connected to the living trees through a network of mycelium (i.e., fungus). Furthermore, the soil moisture, nutrient, and light regimes may be affected during clearing activities, which could result in alteration of a site’s potential to provide habitat for devil’s club. Residual effects to soapberry are not expected. The summary of predicted residual effects on culturally/economically important plants and associated mitigation measures is presented in Table 16.6-5.

Table 16.6-5. Summary of Predicted Residual Effects on Culturally/Economically Important Plants

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect | Description of Mitigation Measure(s) | Description of Residual Effect |
|---|----------------------------------|--|---|--|--------------------------------|
| Culturally or Economically Important Plants (specifically devil’s club and pine mushroom) | Construction and Operation | Brucejack Access Road and Brucejack Transmission Line Surface clearing road and transmission line maintenance and road use | Surface clearing, deposition of fugitive dust | Minimize clearing areas; dust suppression; effective internal reporting of environmental incidents and concerns. | Loss of habitat |

16.6.6 Residual Effects on Rare Plants and Lichens

Alteration of rare plant and/or lichen habitat is considered a residual effect because indirect effects, such as dust deposition and changes to hydrology, are expected to alter critical habitat. Rare plants and lichens are habitat-specific and the unique combinations of environmental conditions that characterize their habitats are also rare and cannot be easily reproduced, if at all. These effects can be minimized but not avoided entirely. The summary of predicted residual effects on rare plants and lichens as well as their associated habitat, together with proposed mitigation measures, is summarized in Table 16.6-6.

Table 16.6-6. Summary of Predicted Residual Effects on Rare Plants and Lichens

| Receptor Valued Component | Project Phase (timing of effect) | Project Component/ Physical Activity | Description of Cause-Effect | Description of Mitigation Measure(s) | Description of Residual Effect |
|---------------------------|----------------------------------|--|---|---|---|
| Rare Plants and Lichens | Construction and Operation | Brucejack Mine Site activities, vehicular travel, dust, changes to hydrological connectivity | Vehicular movement during general operation and maintenance; surface disturbances throughout the life of the mine; dust deposition (acidification and/or eutrophication) and changes in hydrological connectivity | Avoidance; minimize clearing areas; dust suppression; creation of exclusion areas; effective internal reporting of environmental incidents or concerns. | Alteration of rare plant and lichen habitat |

16.7 CHARACTERIZING RESIDUAL EFFECTS, SIGNIFICANCE, LIKELIHOOD, AND CONFIDENCE ON TERRESTRIAL ECOLOGY

The residual effects on terrestrial ecology receptor VCs were characterized in terms of magnitude, geographic extent, duration, frequency, reversibility, and resiliency according to the definitions in Table 16.7-1.

Table 16.7-1. Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology Receptor Valued Components

| Ecological Context | Probability | Significance of Adverse Residual Effects | Confidence |
|--|--|---|--|
| <i>What is the current condition of the ecosystem and how commonly is it represented in the LSA?</i> | <i>How likely is the effect to occur?</i> | <i>Will the effect result in irreversible structural and/or functional changes in populations, communities, and/or ecosystems at a regional or beyond regional level?</i> | <i>How certain is this analysis? Consider potential for error, confidence intervals, unknown variables, etc.</i> |
| Low: the receptor is considered to have little to no unique attributes or provision of functions is severely degraded. | High: It is highly likely that this effect will occur. | Not Significant Residual effects have no or low magnitude, local geographic extent, short- or medium-term duration, and occur sporadically if at all. There is a high level of confidence in the analyses. The effects on the receptor VC (e.g., at a species or population level) are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes). Land and resource management plan objectives will be met. | High: > 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty, and variation from the predicted effect is expected to be low. |

(continued)

Table 16.7-1. Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology Receptor Valued Components (completed)

| Ecological Context | Probability | Significance of Adverse Residual Effects | Confidence |
|--|---|--|---|
| Neutral: The receiving environment is considered to have some unique attributes and provides most functions that an undisturbed environment would provide. | Medium: This effect is likely, but may not occur. | | The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area that are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident. |
| High: The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity | Low: This effect is unlikely but could occur. | Significant Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic (i.e., persist into the far future); and occur on a regular or continuous basis. Residual effects on the receptor VC are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted). The ability to meet land and resource management plan objectives is impaired. The probability of the effect occurring is medium or high. Confidence in the conclusions can be high, medium, or low. | Low: < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably. |

16.7.1 Residual Effects Characterization for Terrestrial Ecology

The magnitude of an effect on terrestrial ecology receptor VCs was quantified based on results of a literature search on thresholds and is summarized in Tables 16.7-2 and 16.7-3 (Mace et al. 1996; Mace and Waller 1997; Mace 2004; Schwartz et al. 2006; Interagency Conservation Strategy Team 2007; Price, Holt, and Kremsater 2007).

Table 16.7-2. Magnitude Threshold for Each Terrestrial Ecology Receptor Valued Component by Risk Category

| Definition of Magnitude for Terrestrial Ecology Sub-components | Magnitude of Effect |
|--|---------------------|
| > 90% in Low. No detectable change from baseline conditions | Negligible |
| Moderate + High < 30% and High < 20% | Low |
| Moderate + High > 30% and < 50% and High < 20% | Moderate |
| Moderate + High ≥ 30% and High ≥ 20% | High |

The magnitude of an effect on rare plants and lichens or associated habitat was determined based on the SARA, BC CDC, and NatureServe conservation ranks, which provide definitions on the level of rarity of a species. This information was used to determine severity of residual effects to rare plants and lichens (Table 16.7-3).

Table 16.7-3. Magnitude Threshold for Rare Plants and Lichens

| Rank Status | Definition | Effect | Magnitude of Effect |
|------------------|--|--|---------------------|
| T | SARA- and COSEWIC-listed (Threatened) | Loss or alteration of species or habitat | High |
| S1; Red Listed | Extremely rare at the provincial level; 5 or fewer occurrences in BC, or very few remaining individuals; critically imperilled and susceptible to extirpation due to a factor of its biology | | High |
| S2; Red Listed | Rare at the provincial level; 6 to 20 occurrences in BC or few remaining individuals; imperilled, may be susceptible to extirpation due to some factor of its biology | | High |
| S1S2; Red Listed | Extremely rare to rare at the provincial level | | High |
| S2S3; Red Listed | Rare to vulnerable at the provincial level | | High |
| S3; Blue Listed | Vulnerable at the provincial level; 21 to 100 occurrences in BC; may be rare and local throughout the province or may occur in a restricted provincial range (may be abundant in some places); may be susceptible to extirpation by large scale disturbances | | Moderate |
| S4 | Common at the provincial level; more than 100 occurrences; generally widespread and abundant but may be rare in parts of its range; apparently secure | | Low |
| S3S4 | Vulnerable to common at the provincial level | | Low |
| S5 | Very common and demonstrably secure at the provincial level; more than 100 occurrences; widespread and abundant, but may be rare in parts of its range | | Low |
| S4S5 | Common to very common at the provincial level | | Low |

16.7.1.1 Likelihood

The likelihood of a cumulative residual effect occurring is calculated as a measure of probability, to determine the potential for the Project to cause an effect. The likelihood of a residual effect does not influence the determination of significance, rather it influences the risk of an effect occurring. Likelihood has been considered here in keeping with the most recent guidance issued in September 2013 by the BC EAO (2013): *Guidelines for the Selection of Valued Components and Assessment of Potential Effects*.

The likelihood or probability that a Project activity (mine construction, road use, tower installation etc.) will result in an effect on ecosystem function or extent was determined through reviews of relevant literature, proposed Project activities, baseline information, and/or professional judgement.

16.7.1.2 Confidence

Confidence, which can also be thought of as scientific certainty/uncertainty, is a measure of how well residual effects are understood. The predicted residual effects were assessed for their reliability to portray the certainty in the predicted outcome, based on the acceptability of the data inputs and analytical methods used in the characterization.

The confidence regarding how well residual effects are understood, which includes a consideration of the acceptability of the data inputs and analytical methods used to predict and assess project effects, was taken into consideration when characterizing residual effects.

16.8 EVALUATION OF RESIDUAL EFFECTS AND SIGNIFICANCE FOR TERRESTRIAL ECOLOGY

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from the Construction, Operation, Closure, and Post-closure activities of the Project; however, direct and indirect effects cannot be fully mitigated and thus loss and/or alteration of alpine ecosystems, parkland ecosystems, forested ecosystems, floodplain ecosystems, plants of cultural/economic importance, and rare plants and lichens are expected (Table 16.8-1).

The vast majority of loss of ecosystem function and extent will occur at a local level due to physical clearing during the site preparation at the Brucejack Mine Site, transmission line tower placement, and to a lesser extent at the Knipple Transfer Area and Tide Staging Area. Incremental losses are also expected during closure and reclamation due to slope stabilization, re-vegetation, and maintenance activities.

Alteration of ecosystem function or extent will occur at a local level as a result of dust deposition during Operation. Edge effects (e.g., species isolation, increased species diversity, favourable conditions for invasive plants), windthrow (i.e., trees uprooted or broken due to wind), and fragmentation (i.e., creating non-natural discontinuities in previously intact ecosystems that affect ecosystem functions, such as habitat) may occur throughout the life of the Project but mostly during the Construction phase along the Brucejack Transmission Line and during the Operation phase along the Brucejack Access Road. The introduction and/or spread of invasive plants during any phase of the Project is possible and is dependent on the ability of staff to collectively recognize potential problems, availability of potential vectors of introduction (e.g., vehicular traffic along Highway 37) as well as the success of eradication, control, and management measures. The interruption or removal of hydrological connectivity during the Construction and Operation phases is expected to occur at the local level but may extend to a landscape level effect, depending on the extent of alteration.

16.8.1 Alpine Ecosystems

16.8.1.1 Characterization

The majority of the alpine ecosystems affected have shallow, poorly developed soils, low functioning capacity, and/or have already been disturbed by historic activities. Therefore, Project effects represent a moderate magnitude effect to alpine ecosystems. The effects that do occur will be sporadic, landscape in extent, last into the far future, and will occur once.

16.8.1.2 Probability

There is a high probability that effects to alpine ecosystems will occur. Clearing activities associated with the construction of the mill building, Brucejack Camp, truck shop, warehouse and additional ancillary buildings will result in the loss or alteration of alpine ecosystems. Furthermore, based on the current mine design and the results of the atmospheric model (Chapter 7, Air Quality Predictive Study) there is a high likelihood that dust will be deposited on alpine ecosystems. Effects due specifically to dust deposition and subsequent chemical transformations in soil and uptake by vegetation are well understood; however, due to the number of possible pathways and the interference between many factors, the probability of dust effects, including acidification and eutrophication on alpine ecosystems, is considered medium.

16.8.1.3 Significance

Loss and alteration of alpine ecosystem function and/or extent are considered not significant.

Table 16.8-1. Characterization of Residual Effects, Significance, Confidence, and Likelihood on Terrestrial Ecology Receptor Valued Components

| Residual Effects | Evaluation Criteria | | | | | | | Likelihood (low, medium, high) | Significance of Adverse Residual Effects (not significant; significant) | Confidence (low, medium, high) |
|--|------------------------------------|---|--|--|--|------------------------------------|--|-----------------------------------|--|-----------------------------------|
| | Magnitude (low, moderate, high) | Duration (short, medium, long, far future) | Frequency (once, sporadic, regular, continuous) | Geographic Extent (local, landscape, regional, beyond regional) | Reversibility (reversible short term; reversible long term; irreversible) | Resiliency (low, neutral, high) | Ecological Context (low, neutral, high) | | | |
| Loss and alteration of ecosystem function and/or extent on alpine ecosystems | Moderate | Far future | Regular | Landscape | Irreversible | Low | Neutral | High | Not significant | Medium |
| Loss and alteration of ecosystem function and/or extent on parkland ecosystems | Low | Far future | Sporadic | Local | Reversible | Low | Neutral | Medium | Not significant | Medium |
| Loss and alteration of ecosystem function and/or extent on forested ecosystems | Low | Long | Sporadic | Landscape | Reversible medium term | Neutral | Neutral | High | Not significant | Medium |
| Loss and alteration of ecosystem function and/or extent on floodplain ecosystems | Low | Medium | Sporadic | Local | Reversible medium term | Neutral | Neutral | Medium | Not significant | High |
| Loss of culturally or economically important plant habitat | Low | Medium | Sporadic | Local | Reversible medium term | Neutral | Neutral | Medium | Not significant | Medium |
| Loss and/or alteration of rare plant and lichen habitat | Moderate | Far future | Once | Beyond regional | Irreversible | Low | High | Medium | Not significant | Medium |

16.8.1.4 *Confidence*

There is a medium level of confidence in the analyses because although direct effects to alpine areas are well understood; there is some uncertainty regarding the indirect effects of dust on alpine soils and vegetation due to the number of possible pathways and the ecological processes between components. Additionally, the ability to reclaim these sites over the long term may not be feasible (Frank and del Moral 1986; Forbes, Ebersole, and Strandberg 2001; Mingyu et al. 2009).

16.8.2 **Parkland Ecosystems**

16.8.2.1 *Characterization*

Most of the effects are attributable to fragmentation, edge effects, and changes to hydrological connectivity due to vegetation clearing along the Brucejack Transmission Line route in krummholz ecosystems. In actuality, the effect to the parkland ecosystem may be less if vegetation clearing activities can be minimized or even avoided.

The effect is local in extent, will last into the far future or long term, and will occur sporadically if at all. The effects to parkland ecosystems are considered reversible in the long term and may be distinguishable from background conditions depending on the resiliency of the specific ecosystem. In an ecological context, parkland ecosystems have unique attributes and are considered neutral according to the definitions in Table 16.7-1. Project effects do not pose a risk to the short-, medium-, or long-term viability of this resource.

16.8.2.2 *Probability*

There is a medium level of probability that effects to parkland ecosystems will occur because the current design for the transmission line passes through parkland ecosystems; however, uncertainty exists with respect to where the transmission line towers will be placed and the extent to which parkland ecosystems may be cleared during site preparation.

16.8.2.3 *Significance*

Loss and alteration of parkland ecosystem function and/or extent are considered not significant because the majority of Project activities represent a minor magnitude effect to parkland ecosystems and effects are not expected to result in irreversible structural and/or functional changes in populations, communities, and/or ecosystems at a regional or beyond regional level.

16.8.2.4 *Confidence*

There is a medium level of confidence in the analyses because uncertainty exists with respect to the precise location of the Brucejack Transmission Line towers, the amount and intensity of clearing activities required and the type of parkland ecosystems (e.g., herb meadow vs. krummholz vs. rock) that may be affected. Parkland ecosystems vary in terms of their response and ability to recover from disturbance and thus there remains some uncertainty regarding the magnitude of the effect on these ecosystems.

16.8.3 **Forested Ecosystems**

16.8.3.1 *Characterization*

Loss of forested ecosystems due to surface clearing activities along the Brucejack Transmission Line are minor in magnitude, as they will directly affect a very small portion of forested ecosystems. Indirect effects, including windthrow, fragmentation, edge effects, and changes to hydrology are moderate magnitude, landscape in extent, long term in duration, and will occur sporadically. Effects are

considered reversible in the long term. Forested ecosystems are considered to be of neutral resiliency. In an ecological context, forested ecosystems have unique attributes and are considered neutral according to the definitions in Table 16.7-1.

16.8.3.2 Probability

There is a high level of probability that effects to forested ecosystems will occur. The majority of the effects to forested ecosystems, including fragmentation and edge effects are expected to occur as a result of the continued use of the existing road. There is little uncertainty regarding where these effects will occur as the road location is known. Furthermore, most of the effects to forested ecosystems are well understood and well documented in the scientific literature.

16.8.3.3 Significance

Loss and alteration of forested ecosystem function and/or extent are considered not significant.

16.8.3.4 Confidence

There is a high level of confidence in the data sources (i.e., British Columbia Ministry of Forests, Lands and Natural Resource Operations Freshwater Atlas and the Vegetation Resources Inventory; BC MFLNRO n.d.) used for this analysis as well as the likely effects on forested ecosystems. Nevertheless, uncertainty exists with respect to where and to what degree alteration of functions may occur due to the complexity of ecological processes between components and their response to Project related disturbance. Therefore, there is an overall medium confidence level in the assessment of effects on forested ecosystems.

16.8.4 Floodplain Ecosystems

16.8.4.1 Characterization

Loss and alteration of floodplain ecosystem function and/or extent are considered not significant. Project activities will affect a small portion of this ecosystem and are considered a minor magnitude effect. The effects are not expected to affect the viability of this resource in the short, medium, or long term. Loss of floodplain ecosystems due to surface clearing activities is considered reversible because the specific floodplain ecosystems impacted have developed on regosolic gravely soils, which can recover from disturbance. The effects of windthrow, fragmentation, edge effects, and changes to hydrology are local in extent, medium term in duration, and will occur sporadically if at all. In an ecological context, floodplain ecosystems have unique attributes and are considered neutral according to the definitions in Table 16.7-1. There is a medium level of confidence in the analyses because uncertainty exists with respect to what degree alteration of functions may occur due to the complexity of ecological processes between components and their response to Project related disturbance.

16.8.4.2 Probability

There is a medium level of probability that effects to floodplains ecosystems will occur. The majority of the effects to floodplain ecosystems are expected to occur at the known location of the aerodrome; however, some uncertainty exists with regards to the magnitude of the effect due to the number of possible pathways and interactions involved and thus the overall effect on floodplain ecosystems.

16.8.4.3 Significance

Loss and alteration of floodplain ecosystem function and/or extent are considered not significant.

16.8.4.4 *Confidence*

There is a medium level of confidence in the analyses because uncertainty exists with respect to where and to what degree alteration of functions may occur. The majority of the effects to floodplain ecosystems are expected to occur at the known location of the aerodrome. However, the emission factors used in the atmospheric model, derived from the United States Environmental Protection Agency's AP-42, vary from A (excellent) to F (poor). A quality rating of "A" indicates that the factor is developed from source tests which are performed by "a sound or generally sound methodology and are reported in enough detail for adequate validation" and data are taken from "many randomly chosen facilities in the industry population" (US EPA 1995). On the other end of the spectrum, a quality rating of "F" (poor) indicates that the factor is developed from "a generally unacceptable method, but the method may provide an order-of-magnitude value for the source" and "the facilities tested do not represent a random sample of the industry" (US EPA 1995). Some emission factors used in the calculation of fugitive dust, such as bulldozing of overburden and grading, include emission factors rating from the lower end of the spectrum.

16.8.5 **Culturally/Economically Important Plant Habitat**

16.8.5.1 *Characterization*

Project activities will affect a very small portion of culturally/economically important habitat and are thus considered of minor magnitude. The effect is local in extent, medium term in duration, and will occur sporadically if at all. The effects to culturally/economically important plant habitat are considered reversible in the long term and will be indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes). Soapberry and devils club habitat is considered to have neutral resiliency. Pine mushroom habitat is considered to have low resiliency due to the complexity of the relationship between pine mushroom mycelium and host trees. In an ecological context, culturally important plant habitat has some unique attributes and is considered neutral according to the definitions in Table 16.7-1. Overall, Project effects do not pose a risk to the short-, medium-, or long-term viability of this resource.

16.8.5.2 *Probability*

There is a medium level of probability that effects to culturally/economically important plant habitat will occur as a result of the Project. Uncertainty exists regarding the precise location of each culturally/economically important plant as well as the exact location of some infrastructure components (i.e., transmission line towers). However, Project infrastructure overlaps with many different ecosystem types and as such it is likely that at least some of these ecosystems will contain culturally/economically important plants.

16.8.5.3 *Significance*

Loss of culturally/economically important plant habitat is considered not significant.

16.8.5.4 *Confidence*

There is a medium level of confidence in the analyses because the level of survey intensity for the Project was designed to guide and refine the terrain and terrestrial ecosystem mapping and was not designed to verify the presence or absence of specific vegetation types apart from rare plants and lichens.

16.8.6 Rare Plant and Lichens and Associated Habitat

16.8.6.1 *Characterization*

Rare plants and lichens represent at-risk components of regional, provincial, federal, or global biodiversity. These species are often highly habitat-specific with low resiliency to habitat loss or degradation, invasive alien species, changes in ecological dynamics or natural processes, and disturbance (BC MOE 2008). The magnitude of the removal or alteration of rare plants and lichens or their associated habitat will vary from moderate to major depending on the species affected and their associated conservation rank. The effect is beyond regional, will occur once, and will last into the far future. Loss of rare plants and lichens is considered an irreversible effect as transplantation is usually ineffective (Schemske et al. 1994; Howald 1996; Hubbard et al. 2001; Fahselt 2007). Furthermore, rare plants and lichens can have limited dispersal ability, poor recruitment or reproduction, population fluctuations, inbreeding, and/or restricted ranges. In an ecological context, rare plants and lichens (depending on their conservation rank) are considered unique attributes according to the definitions in Table 16.7-1.

16.8.6.2 *Probability*

There is a medium level of probability that effects to rare plants and lichens will occur as a result of the Project. There is a high level of confidence in the location and identification of the species; however, there is uncertainty regarding the accuracy of dust and acidification predictions due to the number of possible pathways and ecological processes involved.

16.8.6.3 *Significance*

Loss and alteration of rare plants and lichens and their associated habitat is considered not significant.

16.8.6.4 *Confidence*

There is a high level of confidence in the location and identification of the species but uncertainty exists with respect to where and to what degree loss or alteration of rare plant and lichen populations may occur. Furthermore, uncertainty exists with regards to the rarity of each species due to the limited knowledge of local and regional floral biodiversity.

16.9 SUMMARY OF RESIDUAL EFFECTS ON TERRESTRIAL ECOLOGY

In summary, the Project-related residual effects of loss and/or alteration of ecosystem function or extent will result in not significant effects on alpine, parkland, forested, and floodplain ecosystems and culturally/economically important plant habitat. The Project-related residual effects of loss and/or alteration of rare plant and lichen species or associated habitat will result in a not significant effect. The residual effects, mitigation, and significance on terrestrial ecology receptor VCs are summarized in Table 16.9-1.

Table 16.9-1. Summary of Residual Effects, Mitigation, and Significance on Terrestrial Ecology Receptor Valued Components

| Residual Effect and Terrestrial Ecology Receptor Valued Components | Project Phase(s) | Mitigation Measures | Significance |
|--|-------------------------------|--|-----------------|
| <i>Alpine Ecosystems</i> | | | |
| Loss and/or alteration of ecosystem function and extent | Construction and Operation | Avoidance; re-vegetation adherence to management procedures for alpine ecosystems; enforcement of travel on designated road surfaces only; inspections for target invasive plants; education and training for the environmental monitor; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns. | Not significant |
| <i>Parkland Ecosystems</i> | | | |
| Alteration of ecosystem function and extent | Construction and Operation | Minimize loss and adaptively manage effects through an ecosystem based approach, including, managing for hydrological connectivity wherever possible; adherence to best management practices for forested ecosystems; dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns. | Not significant |
| <i>Forested Ecosystems</i> | | | |
| Alteration of ecosystem function and extent | Construction and Operation | Minimize loss and adaptively manage effects through an ecosystem based approach. | Not significant |
| <i>Floodplain Ecosystems</i> | | | |
| Alteration of ecosystem function and extent | Construction and Operation | Minimize loss and adaptively manage for hydrological connectivity; adherence to best management practices for riparian ecosystems; dust suppression; vehicle inspections for target invasive plants; clear communication between environmental monitor and employees/contractors; coordination with other management plans; effective internal reporting of environmental incidents and concerns. | Not significant |
| <i>Culturally or Economically Important Plants</i> | | | |
| Loss of habitat | Construction and Operation | Minimize clearing areas; dust suppression; effective internal reporting of environmental incidents and concerns. | Not significant |
| <i>Rare Plants and Lichen</i> | | | |
| Loss of Species and/or Loss or Alteration of Habitat | Construction and/or Operation | Avoidance, minimize clearing areas; dust suppression; creation of exclusion areas; effective internal of environmental incidents and concerns. | Not Significant |

16.10 CUMULATIVE EFFECTS ASSESSMENT FOR TERRESTRIAL ECOLOGY

Cumulative effects are defined in this EA as “effects which are likely to result from the designated project in combination with other projects and activities that have been or will be carried out.” This definition follows that in Section 19(1) of the *Canadian Environmental Assessment Act, 2012* (2012) and is consistent with the International Finance Corporation Good Practice Note on Cumulative Impact Assessment (Bittman 1995), which refers to consideration of other existing, planned, and/or reasonably foreseeable future projects and developments. A cumulative effects assessment (CEA) is a requirement of the AIR and the EIS Guidelines and is necessary for the proponent to comply with the *Canadian Environmental Assessment Act, 2012* (Mingyu et al. 2009) and the *BC Environmental Assessment Act* (2002a).

The Canadian Environmental Assessment Agency (CEA Agency) issued an Operational Policy Statement in May 2013 entitled *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* (CEA Agency 2013), which provides a method for undertaking a CEA. Recently the BC EAO also released the updated *Guideline for the Selection of Valued Components and the Assessment of Potential Effects* (BC EAO 2013), which includes advice for determining the need for a cumulative impact assessment. The CEA assessment methodology adopted in this Application/EIS therefore follows the guidance of the CEA Agency as outlined above, as well as the selection criteria in BC EAO (2013).

The method involves the following key steps which are further discussed in the proceeding sub-sections:

- scoping;
- analysis;
- identification of mitigation measures;
- identification of residual cumulative effects; and
- determination of significance.

16.10.1 Establishing the Scope of the Cumulative Effects Assessment

The scoping process involves identification of the intermediate components and receptor VCs for which residual effects are predicted, definition of the spatiotemporal boundaries of the assessment, and an examination of the relationship between the residual effects of the Project and those of other projects and activities.

16.10.1.1 Identifying Intermediate Components and Receptor Valued Components for the Cumulative Effects Assessment

Intermediate components and receptor VCs included in the terrestrial ecology CEA were selected using four criteria following BC EAO (2013):

- there must be a residual environmental effect of the project being proposed;
- that environmental effect must be demonstrated to interact cumulatively with the environmental effects from other projects or activities;
- it must be known that the other projects or activities have been or will be carried out and are not hypothetical; and
- the cumulative environmental effect must be likely to occur.

The receptor VCs included in this terrestrial ecology CEA are:

- alpine ecosystems;
- parkland ecosystems;
- forested ecosystems;
- riparian and floodplain ecosystems;
- culturally/economically important plants; and
- rare plants and lichens and associated habitat.

16.10.2 Potential Interaction of Projects and Activities with the Brucejack Gold Mine Project for Terrestrial Ecology

A review of the interaction between potential residual effects of the Project and the residual effects of other projects and activities on terrestrial ecology receptor VCs was undertaken to determine the potential cumulative effects on terrestrial ecosystems, culturally/economically important plants, and rare lichens and plants (including their habitats). The review assessed the projects and activities identified in Section 6.9.2, Project and Activities Considered, including:

- regional projects and activities that are likely to affect receptor VC, even if they are located outside the direct zone of influence of the Project;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions of receptor VC); and
- activities not limited to other reviewable projects, if those activities are likely to affect receptor VCs cumulatively (e.g., forestry, mineral exploration, and commercial recreational activities). A matrix identifying the potential cumulative effect interactions for terrestrial ecology VCs is provided in Table 16.10-1.

Table 16.10-1. Potential Cumulative Effect Interactions for Terrestrial Ecology Receptor Valued Components

| Projects and Activities | Terrestrial Ecology Receptor Valued Components |
|---|--|
| <i>Past Projects</i> | |
| Eskay Creek Mine | |
| Galore Creek Project - Access Road Only | |
| Goldwedge Mine | |
| Granduc Mine (Past Producer) | |
| Johnny Mountain Mine | |
| Kitsault Mine (Past Producer) | |
| Silbak Premier Mine | |
| Snip Mine | |
| Snowfield Exploration Project | |
| Sulphurets Advanced Exploration Project | |
| Swamp Point Aggregate Mine | |

(continued)

Table 16.10-1. Potential Cumulative Effect Interactions for Terrestrial Ecology Receptor Valued Components (continued)

| Projects and Activities | Terrestrial Ecology Receptor Valued Components |
|--|--|
| <i>Present</i> | |
| Brucejack Exploration and Bulk Sample Program | |
| Forrest Kerr Hydroelectric Power Facility | |
| Long Lake Hydroelectric Power Facility | |
| McLymont Creek Hydroelectric Project | |
| Northwest Transmission Line | |
| Red Chris Project | |
| <i>Reasonably Foreseeable Future</i> | |
| Arctos Anthracite Coal Mine | |
| Bear River Gravel | |
| Bronson Slope Mine | |
| Coastal GasLink Pipeline Project | |
| Galore Creek Project | |
| Granduc Copper Mine | |
| Granduc Copper Mine | |
| KSM Project | |
| Kinskuch Hydroelectric Project | |
| Kitsault Mine | |
| Kutcho Project | |
| LNG Canada Export Terminal Project | |
| Northern Gateway Pipeline Project | |
| Prince Rupert Gas Transmission Project | |
| Prince Rupert LNG Project | |
| Schaft Creek Project | |
| Spectra Energy Gas Pipeline | |
| Storie Moly Project | |
| Treaty Creek Hydroelectric Project | |
| Turnagain Project | |
| Volcano Hydroelectric Project | |
| <i>Land Use Activities - All Stages (past, present, future)</i> | |
| Parks and Protected Areas | |
| Guide Outfitting | |
| Aboriginal Harvest (fishing, hunting/trapping, plant gathering) | |
| Hunting | |

(continued)

Table 16.10-1. Potential Cumulative Effect Interactions for Terrestrial Ecology Receptor Valued Components (completed)

| Projects and Activities | Terrestrial Ecology Receptor Valued Components |
|--|--|
| <i>Land Use Activities - All Stages (past, present, future) (cont'd)</i> | |
| Trapping | |
| Commercial Recreation (including fishing) | |
| Forestry | |
| Transportation | |

Black = likely interaction between Brucejack Gold Mine Project and other project or activity

Grey = possible interaction between Brucejack Gold Mine Project and other project or activity

White = unlikely interaction between Brucejack Gold Mine Project and other project or activity

16.10.3 Spatiotemporal Boundaries of the Cumulative Effects Assessment

The CEA boundary for terrestrial ecology receptor VCs represents the maximum limit within which the effects assessment is conducted. It encompasses the areas within, and times during, which the Project is expected to interact with the receptor VC and with other projects and activities, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries) and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the terrestrial ecology CEA, and encompasses possible direct, indirect, and induced effects of the Project on terrestrial ecology receptor VCs.

16.10.3.1 Spatial Boundaries

The CEA spatial boundary is the same boundary used for the regional study area. As previously indicated, this boundary represents the area beyond which effects of the Project are not expected to cumulatively interact with effects of other projects. It is also intended to be ecologically relevant based on the ecosystems that provide habitat within the home range of key wildlife species known to inhabit the region. This boundary encompasses an area of 374,433 ha and is depicted in Figure 16.10-1.

16.10.3.2 Temporal Boundaries

The CEA temporal boundary commences in 1918 (initiation of early exploration activities within the CEA spatial boundary) and extends to 20 years beyond the Post-closure phase of the Project. This time frame encompasses past, present, and reasonably foreseeable cumulative transient and residual permanent effects from the Project in combination with other relevant projects. It is expected that the majority of predictable cumulative effects have occurred or will have occurred within this time frame.

- Past - 1964 to 2011: coinciding with the development of the Granduc Mine, which influenced the growth of the community of Stewart and other human activities in the area;
- Present - 2011 to 2014: from the start of Brucejack Gold Mine Project baseline studies to the completion of the environmental effects assessment; and
- Future - variable according to the time estimated for VCs to recover to baseline conditions.

16.10.3.3 Ecological Boundaries

Nine BEC units occur within the CEA boundary, including both coastal and interior units (Table 16.3-1). Six of the nine BEC units are forested and cover approximately 42% of the CEA study area, while the three alpine and parkland BEC zones collectively contribute more than 58% of the CEA boundary.

16.10.4 Identification of Cumulative Effects

Potential Project-related residual effects in combination with residual effects from other past, present, or future project or development activities in the CEA study area on the terrestrial ecology receptor VC were identified through reviews of relevant literature (e.g., Project description, data made available from First Nations and local stakeholders or through ethnographic reports, scientific literature, data acquired via data sharing agreements, government documents, and publically available data associated with relevant adjacent projects) and professional judgement and experience.

Based on this review, it is expected that past, existing, and future activities will also result in loss or alteration of alpine ecosystems, forested ecosystems, floodplain ecosystem function and/or extent, as well as loss of rare plants and lichens or associated critical habitat. Parkland ecosystems and culturally/economically important plant habitat was not included in the cumulative effects assessment. The Project is not expected to contribute to cumulative effects on parkland ecosystems. In the worst case scenario, the Project is expected to affect a very small amount of culturally/economically important plant habitat (see Section 16.5.5, Key Effects on Terrestrial Ecology), most of which is expected to recover in the long term. The summary of potential cumulative effects between the Project's terrestrial ecology receptor VC and other projects and activities is summarized in Table 16.10-2.

16.10.5 Analysis of Cumulative Effects

Cumulative effects occur when there are interactions between projects, between projects and the environment, and between components of the environment. For cumulative effects to occur there must be a pathway between action and effect, with these pathways also existing amongst other projects within the established boundary for a CEA.

For terrestrial ecology VCs, these can occur in various ways:

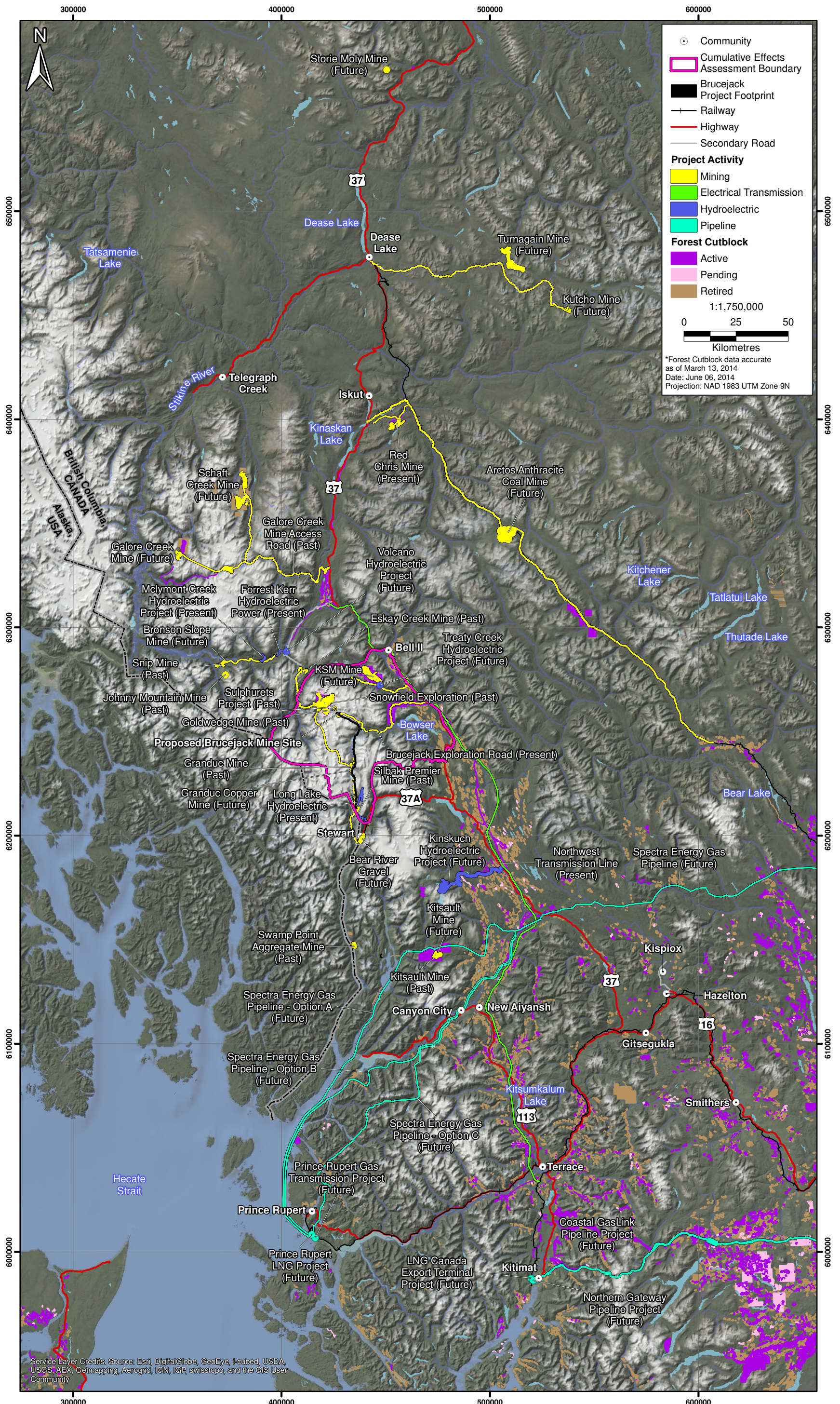
- Physical-chemical transport - a physical or chemical constituent is transported away from the action under review where it then interacts with another action. An example of this would be the spread of invasive plants.
- Nibbling loss - the gradual disturbance and loss of land and habitat. This occurs with removal of terrestrial ecosystems from the landscape.
- Spatial and temporal crowding - cumulative effects can occur when too much is happening within too small an area and in too brief a period of time. A threshold may be exceeded and the environment may not be able to recover to pre-disturbance conditions. This occurs with the fragmentation of ecosystems.
- Synergistic - combined effects along a pathway that collectively result in an increased effect that may not have existed if the effect occurred in isolation.
- Additive - combined effects along a pathway that equal the sum of the individual effects.
- Growth inducing - Each new action can induce further actions to occur. For example, creation of edges could lead to windthrow and introduction of invasive plants.

16.10.5.1 Terrestrial Ecosystems

Cumulative loss of terrestrial ecosystems was determined by overlaying the footprint of each past, present, and future project on the baseline PEM data within the CEA boundary. This information is summarized per terrestrial ecology receptor VC in Tables 16.10-3 to 16.10-5.

Figure 16.10-1

Cumulative Effects Scoping: Projects and Activities Interacting with the Brucejack Project for Terrestrial Ecology



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Table 16.10-2. Potential Cumulative Effects between the Brucejack Gold Mine Project Terrestrial Ecology Receptor Valued Component and Other Projects and Activities

| CEA Temporal Project Status | Projects within the CEA Boundary | Loss of Alpine, Forest and/or Floodplain Ecosystem Function and/or Extent | Alteration of Alpine, Forest and Floodplain Ecosystem Function and/or Extent | Loss of Rare Plants/Lichens or Associated Habitat | Alteration of Rare Plant or Lichen Habitat | Type of Potential Cumulative Effect ¹ |
|-----------------------------|---|---|--|---|--|--|
| Past Project or Activity | Goldwedge Mine | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss; physical-chemical transport |
| | Granduc Mine | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss; physical-chemical transport |
| | Silbak Premier Mine | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss; physical-chemical transport |
| | Sulphurets Project | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss; physical-chemical transport |
| | Long Lake Hydroelectric | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss |
| | Brucejack Exploration Project | ✓ | ✓ | ✓ | ✓ | Nibbling loss, synergistic, additive, physical-chemical transport, growth inducing |
| | Forestry | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss, synergistic, additive, physical-chemical transport, growth inducing |
| | Snowfield Exploration Project | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss, synergistic, additive, physical-chemical transport |
| | Aboriginal Harvest (fishing, hunting/trapping, plant gathering) | None expected | None expected | None expected | None expected | None expected |
| Present Activity | Forestry | None expected | ✓ | Information unavailable | Information unavailable | Synergistic, additive, physical-chemical transport |
| | Aboriginal Harvest (fishing, hunting/trapping, plant gathering) | None expected | None expected | None expected | None expected | None expected |

(continued)

Table 16.10-2. Potential Cumulative Effects between the Brucejack Gold Mine Project Terrestrial Ecology Receptor Valued Components and Other Projects and Activities (completed)

| CEA Temporal Project Status | Projects within the CEA Boundary | Loss of Alpine, Forest and/or Floodplain Ecosystem Function and/or Extent | Alteration of Alpine, Forest and Floodplain Ecosystem Function and/or Extent | Loss of Rare Plants/Lichens or Associated Habitat | Alteration of Rare Plant or Lichen Habitat | Type of Potential Cumulative Effect ¹ |
|---|---|---|--|---|--|--|
| Reasonably Foreseeable Future Project or Activity | KSM Project | ✓ | ✓ | ✓ | ✓ | Nibbling loss, synergistic, additive, spatial and temporal crowding, physical-chemical transport |
| | Treaty Creek Hydroelectric | None expected | None expected | None expected | None expected | None expected |
| | Granduc Mine | ✓ | ✓ | Information unavailable | Information unavailable | Nibbling loss, additive, physical-synergistic, chemical transport |
| | Brucejack Gold Mine Project | ✓ | ✓ | ✓ | ✓ | Nibbling loss, additive, physical-synergistic, chemical transport |
| | Forestry | None expected | ✓ | Information unavailable | Information unavailable | Nibbling loss, additive, physical-synergistic, chemical transport, growth inducing |
| | Aboriginal Harvest (fishing, hunting/trapping, plant gathering) | None expected | None expected | None expected | None expected | None expected |

¹ Potential type of effect includes physical-chemical transport, nibbling loss, spatial crowding, temporal crowding, synergistic, additive, growth inducing.

The cumulative loss of terrestrial ecosystems within the CEA boundary—excluding the Project—is 5,358 ha (1.7 %). The Project may result in the loss of 217 ha (0.1%) of alpine ecosystems, 178 ha (0.12%) of forested ecosystems, and 15 ha (0.19%) of floodplain ecosystems. The cumulative loss of terrestrial ecosystems within the CEA boundary—including the Project—is 5,769 ha (1.9%), including 1,706 ha (1.1%) of alpine ecosystems; 4,051 ha (2.8%) of forested ecosystems, and 225 ha (2.8%) of floodplain ecosystems. The Brucejack Gold Mine Project contributes approximately 7.1% of the total cumulative loss of ecosystems expected within the CEA boundary.

The cumulative alteration of terrestrial ecosystems within the CEA boundary—excluding the Project—is 20,582 ha (6.6 %). The Project may result in the alteration of 196 ha (0.1%) of alpine ecosystems, 983 ha (0.68%) of forested ecosystems, and 102 ha (1.25%) of floodplain ecosystems. The cumulative alteration of terrestrial ecosystems within the CEA boundary – including the Project – is 21,806 ha (7.0%), including 3,442 ha (2.1%) of alpine ecosystems; 17,654 ha (12.16%) of forested ecosystems, and 710 ha (8.69%) of floodplain ecosystems. The Brucejack Gold Mine Project contributes approximately 5.88% of the total cumulative alteration of ecosystems expected within the CEA boundary.

A summary of the cumulative loss and alteration of terrestrial ecosystems is provided by receptor valued components, project, and timeline in Tables 16.10-3a to 16.10-3d and 16.10-4a to 16.10-4d, respectively.

Table 16.10-3a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|-----------------------|---------------|-----------|---------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Brucejack Mine Site | | | | | RO | Sparsely Vegetated | Sparse/bryoid (NS) | 196 | 1 | 17,090 |
| | | | | | MP | Mesic Herb | Herb (H) | 4 | 0 | 1,563 |
| | | | | | AM | Mesic Herb | Herb (H) | 14 | 1 | 1,103 |
| | | | | | CL | Sparsely Vegetated | Sparse/bryoid (NS) | 2 | 2 | 96 |
| | | | | | TA | Sparsely Vegetated | Sparse/bryoid (NS) | 2 | 2 | 89 |
| Brucejack Access Road | Mining | Present | BAFAunp | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 1,103 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 2 | 0 | 27,090 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 1 | 0 | 16,952 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 0 | 0 | 2,503 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 1 | 0 | 3,937 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,713 |
| Goldwedge | Mining | Historic | CMAunp | 00 | BA | Sparsely Vegetated | Sparse/Byroid (1) | 3 | 0 | 13,781 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 2,939 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 1 | 0 | 1,349 |
| Granduc Copper Mine | Mining | Future | BAFAunp | 00 | AM | Mesic Herb | Herb (2) | 4 | 0 | 1,103 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 45 | 0 | 27,090 |
| | | | | | DH | Drier Herb | Herb (2) | 3 | 1 | 406 |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 1 | 0 | 701 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 27 | 0 | 16,952 |
| | | | | | GI | Non-vegetated | n/a | 0 | 0 | 66,607 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 25 | 1 | 2,503 |
| | | | | | MP | Mesic Herb | Herb (2) | 37 | 1 | 3,343 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 1 | 0 | 3,937 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,713 |
| | | | | | VW | Wetter Herb | Herb (2) | 2 | 0 | 342 |

(continued)

Table 16.10-3a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|------------------------------|---------------|-----------|---------|-------------|----------|-------------------------------|-------------------|----------------|---------------|-------------------------------|
| Granduc Mine (Past Producer) | Mining | Historic | BAFAunp | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 1,103 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 30 | 0 | 27,090 |
| | | | | | DH | Drier Herb | Herb (2) | 0 | 0 | 406 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 10 | 0 | 16,952 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 1 | 0 | 2,503 |
| | | | | | MP | Mesic Herb | Herb (2) | 3 | 0 | 3,343 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 3,937 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,713 |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 0 | 342 |
| | | | CMAunp | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 358 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 1 | 0 | 13,781 |
| | | | | | DH | Drier Herb | Herb (2) | 0 | 0 | 191 |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 0 | 0 | 684 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 7 | 0 | 9,087 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 1 | 0 | 2,116 |
| | | | | | MP | Mesic Herb | Herb (2) | 3 | 0 | 1,563 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 2,939 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,349 |
| KSM | Mining | Future | BAFAunp | 00 | BA | Sparsely Vegetated | Sparse/Byroid (1) | 2 | 0 | 27,090 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 4 | 0 | 16,952 |
| | | | | | GI | Non-vegetated | n/a | 93 | 0 | 66,607 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 0 | 0 | 2,503 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 3,937 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,713 |

(continued)

Table 16.10-3a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|---|-----------------|-----------------|--------|-------------|----------|-------------------------------|-------------------|----------------|---------------|-------------------------------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | CMAunp | 00 | AM | Mesic Herb | Herb (2) | 9 | 3 | 358 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 470 | 3 | 13,781 |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 7 | 1 | 684 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 117 | 1 | 9,087 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 67 | 3 | 2,116 |
| | | | | | MP | Mesic Herb | Herb (2) | 16 | 1 | 1,563 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 115 | 4 | 2,939 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 86 | 6 | 1,349 |
| | | | VW | Wetter Herb | Herb (2) | 2 | 2 | 92 | | |
| Snowfield Exploration Project | Mining | Historic | CMAunp | 00 | BA | Sparsely Vegetated | Sparse/Byroid (1) | 4 | 0 | 13,781 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 1,349 |
| Sulphurets Advanced Exploration Project | Mining | Historic | CMAunp | 00 | AM | Mesic Herb | Herb (2) | 3 | 1 | 358 |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 52 | 0 | 13,781 |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 0 | 0 | 684 |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 3 | 0 | 9,087 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub (3) | 0 | 0 | 2,116 |
| | | | | | MP | Mesic Herb | Herb (2) | 5 | 0 | 1,563 |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 8 | 0 | 2,939 |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 4 | 0 | 1,349 |
| | | | VW | Wetter Herb | Herb (2) | 1 | 1 | 92 | | |

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|-----------------------|---------------|---------------|----------------------------|-------------|----------|--------------------|----------------------------|----------------------------|---------------|-------------------------------|--------|
| Brucejack Mine Site | Mining | Future | ESSFwv | 00 | AM | Mesic Herb | Herb (2) | 1 | 0 | 1,592 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 3 | 0 | 10,708 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 15 | 0 | 6,900 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 0 | 0 | 1,316 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 3 | 0 | 3,356 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 1 | 0 | 2,586 | |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 0 | 142 | |
| | | | | 01 | FA | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 20,732 | |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest (6/7) | 0 | 0 | 297 | |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 2,002 | |
| 08 | FH | Wetter Forest | Mature to Old Forest (6/7) | 0 | 0 | 1,376 | | | | | |
| Brucejack Access Road | Mining | Present | ESSFwv | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 1,592 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 4 | 0 | 10,708 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 16 | 0 | 6,900 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 6 | 0 | 3,356 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 2 | 0 | 2,586 | |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 0 | 142 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest (6/7) | 42 | 0 | 20,732 |
| | | | | 02 | LC | Drier Forest | Mature to Old Forest (6/7) | 0 | 0 | 512 | |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest (6/7) | 0 | 0 | 297 | |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest (6/7) | 2 | 0 | 2,002 | |
| | | | | 05 | FO | Mesic Forest | Mature to Old Forest (6/7) | 10 | 0 | 2,423 | |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest (6/7) | 5 | 0 | 1,376 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 276 |
| | | | | | | Avm | Avalanche Track | Shrub (3) | 4 | 0 | 2,822 |
| | | | | | | Avs | Avalanche Track | Shrub (3) | 0 | 0 | 867 |
| | | | BA | | | Sparsely Vegetated | Sparse/Byroid (1) | 13 | 1 | 969 | |

(continued)

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|--------------------------------|-----------------|------------------|----------------------------|-------------|----------|--------------------|----------------------------|----------------------------|---------------|-------------------------------|--------|
| Brucejack Access Road (cont'd) | Mining (cont'd) | Present (cont'd) | ICHvc (cont'd) | 00 (cont'd) | DS | Drier Shrub/Herb | Shrub (3) | 0 | 0 | 128 | |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 0 | 0 | 215 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 1 | 0 | 336 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 0 | 0 | 404 | |
| | | | | | GW | Wetland Shrub/Herb | Herb (2) | 1 | 1 | 124 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 8 | 0 | 8,460 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 3 | 0 | 3,107 | |
| | | | | | VW | Wetter Herb | Herb (2) | 2 | 0 | 533 | |
| | | | | | 01 | HD | Mesic Forest | Mature to Old Forest (6/7) | 25 | 0 | 14,943 |
| | | | | | 02 | HM | Drier Forest | Mature to Old Forest (6/7) | 1 | 0 | 537 |
| | | | | 03 | SD | Moist Forest | Mature to Old Forest (6/7) | 8 | 0 | 4825 | |
| Granduc Copper Mine | Mining | Future | ESSFwv | 00 | AM | Mesic Herb | Herb (2) | 2 | 0 | 1,592 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 0 | 0 | 10,708 | |
| | | | | | Avs | Avalanche Track | Shrub (3) | 0 | 0 | 7,671 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 8 | 0 | 6,900 | |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 10 | 0 | 2,878 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 0 | 0 | 1,316 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 0 | 0 | 1,555 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 20,732 |
| 04 | MH | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 2,002 | | | | | |
| Granduc Mine (Past Producer) | Mining | Historic | ESSFwv | 00 | AM | Mesic Herb | Herb (2) | 1 | 0 | 1,592 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 0 | 0 | 10,708 | |
| | | | | | Avs | Avalanche Track | Shrub (3) | 0 | 0 | 7,671 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 2 | 0 | 6,900 | |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 0 | 0 | 2,878 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 0 | 0 | 1,316 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 0 | 0 | 1,555 | |

(continued)

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|---|------------------|----------------------|--------------------|-------------------------------|-----------|--------------------|-------------------|----------------------------|---------------|-------------------------------|--------|
| Granduc Mine (Past Producer) (cont'd) | Mining (cont'd) | Historic (cont'd) | ESSFwv (cont'd) | 00 (cont'd) | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 3,356 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 2,586 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 20,732 |
| | | | | | 02 | LC | Drier Forest | Mature to Old Forest (6/7) | 0 | 0 | 512 |
| | | | | | 04 | MH | Mesic Forest | Mature to Old Forest (6/7) | 0 | 0 | 2,002 |
| KSM | Mining | Future | CWHwm | 00 | Avs | Avalanche Track | Shrub (3) | 6 | 0 | 1,201 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 0 | 0 | 242 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 0 | 1 | 24 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 0 | 0 | 57 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 2 | 1 | 325 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 1 | 1 | 163 | |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 1 | 5 | |
| | | | | | 01/03 | HB/SO | Mesic Forest | Mature to Old Forest (6/7) | 43 | 1 | 5,745 |
| | | | | | 02 | HM | Drier Forest | Mature to Old Forest (6/7) | 3 | 1 | 457 |
| | | | | | 04 | SD | Moist Forest | Mature to Old Forest (6/7) | 14 | 1 | 1,393 |
| | | | | | 06 | CD | Floodplain Forest | Mature to Old Forest (6/7) | 0 | 0 | 46 |
| | | | | | 08 | HS | Wetter Forest | Mature to Old Forest (6/7) | 2 | 1 | 195 |
| | | | | | ESSFwv | 00 | AM | Mesic Herb | Herb (2) | 4 | 0 |
| | | | Avm | Avalanche Track | | | Shrub (3) | 181 | 2 | 10,708 | |
| | | | Avs | Avalanche Track | | | Shrub (3) | 13 | 0 | 7,671 | |
| | | | BA | Sparsely Vegetated | | | Sparse/Byroid (1) | 16 | 0 | 6,900 | |
| | | | ET | Sparsely Vegetated | | | Sparse/Byroid (1) | 0 | 0 | 2,878 | |
| | | | GTm | Avalanche Track | | | Herb (2) | 3 | 0 | 1,316 | |
| | | | GTs | Avalanche Track | | | Herb (2) | 1 | 0 | 1,555 | |
| | | | PK | Parkland Forest/ Krummholz | Shrub (3) | 0 | 0 | 1,390 | | | |
| VF | Mesic Shrub/Herb | Shrub (3) | 58 | 2 | 3,356 | | | | | | |

(continued)

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|--------------|-----------------|-----------------|-----------------|-------------|----------|--------------------|----------------------------|----------------------------|---------------|-------------------------------|--------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | ESSFwv (cont'd) | 00 | VS | Wetter Shrub/Herb | Shrub (3) | 169 | 7 | 2,586 | |
| | | | | | VW | Wetter Herb | Herb (2) | 1 | 1 | 142 | |
| | | | | 01 | FA | Mesic Forest | Mature to Old Forest (6/7) | 747 | 4 | 20,732 | |
| | | | | 02 | LC | Drier Forest | Mature to Old Forest (6/7) | 3 | 0 | 512 | |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest (6/7) | 3 | 1 | 297 | |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest (6/7) | 22 | 1 | 2,002 | |
| | | | | 05 | FO | Mesic Forest | Mature to Old Forest (6/7) | 397 | 16 | 2,423 | |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest (6/7) | 259 | 19 | 1,376 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 276 |
| | | | | | | Avm | Avalanche Track | Shrub (3) | 7 | 0 | 2,822 |
| | | | | | | Avs | Avalanche Track | Shrub (3) | 1 | 0 | 867 |
| | | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 4 | 0 | 969 |
| | | | | | | DS | Drier Shrub/Herb | Shrub (3) | 0 | 0 | 128 |
| | | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 0 | 0 | 215 |
| | | | | | | GTm | Avalanche Track | Herb (2) | 1 | 0 | 336 |
| | | | | | GTs | Avalanche Track | Herb (2) | 0 | 0 | 404 | |
| | | | | | GW | Wetland Shrub/Herb | Herb (2) | 0 | 0 | 124 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 23 | 0 | 8,460 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 11 | 0 | 3,107 | |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 0 | 533 | |
| | | | | | 01 | HD | Mesic Forest | Mature to Old Forest (6/7) | 41 | 0 | 14,943 |
| | | | | | 02 | HM | Drier Forest | Mature to Old Forest (6/7) | 2 | 0 | 537 |
| | | | | | 03 | SD | Moist Forest | Mature to Old Forest (6/7) | 17 | 0 | 4,825 |
| | | | MHmm2 | 00 | AM | Mesic Herb | Herb (2) | 5 | 8 | 60 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 217 | 6 | 3,746 | |
| | | | | | Avs | Avalanche Track | Shrub (3) | 180 | 4 | 4,472 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 5 | 3 | 167 | |

(continued)

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|-------------------------|-----------------|-----------------|----------------------------|-------------|----------|-------------------------------|-------------------|----------------------------|---------------|-------------------------------|-------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | MHmm2 (cont'd) | 00 (cont'd) | DH | Drier Herb | Herb (2) | 0 | 0 | 33 | |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 1 | 0 | 249 | |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 146 | 4 | 4,103 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 29 | 15 | 191 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 19 | 5 | 410 | |
| | | | | | GW | Wetland Shrub/Herb | Herb (2) | 0 | 17 | 1 | |
| | | | | | MP | Mesic Herb | Herb (2) | 29 | 2 | 1,392 | |
| | | | | | PK | Parkland Forest/ Krummholz | Shrub (3) | 54 | 10 | 547 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 16 | 4 | 436 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 78 | 9 | 849 | |
| | | | | | VW | Wetter Herb | Herb (2) | 1 | 2 | 38 | |
| | | | | | 01 | MB | Mesic Forest | Mature to Old Forest (6/7) | 461 | 7 | 6,564 |
| | | | | | 02 | MM | Drier Forest | Mature to Old Forest (6/7) | 15 | 4 | 394 |
| | | | | | 03 | MO | Mesic Forest | Mature to Old Forest (6/7) | 106 | 5 | 2,110 |
| | | | | | 04 | AB | Moist Forest | Mature to Old Forest (6/7) | 37 | 8 | 436 |
| | | | | | 05 | MT | Moist Forest | Mature to Old Forest (6/7) | 83 | 6 | 1,462 |
| 06 | MD | Wetter Forest | Mature to Old Forest (6/7) | 74 | 13 | 568 | | | | | |
| Long Lake Hydroelectric | Hydro-electric | Present | MHmm2 | 00 | AM | Mesic Herb | Herb (2) | 9 | 14 | 60 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 4 | 0 | 3,746 | |
| | | | | | Avs | Avalanche Track | Shrub (3) | 14 | 0 | 4,472 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 23 | 14 | 167 | |
| | | | | | DH | Drier Herb | Herb (2) | 0 | 1 | 33 | |
| | | | | | DS | Drier Shrub/Herb | Shrub (3) | 2 | 1 | 249 | |
| | | | | | ET | Sparsely Vegetated | Sparse/Byroid (1) | 25 | 1 | 4,103 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 1 | 1 | 191 | |
| | | | | | GTs | Avalanche Track | Herb (2) | 4 | 1 | 410 | |

(continued)

Table 16.10-3b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|----------------------------------|-------------------------|------------------|----------------|----------------------------|----------|--------------------|-------------------|----------------------------|---------------|-------------------------------|--------|
| Long Lake Hydroelectric (cont'd) | Hydro-electric(cont'd) | Present (cont'd) | MHmm2 (cont'd) | 00 (cont'd) | MP | Mesic Herb | Herb (2) | 84 | 6 | 1,392 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 6 | 1 | 436 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 2 | 0 | 849 | |
| | | | | | VW | Wetter Herb | Herb (2) | 2 | 6 | 38 | |
| | | | | | 01 | MB | Mesic Forest | Mature to Old Forest (6/7) | 31 | 0 | 6,564 |
| | | | | | 02 | MM | Drier Forest | Mature to Old Forest (6/7) | 3 | 1 | 394 |
| | | | | | 04 | AB | Moist Forest | Mature to Old Forest (6/7) | 13 | 3 | 436 |
| | | | | | 05 | MT | Moist Forest | Mature to Old Forest (6/7) | 1 | 0 | 1,462 |
| | 06 | MD | Wetter Forest | Mature to Old Forest (6/7) | 8 | 1 | 568 | | | | |
| Northwest Transmission Line | Electrical Transmission | Present | ICHvc | 00 | AM | Mesic Herb | Herb (2) | 0 | 0 | 276 | |
| | | | | | Avm | Avalanche Track | Shrub (3) | 3 | 0 | 2,822 | |
| | | | | | BA | Sparsely Vegetated | Sparse/Byroid (1) | 0 | 0 | 969 | |
| | | | | | GTm | Avalanche Track | Herb (2) | 1 | 0 | 336 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub (3) | 0 | 0 | 8,460 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub (3) | 0 | 0 | 3,107 | |
| | | | | | VW | Wetter Herb | Herb (2) | 0 | 0 | 533 | |
| | | | | | 01 | HD | Mesic Forest | Mature to Old Forest (6/7) | 2 | 0 | 14,943 |
| | 03 | SD | Moist Forest | Mature to Old Forest (6/7) | 1 | 0 | 4,825 | | | | |

Table 16.10-3c. Cumulative Loss of Floodplain Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|------------------------------|---------------|----------------|----------------------------|-------------|----------|-------------------|----------------------------|----------------------------|---------------|-------------------------------|-------|
| Brucejack Mine Site | Mining | Future | ESSFwv | 09 | FL | Wetland Forest | Mature to Old Forest (6/7) | 0 | 0 | 277 | |
| Brucejack Access Road | Mining | Present | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest (6/7) | 1 | 0 | 1,975 | |
| | | | | 09 | FL | Wetland Forest | Mature to Old Forest (6/7) | 1 | 0 | 277 | |
| | | | | 04/05 | DD/CD | Floodplain Forest | Young Forest (5) | 2 | 0 | 3,206 | |
| | | | | | | | Mature Forest (6) | 11 | 0 | 3,206 | |
| | | | | | | | Mature to Old Forest (6/7) | 1 | 0 | 3,206 | |
| 06 | SH | Wetland Forest | Mature to Old Forest (6/7) | 0 | 0 | 695 | | | | | |
| Granduc Mine (Past Producer) | Mining | Historic | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest (6/7) | 0 | 0 | 1,975 | |
| KSM | Mining | Future | CWHwm | 05 | SS | Floodplain Forest | Mature to Old Forest (6/7) | 0 | 0 | 42 | |
| | | | | 07 | CW | Floodplain Forest | Mature to Old Forest (6/7) | 1 | 1 | 136 | |
| | | | | 09/10 | SC/LS | Wetland Forest | Mature to Old Forest (6/7) | 0 | 0 | 97 | |
| | | | | | | | Mature to Old Forest (6/7) | 0 | 0 | 97 | |
| | | | | ESSFwv | FD | Wetter Forest | Mature to Old Forest (6/7) | 65 | 3 | 1,975 | |
| | | | | | | | Mature to Old Forest (6/7) | 15 | 6 | 263 | |
| | | | | | | | Mature to Old Forest (6/7) | 37 | 13 | 277 | |
| | | | | ICHvc | 04/05 | DD/CD | Floodplain Forest | Mature Forest (6) | 2 | 0 | 3,206 |
| | | | | | | | | Mature to Old Forest (6/7) | 4 | 0 | 3,206 |
| | | | | MHmm2 | 07 | YH | Wetter Forest | Mature to Old Forest (6/7) | 41 | 4 | 930 |
| Mature to Old Forest (6/7) | 25 | 12 | 203 | | | | | | | | |
| 08/09 | YS /YC | Wetland Forest | Mature to Old Forest (6/7) | 25 | 12 | 203 | | | | | |
| | | | Mature to Old Forest (6/7) | 25 | 12 | 203 | | | | | |
| Long Lake Hydroelectric | Hydroelectric | Present | MHmm2 | 07 | YH | Wetter Forest | Mature to Old Forest (6/7) | 4 | 0 | 930 | |
| | | | | 08/09 | YS /YC | Wetland Forest | Mature to Old Forest (6/7) | 11 | 5 | 203 | |

Table 16.10-3d. Cumulative Loss of Terrestrial Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Valued Component | Time | Label | Area (ha) | Area (%) | Area within CEA Boundary |
|--|-----------------------------|---|-----------------------|------------|--------------------------|
| Alpine Ecosystem | Future | Granduc Copper Mine | 144 | 0.1 | |
| | | KSM | 990 | 0.6 | |
| | Historic | Goldwedge | 3 | 0.0 | |
| | | Granduc Mine (Past Producer) | 56 | 0.0 | |
| | | Snowfield Exploration Project | 4 | 0.0 | |
| | | Sulphurets Advanced Exploration Project | 78 | 0.0 | |
| | Present | Brucejack Access Road | 4 | 0.0 | |
| | | Brucejack Mine Site | 213 | 0.0 | |
| Alpine Ecosystem Total | | | 1,493 | 1.0 | 156,858 |
| Floodplain/Riparian Ecosystem | Future | Brucejack Mine Site | 0 | 0.0 | |
| | | KSM | 195 | 2.4 | |
| | Historic | Granduc Mine (Past Producer) | 0 | 0.0 | |
| | | Present | Brucejack Access Road | 15 | |
| | Long Lake Hydroelectric | | 15 | 0.2 | |
| Floodplain/Riparian Ecosystem Total | | | 225 | 2.8 | 8,174 |
| Forested Ecosystem | Future | Brucejack Mine Site | 23 | 0.0 | |
| | | Granduc Copper Mine | 20 | 0.0 | |
| | | KSM | 3,609 | 2.5 | |
| | Historic | Granduc Mine (Past Producer) | 4 | 0.0 | |
| | | Present | Brucejack Access Road | 154 | |
| | Long Lake Hydroelectric | | 232 | 0.2 | |
| | Northwest Transmission Line | 8 | 0.0 | | |
| Forested Ecosystem Total | | | 4,051 | 2.8 | 145,196 |
| Grand Total | | | 5,769 | | 310,228 |

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|-----------------------|---------------|-----------|---------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Brucejack Access Road | Mining | Present | BAFAunp | 00 | AM | Mesic Herb | Herb (H) | 0.2 | 0.0 | 1,103.5 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 18.1 | 0.1 | 27,089.7 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.5 | 0.1 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 1.0 | 0.0 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 0.0 | 0.0 | 66,606.8 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 0.5 | 0.0 | 2,503.0 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 6.2 | 0.2 | 3,936.6 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 3.2 | 0.2 | 1,712.6 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.2 | 0.1 | 341.8 |
| Brucejack Mine Site | | | | | RO | Sparsely Vegetated | Sparse/bryoid (NS) | 40.5 | 2.1 | 17,089.7 |
| | | | | | MP | Mesic Herb | Herb (H) | 3.5 | 0.2 | 1,563.3 |
| | | | | | AM | Mesic Herb | Herb (H) | 10.0 | 0.9 | 1,103.5 |
| | | | | | CL | Sparsely Vegetated | Sparse/bryoid (NS) | 2.0 | 0.0 | 96.0 |
| | | | | | TA | Sparsely Vegetated | Sparse/bryoid (NS) | 0.5 | 0.0 | 89.0 |
| Forestry | Forestry | Present | BAFAunp | 00 | AM | Mesic Herb | Herb (H) | 9.3 | 0.8 | 1,103.5 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 590.0 | 2.2 | 27,089.7 |
| | | | | | DH | Drier Herb | Herb (H) | 0.8 | 0.2 | 406.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 25.8 | 3.7 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 205.1 | 1.2 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 70.9 | 0.1 | 66,606.8 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 51.4 | 2.1 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 123.7 | 3.7 | 3,342.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 166.8 | 4.2 | 3,936.6 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 96.1 | 5.6 | 1,712.6 |
| | | | | | VW | Wetter Herb | Herb (H) | 11.6 | 3.4 | 341.8 |

(continued)

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|----------------------|----------------------|---------------------|---------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Forestry (cont'd) | Forestry (cont'd) | Present (cont'd) | CMAunp | 00 | AM | Mesic Herb | Herb (H) | 4.5 | 1.3 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 199.1 | 1.4 | 13,781.1 |
| | | | | | DH | Drier Herb | Herb (H) | 0.8 | 0.4 | 191.4 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 6.0 | 0.9 | 684.1 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 81.5 | 0.9 | 9,086.5 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 12.0 | 0.6 | 2,115.8 |
| | | | | | MP | Mesic Herb | Herb (H) | 3.5 | 0.2 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 30.9 | 1.1 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 14.6 | 1.1 | 1,349.0 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.1 | 0.1 | 91.7 |
| Goldwedge | Mining | Historic | CMAunp | 00 | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 12.0 | 0.1 | 1,3781.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.2 | 0.0 | 684.1 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 1.0 | 0.0 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.5 | 0.0 | 1,349.0 |
| Granduc Copper Mine | Mining | Future | BAFAunp | 00 | AM | Mesic Herb | Herb (H) | 1.2 | 0.1 | 1,103.5 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 15.4 | 0.1 | 27,089.7 |
| | | | | | DH | Drier Herb | Herb (H) | 0.5 | 0.1 | 406.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.2 | 0.0 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 8.5 | 0.1 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 0.0 | 0.0 | 66,606.8 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 11.7 | 0.5 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 21.6 | 0.6 | 3,342.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 3,936.6 |
| VW | Wetter Herb | Herb (H) | 0.2 | 0.1 | 341.8 | | | | | |

(continued)

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|---------------------------------|---------------|-----------|---------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Granduc Mine (Past Producer) | Mining | Historic | BAFAunp | 00 | AM | Mesic Herb | Herb (H) | 5.6 | 0.5 | 1,103.5 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 19.2 | 0.1 | 27,089.7 |
| | | | | | DH | Drier Herb | Herb (H) | 4.4 | 1.1 | 406.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 2.6 | 0.4 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 22.3 | 0.1 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 0.0 | 0.0 | 66,606.8 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 55.6 | 2.2 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 54.0 | 1.6 | 3,342.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 2.1 | 0.1 | 3,936.6 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.5 | 0.0 | 1,712.6 |
| | | | CMAunp | 00 | VW | Wetter Herb | Herb (H) | 2.0 | 0.6 | 341.8 |
| | | | | | AM | Mesic Herb | Herb (H) | 7.4 | 2.1 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 7.5 | 0.1 | 13,781.1 |
| | | | | | DH | Drier Herb | Herb (H) | 6.9 | 3.6 | 191.4 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 10.4 | 1.5 | 684.1 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 25.9 | 0.3 | 9,086.5 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 123.9 | 5.9 | 2,115.8 |
| | | | | | MP | Mesic Herb | Herb (H) | 48.5 | 3.1 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 13.8 | 0.5 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 1.5 | 0.1 | 1,349.0 |
| VW | Wetter Herb | Herb (H) | 1.1 | 1.2 | 91.7 | | | | | |
| KSM | Mining | Future | BAFAunp | 00 | AM | Mesic Herb | Herb (H) | 0.8 | 0.1 | 1,103.5 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 5.1 | 0.0 | 27,089.7 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 3.5 | 0.5 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 2.4 | 0.0 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 0.3 | 0.0 | 66,606.8 |

(continued)

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|--|-----------------|-----------------|------------------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | BAFAunp (cont'd) | 00 (cont'd) | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 21.1 | 0.8 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 4.1 | 0.1 | 3,342.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 39.0 | 1.0 | 3,936.6 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 19.1 | 1.1 | 1,712.6 |
| | | | | | VW | Wetter Herb | Herb (H) | 1.1 | 0.3 | 341.8 |
| | | | CMAunp | 00 | AM | Mesic Herb | Herb (H) | 25.9 | 7.2 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 449.4 | 3.3 | 13,781.1 |
| | | | | | DH | Drier Herb | Herb (H) | 0.6 | 0.3 | 191.4 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 10.2 | 1.5 | 684.1 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 148.9 | 1.6 | 9,086.5 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 92.8 | 4.4 | 2,115.8 |
| | | | | | MP | Mesic Herb | Herb (H) | 14.2 | 0.9 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 132.6 | 4.5 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 42.0 | 3.1 | 1,349.0 |
| | | | | | VW | Wetter Herb | Herb (H) | 2.3 | 2.5 | 91.7 |
| Snowfield Exploration Project | Mining | Historic | CMAunp | 00 | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 7.6 | 0.1 | 13,781.1 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.1 | 0.0 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 1,349.0 |
| Sulphurets Advanced Exploration Project | Mining | Historic | CMAunp | 00 | AM | Mesic Herb | Herb (H) | 0.0 | 0.0 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 21.3 | 0.2 | 13,781.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.2 | 0.0 | 684.1 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 0.9 | 0.0 | 9,086.5 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 0.5 | 0.0 | 2,115.8 |
| | | | | | MP | Mesic Herb | Herb (H) | 0.3 | 0.0 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 2.7 | 0.1 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 3.9 | 0.3 | 1,349.0 |
| VW | Wetter Herb | Herb (H) | 0.1 | 0.1 | 91.7 | | | | | |

(continued)

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|--|------------------|-----------------|---------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Brucejack Transmission Line (unforested) | Mining | Future | BAFAunp | 00 | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 9.8 | 0.0 | 27,089.7 |
| | | | | | DH | Drier Herb | Herb (H) | 0.0 | 0.0 | 406.1 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 701.0 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 3.8 | 0.0 | 16,952.0 |
| | | | | | GI | Non-vegetated | n/a | 29.5 | 0.0 | 66,606.8 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 6.5 | 0.3 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 8.4 | 0.3 | 3,342.9 |
| | | | CMAunp | 00 | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.4 | 0.0 | 3,936.6 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 1,712.6 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.0 | 0.0 | 341.8 |
| | | | | | AM | Mesic Herb | Herb (H) | 0.1 | 0.0 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 6.1 | 0.0 | 13,781.1 |
| | | | | | DH | Drier Herb | Herb (H) | 0.9 | 0.5 | 191.4 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 4.2 | 0.0 | 9,086.5 |
| | | | | | MP | Mesic Herb | Herb (H) | 9.3 | 0.6 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 2,939.0 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.1 | 0.1 | 91.7 |
| Brucejack Transmission Line (forested) | Mining | Future | BAFAunp | 00 | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 0.0 | 0.0 | 27,089.7 |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 701.0 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 2.0 | 0.1 | 2,503.0 |
| | | | | | MP | Mesic Herb | Herb (H) | 2.7 | 0.1 | 3,342.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 2.4 | 0.1 | 3,936.6 |
| | | | CMAunp | 00 | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.6 | 0.0 | 1,712.6 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.0 | 0.0 | 341.8 |
| | | | | | AM | Mesic Herb | Herb (H) | 0.4 | 0.1 | 358.4 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 1.1 | 0.0 | 13,781.1 |
| | | | | | DH | Drier Herb | Herb (H) | 0.5 | 0.3 | 191.4 |
| DS | Drier Shrub/Herb | Shrub/Herb (SH) | 1.1 | 0.2 | 684.1 | | | | | |

(continued)

Table 16.10-4a. Cumulative Loss of Alpine Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|---|-----------------|-----------------|-----------------|-------------|----------|-------------------------------|--------------------|----------------|---------------|-------------------------------|
| Brucejack Transmission Line (forested) (cont'd) | Mining (cont'd) | Future (cont'd) | CMAunp (cont'd) | 00 (cont'd) | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 1.5 | 0.0 | 9,086.5 |
| | | | | | KH | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 12.6 | 0.6 | 2,115.8 |
| | | | | | MP | Mesic Herb | Herb (H) | 2.8 | 0.2 | 1,563.3 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 1.6 | 0.1 | 2,939.0 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.3 | 0.0 | 1,349.0 |
| | | | | | VW | Wetter Herb | Herb (H) | 0.2 | 0 | 91.7 |

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|---------------------|---------------|---------------|----------------------|-------------|----------|--------------------|--------------------|----------------------|---------------|-------------------------------|----------|
| Brucejack Mine Site | Mining | Future | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 0.1 | 0.0 | 1,592.4 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 1.7 | 0.0 | 10,708.2 | |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 0.0 | 0.0 | 7,671.3 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 16.6 | 0.2 | 6,899.9 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 3.2 | 0.1 | 3,355.8 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 1.2 | 0.0 | 2,585.5 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 1.1 | 0.0 | 20,731.6 |
| | | | | | 02 | LC | Drier Forest | Mature to Old Forest | 0.1 | 0.0 | 512.1 |
| | | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 0.0 | 0.0 | 2,002.3 |
| 05 | FO | Mesic Forest | Mature to Old Forest | 0.1 | 0.0 | 2,423.5 | | | | | |
| 08 | FH | Wetter Forest | Mature to Old Forest | 0.1 | 0.0 | 1,376.3 | | | | | |
| Existing Road | Mining | Present | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 0.5 | 0.0 | 1,592.4 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 37.8 | 0.4 | 10,708.2 | |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 1.7 | 0.0 | 7,671.3 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 56.6 | 0.8 | 6,899.9 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 0.4 | 0.0 | 2,878.0 | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|---------------------------|--------------------|---------------------|--------------------|----------------|--------------------|----------------------|----------------------|----------------|---------------|-------------------------------|-------|
| Existing Road (cont'd) | Mining (cont'd) | Present (cont'd) | ESSFwv (cont'd) | 00 (cont'd) | GTm | Avalanche Track | Herb (H) | 0.2 | 0.0 | 1,316.1 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 0.1 | 0.0 | 1,554.9 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 31.3 | 0.9 | 3,355.8 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 12.1 | 0.5 | 2,585.5 | |
| | | | | | VW | Wetter Herb | Herb (H) | 0.1 | 0.1 | 142.2 | |
| | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 244.8 | 1.2 | 20,731.6 | |
| | | | | 02 | LC | Drier Forest | Mature to Old Forest | 1.3 | 0.2 | 512.1 | |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest | 1.5 | 0.5 | 297.2 | |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 11.0 | 0.5 | 2,002.3 | |
| | | | | 05 | FO | Mesic Forest | Mature to Old Forest | 54.8 | 2.3 | 2,423.5 | |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest | 41.7 | 3.0 | 1,376.3 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (H) | 3.2 | 1.2 | 275.9 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 22.4 | 0.8 | 2,822.1 | |
| | | | | | AVs | Avalanche Track | Shrub/Herb (SH) | 1.1 | 0.1 | 866.7 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 69.8 | 7.2 | 969.1 | |
| | | | DH | | Drier Herb | Herb (H) | 0.1 | 1.3 | 6.9 | | |
| | | | DS | | Drier Shrub/Herb | Shrub/Herb (SH) | 1.8 | 1.4 | 127.6 | | |
| | | | ET | | Sparsely Vegetated | Sparse/bryoid (NS) | 6.2 | 2.9 | 215.0 | | |
| | | | GTm | | Avalanche Track | Herb (H) | 8.0 | 2.4 | 336.0 | | |
| | | | GTs | | Avalanche Track | Herb (H) | 3.0 | 0.7 | 403.6 | | |
| | | | GW | | Wetland Shrub/Herb | Herb (H) | 2.6 | 2.1 | 124.0 | | |
| | | | VF | | Mesic Shrub/Herb | Shrub/Herb (SH) | 48.4 | 0.6 | 8,460.5 | | |
| | | | VS | | Wetter Shrub/Herb | Shrub/Herb (SH) | 19.4 | 0.6 | 3,107.0 | | |
| | | | VW | | Wetter Herb | Herb (H) | 8.9 | 1.7 | 532.6 | | |
| | | | 01 | | HD | Mesic Forest | Mature to Old Forest | 127.5 | 0.9 | 14,943.1 | |
| | | | 02 | | HM | Drier Forest | Mature to Old Forest | 5.1 | 1.0 | 537.2 | |
| | | | 03 | SD | Moist Forest | Mature to Old Forest | 52.7 | 1.1 | 4,824.6 | | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|--------------|---------------|-----------|--------------------|-------------|--------------------|-------------------------------|----------------------|----------------------|---------------|-------------------------------|----------|
| Forestry | Forestry | Historic | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 0.1 | 0.0 | 1,592.4 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 0.1 | 0.0 | 10,708.2 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 0.1 | 0.0 | 6,899.9 | |
| | | | | | PK | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 0.1 | 0.0 | 1,389.6 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.0 | 0.0 | 3,355.8 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 0.1 | 0.0 | 20,731.6 |
| | | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 0.1 | 0.0 | 2,002.3 |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest | 0.1 | 0.0 | 1,376.3 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (H) | 169.4 | 61.4 | 275.9 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 86.3 | 3.1 | 2,822.1 | |
| | | | | | AVs | Avalanche Track | Shrub/Herb (SH) | 11.5 | 1.3 | 866.7 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 125.9 | 13.0 | 969.1 | |
| | | | | | DH | Drier Herb | Herb (H) | 2.7 | 39.4 | 6.9 | |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 41.4 | 32.4 | 127.6 | |
| | | ET | Sparsely Vegetated | | Sparse/bryoid (NS) | 1.6 | 0.8 | 215.0 | | | |
| | | GTm | Avalanche Track | | Herb (H) | 2.4 | 0.7 | 336.0 | | | |
| | | GTs | Avalanche Track | | Herb (H) | 0.4 | 0.1 | 403.6 | | | |
| | | GW | Wetland Shrub/Herb | | Herb (H) | 36.8 | 29.7 | 124.0 | | | |
| | | VF | Mesic Shrub/Herb | | Shrub/Herb (SH) | 2655.1 | 31.4 | 8,460.5 | | | |
| | | VS | Wetter Shrub/Herb | | Shrub/Herb (SH) | 732.4 | 23.6 | 3,107.0 | | | |
| | | VW | Wetter Herb | | Herb (H) | 217.7 | 40.9 | 532.6 | | | |
| | | Present | ESSFwv | 00 | 01 | HD | Mesic Forest | Mature to Old Forest | 369.1 | 2.5 | 14,943.1 |
| | | | | | 02 | HM | Drier Forest | Mature to Old Forest | 3.8 | 0.7 | 537.2 |
| | | | | | 03 | SD | Moist Forest | Mature to Old Forest | 256.9 | 5.3 | 4,824.6 |
| | | | | | AM | Mesic Herb | Herb (H) | 8.2 | 0.5 | 1,592.4 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 753.7 | 7.0 | 10,708.2 | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|----------------------|----------------------|---------------------|--------------------|----------------|----------|-------------------------------|----------------------|----------------------|---------------|-------------------------------|----------|
| Forestry (cont'd) | Forestry (cont'd) | Present (cont'd) | ESSFwv (cont'd) | 00 (cont'd) | Avs | Avalanche Track | Shrub/Herb (SH) | 139.3 | 1.8 | 7,671.3 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 141.4 | 2.0 | 6,899.9 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 8.1 | 0.3 | 2,878.0 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 15.4 | 1.2 | 1,316.1 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 4.6 | 0.3 | 1,554.9 | |
| | | | | | MP | Mesic Herb | Herb (H) | 44.5 | 4.0 | 1,103.7 | |
| | | | | | PK | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 93.5 | 6.7 | 1,389.6 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 496.1 | 14.8 | 3,355.8 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 232.5 | 9.0 | 2,585.5 | |
| | | | | | VW | Wetter Herb | Herb (H) | 3.5 | 2.5 | 142.2 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 2265.1 | 10.9 | 20,731.6 |
| | | | | | 02 | LC | Drier Forest | Mature to Old Forest | 27.7 | 5.4 | 512.1 |
| | | | | | 03 | FF | Drier Forest | Mature to Old Forest | 12.3 | 4.1 | 297.2 |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 161.2 | 8.1 | 2,002.3 | |
| | | | | 05 | FO | Mesic Forest | Mature to Old Forest | 400.4 | 16.5 | 2,423.5 | |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest | 329.9 | 24.0 | 1,376.3 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (H) | 3.3 | 1.2 | 275.9 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 190.8 | 6.8 | 2,822.1 | |
| | | | | | AVs | Avalanche Track | Shrub/Herb (SH) | 37.8 | 4.4 | 866.7 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 27.9 | 2.9 | 969.1 | |
| | | | | | DH | Drier Herb | Herb (H) | 0.0 | 0.6 | 6.9 | |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 1.7 | 1.4 | 127.6 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 5.7 | 2.7 | 215.0 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 20.0 | 6.0 | 336.0 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 7.9 | 2.0 | 403.6 | |
| | | | | | GW | Wetland Shrub/Herb | Herb (H) | 0.9 | 0.7 | 124.0 | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | | |
|----------------------|----------------------|---------------------|-------------------|-------------|----------|-------------------|-------------------------------|--------------------|----------------------|-------------------------------|---------|----------|
| Forestry (cont'd) | Forestry (cont'd) | Present (cont'd) | ICHvc (cont'd) | 00 | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 133.8 | 1.6 | 8,460.5 | | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 94.6 | 3.0 | 3,107.0 | | |
| | | | | | VW | Wetter Herb | Herb (H) | 8.4 | 1.6 | 532.6 | | |
| | | | | MHmm2 | 00 | 01 | HD | Mesic Forest | Mature to Old Forest | 1034.4 | 6.9 | 14,943.1 |
| | | | | | | 02 | HM | Drier Forest | Mature to Old Forest | 62.4 | 11.6 | 537.2 |
| | | | | | | 03 | SD | Moist Forest | Mature to Old Forest | 297.2 | 6.2 | 4,824.6 |
| | | | | | | AM | Mesic Herb | Herb (H) | 0.8 | 1.3 | 60.5 | |
| | | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 28.9 | 0.8 | 3,745.5 | |
| | | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 109.5 | 2.4 | 4,471.9 | |
| | | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 3.8 | 2.3 | 166.7 | |
| | | | | | | DH | Drier Herb | Herb (H) | 0.4 | 1.1 | 33.2 | |
| | | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 2.5 | 1.0 | 249.1 | |
| | | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 101.6 | 2.5 | 4,102.5 | |
| | | | | | | GTm | Avalanche Track | Herb (H) | 5.0 | 2.6 | 191.3 | |
| | | | | | | GTs | Avalanche Track | Herb (H) | 21.0 | 5.1 | 410.4 | |
| | | | | | | MP | Mesic Herb | Herb (H) | 37.8 | 2.7 | 1,391.7 | |
| | | | | | | PK | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 20.4 | 3.7 | 546.9 | |
| | | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 3.5 | 0.8 | 435.5 | |
| | | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 1.6 | 0.2 | 848.5 | |
| | | | | | | VW | Wetter Herb | Herb (H) | 0.7 | 2.0 | 37.6 | |
| | | | | | | 01 | MB | Mesic Forest | Mature to Old Forest | 63.8 | 1.0 | 6,563.6 |
| | | | | 02 | MM | Drier Forest | Mature to Old Forest | 2.5 | 0.6 | 393.8 | | |
| | | | | 03 | MO | Mesic Forest | Mature to Old Forest | 4.8 | 0.2 | 2,110.5 | | |
| | | | | 04 | AB | Moist Forest | Mature to Old Forest | 9.1 | 2.1 | 435.9 | | |
| | | | | 05 | MT | Moist Forest | Mature to Old Forest | 4.1 | 0.3 | 1,461.8 | | |
| | | | | 06 | MD | Wetter Forest | Mature to Old Forest | 3.9 | 0.7 | 567.7 | | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|------------------------------|---------------|---------------|----------------------|----------------------|----------|--------------------|----------------------|----------------------|---------------|-------------------------------|----------|
| Granduc Copper Mine | Mining | Future | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 1.8 | 0.1 | 1,592.4 | |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 0.0 | 0.0 | 7,671.3 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 3.3 | 0.0 | 6,899.9 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 2.2 | 0.1 | 2,878.0 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 0.1 | 0.0 | 1,316.1 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 0.6 | 0.0 | 1,554.9 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.3 | 0.0 | 3,355.8 | |
| | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 0.0 | 0.0 | 20,731.6 | |
| | 04 | MH | Mesic Forest | Mature to Old Forest | 0.0 | 0.0 | 2,002.3 | | | | |
| Granduc Mine (Past Producer) | Mining | Historic | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 23.7 | 1.5 | 1,592.4 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 5.5 | 0.1 | 10,708.2 | |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 2.0 | 0.0 | 7,671.3 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 8.0 | 0.1 | 6,899.9 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 2.2 | 0.1 | 2,878.0 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 2.7 | 0.2 | 1,316.1 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 1.9 | 0.1 | 1,554.9 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 10.2 | 0.3 | 3,355.8 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.6 | 0.0 | 2,585.5 | |
| | | | | | VW | Wetter Herb | Herb (H) | 0.1 | 0.1 | 142.2 | |
| | | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 1.8 | 0.0 | 20,731.6 |
| | | | | | 02 | LC | Drier Forest | Mature to Old Forest | 0.5 | 0.1 | 512.1 |
| | | | | | 03 | FF | Drier Forest | Mature to Old Forest | 0.2 | 0.1 | 297.2 |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 4.5 | 0.2 | 2,002.3 | |
| 05 | FO | Mesic Forest | Mature to Old Forest | 0.0 | 0.0 | 2,423.5 | | | | | |
| 08 | FH | Wetter Forest | Mature to Old Forest | 0.0 | 0.0 | 1,376.3 | | | | | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|--------------|---------------|-----------|-------|-------------|----------|-------------------------------|----------------------|----------------------|---------------|-------------------------------|----------|
| KSM | Mining | Future | CWHwm | 00 | Avs | Avalanche Track | Shrub/Herb (SH) | 34.8 | 2.9 | 1,201.0 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 3.3 | 1.4 | 241.9 | |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.4 | 1.6 | 22.9 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 1.0 | 4.0 | 24.1 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 0.8 | 1.4 | 57.0 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 9.4 | 2.9 | 325.2 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 5.9 | 3.6 | 163.2 | |
| | | | | | VW | Wetter Herb | Herb (H) | 0.2 | 3.0 | 5.3 | |
| | | | | 01/03 | HB/SO | Mesic Forest | Mature to Old Forest | 210.2 | 3.7 | 5,744.9 | |
| | | | | 02 | HM | Drier Forest | Mature to Old Forest | 10.7 | 2.3 | 457.3 | |
| | | | | 04 | SD | Moist Forest | Mature to Old Forest | 53.3 | 3.8 | 1,393.2 | |
| | | | | 06 | CD | Floodplain Forest | Mature to Old Forest | 1.2 | 2.7 | 46.3 | |
| | | | | 08 | HS | Wetter Forest | Mature to Old Forest | 7.4 | 3.8 | 194.8 | |
| | | | | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 8.4 | 0.5 | 1,592.4 |
| | | | Avm | | | Avalanche Track | Shrub/Herb (SH) | 414.6 | 3.9 | 10,708.2 | |
| | | | Avs | | | Avalanche Track | Shrub/Herb (SH) | 105.9 | 1.4 | 7,671.3 | |
| | | | BA | | | Sparsely Vegetated | Sparse/bryoid (NS) | 61.9 | 0.9 | 6,899.9 | |
| | | | ET | | | Sparsely Vegetated | Sparse/bryoid (NS) | 5.3 | 0.2 | 2,878.0 | |
| | | | GTm | | | Avalanche Track | Herb (H) | 13.7 | 1.0 | 1,316.1 | |
| | | | GTs | | | Avalanche Track | Herb (H) | 2.7 | 0.2 | 1,554.9 | |
| | | | MP | | | Mesic Herb | Herb (H) | 3.9 | 0.4 | 1,103.7 | |
| | | | PK | | | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 32.7 | 2.4 | 1,389.6 | |
| | | | VF | | | Mesic Shrub/Herb | Shrub/Herb (SH) | 90.2 | 2.7 | 3,355.8 | |
| | | | VS | | | Wetter Shrub/Herb | Shrub/Herb (SH) | 169.5 | 6.6 | 2,585.5 | |
| | | | VW | | | Wetter Herb | Herb (H) | 7.9 | 5.6 | 142.2 | |
| | | | 01 | | | FA | Mesic Forest | Mature to Old Forest | 693.2 | 3.3 | 20,731.6 |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|--------------|-----------------|-----------------|-----------------|-------------|--------------------|--------------------|----------------------|----------------------|---------------|-------------------------------|----------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | ESSFvw (cont'd) | 02 | LC | Drier Forest | Mature to Old Forest | 17.1 | 3.3 | 512.1 | |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest | 12.1 | 4.1 | 297.2 | |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 23.8 | 1.2 | 2,002.3 | |
| | | | | 05 | FO | Mesic Forest | Mature to Old Forest | 119.1 | 4.9 | 2,423.5 | |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest | 40.2 | 2.9 | 1,376.3 | |
| | | | | ICHvc | 00 | AM | Mesic Herb | Herb (H) | 0.3 | 0.1 | 275.9 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 21.7 | 0.8 | 2,822.1 | |
| | | | | | AVs | Avalanche Track | Shrub/Herb (SH) | 6.0 | 0.7 | 866.7 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 7.8 | 0.8 | 969.1 | |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 0.1 | 0.1 | 127.6 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 0.1 | 0.0 | 215.0 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 4.4 | 1.3 | 336.0 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 3.2 | 0.8 | 403.6 | |
| | | | | | GW | Wetland Shrub/Herb | Herb (H) | 0.3 | 0.2 | 124.0 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 58.0 | 0.7 | 8,460.5 | |
| | | | VS | | Wetter Shrub/Herb | Shrub/Herb (SH) | 39.3 | 1.3 | 3,107.0 | | |
| | | | VW | | Wetter Herb | Herb (H) | 3.4 | 0.6 | 532.6 | | |
| | | | MHmm2 | | 01 | HD | Mesic Forest | Mature to Old Forest | 142.4 | 1.0 | 14,943.1 |
| | | | | | 02 | HM | Drier Forest | Mature to Old Forest | 7.0 | 1.3 | 537.2 |
| | | | | | 03 | SD | Moist Forest | Mature to Old Forest | 54.9 | 1.1 | 4,824.6 |
| | | | | 00 | AM | Mesic Herb | Herb (H) | 3.1 | 5.1 | 60.5 | |
| | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 186.1 | 5.0 | 3,745.5 | | |
| | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 226.1 | 5.1 | 4,471.9 | | |
| | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 14.0 | 8.4 | 166.7 | | |
| | | | | DH | Drier Herb | Herb (H) | 0.2 | 0.6 | 33.2 | | |
| | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 3.5 | 1.4 | 249.1 | | |
| | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 109.7 | 2.7 | 4,102.5 | | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | |
|-------------------------|-----------------|-----------------|----------------|-------------|----------|-------------------------------|--------------------|----------------------|---------------|-------------------------------|---------|
| KSM (cont'd) | Mining (cont'd) | Future (cont'd) | MHmm2 (cont'd) | 00 (cont'd) | GTm | Avalanche Track | Herb (H) | 20.6 | 10.7 | 191.3 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 28.8 | 7.0 | 410.4 | |
| | | | | | MP | Mesic Herb | Herb (H) | 35.1 | 2.5 | 1,391.7 | |
| | | | | | PK | Parkland Forest/ Krummholz | Shrub/Herb (SH) | 84.1 | 15.4 | 546.9 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 20.3 | 4.7 | 435.5 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 24.1 | 2.8 | 848.5 | |
| | | | | | VW | Wetter Herb | Herb (H) | 1.0 | 2.6 | 37.6 | |
| | | | | | 01 | MB | Mesic Forest | Mature to Old Forest | 591.2 | 9.0 | 6,563.6 |
| | | | | | 02 | MM | Drier Forest | Mature to Old Forest | 18.9 | 4.8 | 393.8 |
| | | | | | 03 | MO | Mesic Forest | Mature to Old Forest | 116.4 | 5.5 | 2,110.5 |
| | | | | | 04 | AB | Moist Forest | Mature to Old Forest | 25.8 | 5.9 | 435.9 |
| | | | | | 05 | MT | Moist Forest | Mature to Old Forest | 82.2 | 5.6 | 1,461.8 |
| | | | | | 06 | MD | Wetter Forest | Mature to Old Forest | 54.9 | 9.7 | 567.7 |
| Long Lake Hydroelectric | Hydro-electric | Present | MHmm2 | 00 | AM | Mesic Herb | Herb (H) | 8.7 | 14.4 | 60.5 | |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 4.2 | 0.1 | 3,745.5 | |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 13.7 | 0.3 | 4,471.9 | |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 22.9 | 13.7 | 166.7 | |
| | | | | | DH | Drier Herb | Herb (H) | 0.3 | 1.0 | 33.2 | |
| | | | | | DS | Drier Shrub/Herb | Shrub/Herb (SH) | 1.6 | 0.6 | 249.1 | |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 25.0 | 0.6 | 4,102.5 | |
| | | | | | GTm | Avalanche Track | Herb (H) | 1.3 | 0.7 | 191.3 | |
| | | | | | GTs | Avalanche Track | Herb (H) | 4.0 | 1.0 | 410.4 | |
| | | | | | MP | Mesic Herb | Herb (H) | 83.6 | 6.0 | 1,391.7 | |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 5.7 | 1.3 | 435.5 | |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 2.5 | 0.3 | 848.5 | |
| | | | | | VW | Wetter Herb | Herb (H) | 2.1 | 5.5 | 37.6 | |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|--|-------------------------|------------------|----------------------|-------------|-------------|--------------------|----------------------|----------------|---------------|-------------------------------|
| Long Lake Hydroelectric (cont'd) | Hydro-electric (cont'd) | Present (cont'd) | MHmm2 (cont'd) | 01 | MB | Mesic Forest | Mature to Old Forest | 31.2 | 0.5 | 6,563.6 |
| | | | | 02 | MM | Drier Forest | Mature to Old Forest | 2.6 | 0.7 | 393.8 |
| | | | | 04 | AB | Moist Forest | Mature to Old Forest | 13.4 | 3.1 | 435.9 |
| | | | | 05 | MT | Moist Forest | Mature to Old Forest | 1.1 | 0.1 | 1,461.8 |
| | | | | 06 | MD | Wetter Forest | Mature to Old Forest | 8.1 | 1.4 | 567.7 |
| Northwest Transmission Line | Electrical Transmission | Present | ICHvc | 00 | AM | Mesic Herb | Herb (H) | 0.0 | 0.0 | 275.9 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 2.5 | 0.1 | 2,822.1 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 0.2 | 0.0 | 969.1 |
| | | | | | GTm | Avalanche Track | Herb (H) | 1.2 | 0.4 | 336.0 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 0.2 | 0.0 | 8,460.5 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 0.5 | 0.0 | 3,107.0 |
| | | | | VW | Wetter Herb | Herb (H) | 0.4 | 0.1 | 532.6 | |
| | | | | 01 | HD | Mesic Forest | Mature to Old Forest | 1.9 | 0.0 | 14,943.1 |
| 03 | SD | Moist Forest | Mature to Old Forest | 0.5 | 0.0 | 4,824.6 | | | | |
| Brucejack Transmission Line (forested) | Mining | Future | ESSFwv | 00 | AM | Mesic Herb | Herb (H) | 8.4 | 0.5 | 1,592.4 |
| | | | | | Avm | Avalanche Track | Shrub/Herb (SH) | 14.3 | 0.1 | 10,708.2 |
| | | | | | Avs | Avalanche Track | Shrub/Herb (SH) | 5.0 | 0.1 | 7,671.3 |
| | | | | | BA | Sparsely Vegetated | Sparse/bryoid (NS) | 4.3 | 0.1 | 6,899.9 |
| | | | | | ET | Sparsely Vegetated | Sparse/bryoid (NS) | 2.6 | 0.1 | 2,878.0 |
| | | | | | GTm | Avalanche Track | Herb (H) | 0.4 | 0.0 | 1,316.1 |
| | | | | | GTs | Avalanche Track | Herb (H) | 1.3 | 0.1 | 1,554.9 |
| | | | | | VF | Mesic Shrub/Herb | Shrub/Herb (SH) | 5.5 | 0.2 | 3,355.8 |
| | | | | | VS | Wetter Shrub/Herb | Shrub/Herb (SH) | 4.0 | 0.2 | 2,585.5 |
| | | | | 01 | FA | Mesic Forest | Mature to Old Forest | 21.9 | 0.1 | 20,731.6 |
| | | | | 02 | LC | Drier Forest | Mature to Old Forest | 2.7 | 0.5 | 512.1 |
| | | | | 03 | FF | Drier Forest | Mature to Old Forest | 1.9 | 0.6 | 297.2 |
| | | | | 04 | MH | Mesic Forest | Mature to Old Forest | 1.5 | 0.1 | 2,002.3 |

(continued)

Table 16.10-4b. Cumulative Loss of Forested Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|---|-----------------|-----------------|-----------------|-------------|----------|-----------------|----------------------|----------------|---------------|-------------------------------|
| Brucejack Transmission Line (forested) (cont'd) | Mining (cont'd) | Future (cont'd) | ESSFwv (cont'd) | 05 | FO | Mesic Forest | Mature to Old Forest | 1.8 | 0.1 | 2,423.5 |
| | | | | 08 | FH | Wetter Forest | Mature to Old Forest | 0.5 | 0.0 | 1,376.3 |
| | | | MHmm2 | 00 | AM | Mesic Herb | Herb (H) | 0.0 | 0.1 | 60.5 |
| | | | | | DH | Drier Herb | Herb (H) | 0.0 | 0.0 | 33.2 |
| | | | | | GTs | Avalanche Track | Herb (H) | 0.1 | 0.0 | 410.4 |
| | | | | | MP | Mesic Herb | Herb (H) | 0.1 | 0.0 | 1,391.7 |
| | | | | 01 | MB | Mesic Forest | Mature to Old Forest | 4.8 | 0.1 | 6,563.6 |
| | | | | 02 | MM | Drier Forest | Mature to Old Forest | 1.0 | 0.3 | 393.8 |
| | | | | 04 | AB | Moist Forest | Mature to Old Forest | 0.2 | 0.0 | 435.9 |
| | | | | 05 | MT | Moist Forest | Mature to Old Forest | 0.0 | 0.0 | 1,461.8 |
| | | | | 06 | MD | Wetter Forest | Mature to Old Forest | 0.0 | 0.0 | 567.7 |

Table 16.10-4c. Cumulative Loss of Floodplain Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|---------------------|---------------|-----------|----------------|----------------------|----------|-------------------|----------------------|--------------------|---------------|-------------------------------|
| Brucejack Mine Site | Mining | Future | ESSFwv | 09 | FL | Wetland Forest | Mature to Old Forest | 0.5 | 0.2 | 277.4 |
| Existing Road | Mining | Present | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 8.8 | 0.4 | 1,974.7 |
| | | | | 09 | FL | Wetland Forest | Mature to Old Forest | 7.3 | 2.6 | 277.4 |
| | | | ICHvc | 04/05 | DD/CD | Floodplain Forest | Mature Forest (MF) | 64.8 | 2.0 | 3,206.4 |
| | | | | | DD/CD | Floodplain Forest | Mature to Old Forest | 4.6 | 0.1 | 3,206.4 |
| | | | | | DD/CD | Floodplain Forest | Young Forest (YF) | 9.5 | 0.3 | 3,206.4 |
| | 06 | SH | Wetland Forest | Mature to Old Forest | 2.7 | 0.4 | 695.5 | | | |
| Forestry | Forestry | Historic | ESSFwv | 09 | FL | Wetland Forest | Mature to Old Forest | 0.6 | 0.2 | 277.4 |
| | | | | ICHvc | 04/05 | DD/CD | Floodplain Forest | Mature Forest (MF) | 2.0 | 0.1 |
| | | | | | | Floodplain Forest | Mature to Old Forest | 69.0 | 2.2 | 3,206.4 |

(continued)

Table 16.10-4c. Cumulative Loss of Floodplain Ecosystems by Project within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) | | | |
|---------------------------------|----------------------|----------------------|----------------------|-------------|-------------------|----------------------|----------------------|----------------------|----------------------|-------------------------------|----------------------|---------|-------|
| Forestry (cont'd) | Forestry (cont'd) | Historic (cont'd) | ICHvc (cont'd) | 04/05 | DD/CD | Floodplain Forest | Pole/Sapling (PS) | 0.2 | 0.0 | 3,206.4 | | | |
| | | | | | | Floodplain Forest | Young Forest (YF) | 1.1 | 0.0 | 3,206.4 | | | |
| | | | | 06 | SH | Wetland Forest | Mature to Old Forest | 61.2 | 8.8 | 695.5 | | | |
| | | | | Present | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 132.1 | 6.7 | 1,974.7 | |
| | | | | | | 07 | FV | Wetter Forest | Mature to Old Forest | 15.0 | 5.7 | 262.8 | |
| | | | | | | 09 | FL | Wetland Forest | Mature to Old Forest | 67.3 | 24.3 | 277.4 | |
| | | ICHvc | 04/05 | DD /CD | Floodplain Forest | Mature Forest (MF) | 0.5 | 0.0 | 3,206.4 | | | | |
| | | | | | Floodplain Forest | Mature to Old Forest | 10.6 | 0.3 | 3,206.4 | | | | |
| | | | | | Floodplain Forest | Young Forest (YF) | 10.2 | 0.3 | 3,206.4 | | | | |
| | | | | | 06 | SH | Wetland Forest | Mature to Old Forest | 21.3 | 3.1 | 695.5 | | |
| | | | | | MHmm2 | 07 | YH | Wetter Forest | Mature to Old Forest | 4.5 | 0.5 | 930.2 | |
| | | | | | | 08/09 | YS /YC | Wetland Forest | Mature to Old Forest | 1.8 | 0.9 | 203.2 | |
| Granduc Copper Mine | Mining | Future | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 0.0 | 0.0 | 1,974.7 | | | |
| Granduc Mine (Past Producer) | Mining | Historic | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 1.4 | 0.1 | 1,974.7 | | | |
| | | | | 07 | FV | Wetter Forest | Mature to Old Forest | 0.0 | 0.0 | 262.8 | | | |
| KSM | Mining | Future | CWHwm | 05 | SS | Floodplain Forest | Mature to Old Forest | 0.7 | 1.6 | 41.9 | | | |
| | | | | 07 | CW | Floodplain Forest | Mature to Old Forest | 7.1 | 5.2 | 136.1 | | | |
| | | | | 09/10 | SC/LS | Wetland Forest | Mature to Old Forest | 3.1 | 3.2 | 96.7 | | | |
| | | | | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 31.2 | 1.6 | 1,974.7 | | |
| | | | | | | | 07 | FV | Wetter Forest | Mature to Old Forest | 14.7 | 5.6 | 262.8 |
| | | | | | | | 09 | FL | Wetland Forest | Mature to Old Forest | 9.4 | 3.4 | 277.4 |
| | | | | ICHvc | 04/05 | DD/CD | Floodplain Forest | Mature Forest (MF) | 8.6 | 0.3 | 3,206.4 | | |
| | | | | | | | Floodplain Forest | Mature to Old Forest | 5.7 | 0.2 | 3,206.4 | | |
| | | | | ICHvc | 06 | SH | Wetland Forest | Mature to Old Forest | 14.0 | 2.0 | 695.5 | | |
| | | | | | | | MHmm2 | 07 | YH | Wetter Forest | Mature to Old Forest | 54.0 | 5.8 |
| 08/09 | YS/YC | Wetland Forest | Mature to Old Forest | | | | | 46.0 | 22.7 | 203.2 | | | |

(continued)

Table 16.10-4c. Cumulative Loss of Floodplain Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Activity Type | Timeframe | BGC | Site Series | Map Code | Ecosystem | Structural Stage | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary (ha) |
|--|----------------|-----------|--------|-------------|----------|----------------|----------------------|----------------|---------------|-------------------------------|
| Long Lake Hydroelectric | Hydro-electric | Present | MHmm2 | 07 | YH | Wetter Forest | Mature to Old Forest | 4.3 | 0.5 | 930.2 |
| | | | | 08/09 | YS/YC | Wetland Forest | Mature to Old Forest | 10.6 | 5.2 | 203.2 |
| Brucejack Transmission Line (forested) | Mining | Future | ESSFwv | 06 | FD | Wetter Forest | Mature to Old Forest | 3.5 | 0.2 | 1,974.7 |
| | | | | 09 | FL | Wetland Forest | Mature to Old Forest | 0.1 | 0.0 | 277.4 |
| | | | | 07 | YH | Wetter Forest | Mature to Old Forest | 0.0 | 0.0 | 930.2 |

Table 16.10-4d. Cumulative Loss of Terrestrial Ecosystems by Project within the Cumulative Effects Assessment Boundary

| Valued Component | Project Name | Timeframe | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary |
|-------------------------------|--|-----------|----------------|---------------|--------------------------|
| Alpine Ecosystem | Granduc Copper Mine | Future | 59.4 | 0.0 | |
| | KSM | | 1,015.5 | 0.6 | |
| | Brucejack Mine Site | | 56.5 | 0.0 | |
| | Brucejack Transmission Line (unforested) | | 79.2 | 0.1 | |
| | Brucejack Transmission Line (forested) | | 29.7 | 0.0 | |
| | Goldwedge | Historic | 13.6 | 0.0 | |
| | Granduc Mine (Past Producer) | | 415.4 | 0.3 | |
| | Snowfield Exploration Project | | 7.7 | 0.0 | |
| | Sulphurets Advanced Exploration Project | | 30.0 | 0.0 | |
| | Brucejack Access Road | Present | 29.9 | 0.0 | |
| Forestry | 1,704.5 | | 1.1 | | |
| Alpine Total | | | 3,441.5 | 2.2 | 156,858.0 |
| Floodplain/Riparian Ecosystem | Brucejack Mine Site | Future | 0.5 | 0.0 | |
| | Granduc Copper Mine | | 0.0 | 0.0 | |
| | KSM | | 194.4 | 2.4 | |
| | Brucejack Transmission Line Treed | | 3.7 | 0.0 | |
| | Forestry | Historic | 134.1 | 1.6 | |
| Granduc Mine (Past Producer) | 1.5 | | 0.0 | | |

(continued)

Table 16.10-4d. Cumulative Loss of Terrestrial Ecosystems by Project within the Cumulative Effects Assessment Boundary (completed)

| Valued Component | Project Name | Timeframe | Area Loss (ha) | Area Loss (%) | Area within CEA Boundary |
|---|--|-----------|-----------------|---------------|--------------------------|
| Floodplain/Riparian Ecosystem (<i>cont'd</i>) | Brucejack Access Road | Present | 97.7 | 1.2 | |
| | Forestry | | 263.2 | 3.2 | |
| | Long Lake Hydroelectric | | 14.9 | 0.2 | |
| Floodplain/Riparian Total | | | 710.1 | 8.7 | 8,174.0 |
| Forested Ecosystem | Brucejack Mine Site | Future | 24.3 | 0.0 | |
| | Granduc Copper Mine | | 8.5 | 0.0 | |
| | KSM | | 4,155.4 | 2.9 | |
| | Brucejack Transmission Line (forested) | | 82.3 | 0.1 | |
| | Forestry | Historic | 4,714.1 | 3.2 | |
| | Granduc Mine (Past Producer) | | 63.9 | 0.0 | |
| | Brucejack Access Road | | Present | 876.3 | |
| | Forestry | 7,490.2 | | 5.2 | |
| | Long Lake Hydroelectric | 231.9 | | 0.2 | |
| | Northwest Transmission Line | 7.5 | | 0.0 | |
| Forested Total | | | 17,654.4 | 12.2 | 145,196.0 |
| Grand Total | | | 21,805.9 | 7 | 310,228.0 |

16.10.5.2 Rare Plants and Lichens

The cumulative loss of rare plants and lichens within the CEA, summarized by project, effect type, and species, is presented in Table 16.10-5. Known rare plant or lichen locations were assigned a 100 to 200 m buffer to broadly define their associated habitat. During construction of the KSM Project, six rare plants and lichens will be lost, mostly due to the construction of the operational haul road. During operations, 34 plant and/or lichen species will be removed within the Kerr Pit and 25 rare plant and lichens will be lost due to pit development, including six vascular plants, three mosses, and 16 lichens. No rare plants are expected to be directly affected by the current Brucejack Gold Mine Project design.

Table 16.10-5. Cumulative Loss of Rare Plants and Lichens within the Cumulative Effects Assessment Boundary

| Project Name | Effect Type | Lifeform Type | Species Name | BC CDC Rank | NatureServe S Rank | NatureServe G Rank |
|--------------|-----------------------------------|----------------|--|-------------|--------------------|--------------------|
| KSM | Loss | Vascular Plant | <i>Carex praeceptorum</i> | Red | S1S3 | G4G5 |
| | | Vascular Plant | <i>Gymnocarpium jessoense</i> | Blue | S3 | G5T4 |
| | | Vascular Plant | <i>Gymnocarpium jessoense</i> | Blue | S3 | G5T4 |
| | | Vascular Plant | <i>Sticta arctica</i> | Red | S1 | G4 |
| | | Vascular Plant | <i>Micranthes tenuis</i> | Red | S1S3 | G4? |
| | | Vascular Plant | <i>Draba</i> sp. nov | n/a | n/a | n/a |
| | | Vascular Plant | <i>Carex atrata</i> s. lat. | n/a | n/a | n/a |
| | | Vascular Plant | <i>Draba glabella</i> | Blue | S2S3 | G5T5 |
| | | Vascular Plant | <i>Epilobium hornemannii</i> ssp. <i>behringianum</i> | Blue | S2S3 | G5T4 |
| | | Vascular Plant | <i>Carex atrata</i> s. lat. | n/a | n/a | n/a |
| | | Vascular Plant | <i>Poa abbreviata</i> ssp. <i>pattersonii</i> | Blue | S2S3 | G5T5 |
| | | Vascular Plant | <i>Epilobium hornemannii</i> ssp. <i>behringianum</i> | Blue | S2S3 | G5T4 |
| | | Lichen | <i>Psoroma tenue</i> var. <i>boreale</i> | Red | S2? | G3G5T2T4 |
| | | Lichen | <i>Cladonia pseudalcicornis</i> | Blue | S2S3 | GNR |
| | | Lichen | <i>Baeomyces carneus</i> | Red | S1 | GNR |
| | | Lichen | <i>Collema ceraniscum</i> | Red | S1 | GNR |
| | | Lichen | <i>Stereocaulon symphycheilum</i> | Red | S1S2 | G3 |
| | | Lichen | <i>Bryocaulon pseudohyperboreum</i> ined | n/a | n/a | n/a |
| | | Lichen | <i>Rhexophiale rhexoblepharum</i> | n/a | n/a | n/a |
| | | Lichen | <i>Umbilicaria</i> sp nov. | n/a | n/a | n/a |
| Lichen | <i>Allantoparmelia almquistii</i> | Blue | S3 | GNR | | |
| Lichen | <i>Arctoparmelia incurva</i> | Blue | S2S3 | G3G5 | | |
| Brucejack | Loss | Moss | <i>Pohlia cardotii</i> | Red | S2 | G2G3 |
| | | Vascular Plant | <i>Ranunculus occidentalis</i> ssp. <i>hexasepalus</i> | Red | S1S3 | G1G3 |
| | | Moss | <i>Sphagnum aongstroemii</i> | Blue | S2S3 | G3G4 |

Nineteen rare plants and lichens may be degraded/altered in areas adjacent to the KSM Project and 25 lichens, 2 mosses, and 7 vascular plants may be altered due to the Brucejack Gold Mine Project activities (Table 16.10-6).

Table 16.10-6. Cumulative Alteration of Rare Plants and Lichens within the Cumulative Effects Assessment Boundary

| Project Name | Effect Type | Lifeform Type | Species Name | BC CDC Rank | NatureServe S Rank | NatureServe G Rank |
|--------------|-------------|----------------|---|---------------------------|--------------------|--------------------|
| KSM | Alteration | Vascular Plant | <i>Carex enanderi</i> | Blue | S2S3 | GNR |
| | | Vascular Plant | <i>Epilobium hornemannii</i> ssp. <i>beringianum</i> | Blue | S2S3 | G5T4 |
| | | Vascular Plant | <i>Gymnocarpium jessoense</i> | Blue | S3 | G5 |
| | | Vascular Plant | <i>Packera cymbalaria</i> | Blue | S1S3 | G5 |
| | | Vascular Plant | <i>Poa abbreviata</i> ssp. <i>pattersonii</i> | Blue | S2S3 | G5T5 |
| | | Vascular Plant | <i>Antennaria</i> sp. nov. | Unranked | Unranked | Unranked |
| | | Vascular Plant | <i>Carex atrata</i> s. lat. | Unranked | Unranked | Unranked |
| | | Vascular Plant | <i>Ranunculus occidentalis</i> var. <i>hexasepalus</i> | Red | S1S3 | G1G3 |
| | | Lichen | <i>Allantoparmelia almquistii</i> | Blue | S3 | GNR |
| | | Lichen | <i>Cetraria nigricans</i> | Blue | S3 | GNR |
| | | Lichen | <i>Cladonia pseudalcicornis</i> | Blue | S2S3 | GNR |
| | | Lichen | <i>Psoroma tenue</i> var. <i>boreale</i> | Red | S2? | G3G5T2T4 |
| | | Lichen | <i>Sphaerophorus fragilis</i> | Red | S2S3 | G4G5 |
| | | Lichen | <i>Umbilicaria lambii</i> | Blue | S3 | G2G4 |
| | | Lichen | <i>Arctoparmelia incurva</i> | Blue | S2S3 | G3G5 |
| | | Lichen | <i>Cladonia coccifera</i> | Red | S1 | G5 |
| | | Lichen | <i>Peltigera gowardii</i> (<i>Hydrothyria venosa</i>) | Red: SARA candidate | S1S2 | GNR |
| | | Vascular Plant | <i>Carex enanderi</i> | Blue | S2S3 | GNR |
| | | Vascular Plant | <i>Epilobium hornemannii</i> ssp. <i>beringianum</i> | Blue | S2S3 | G5T4 |
| | | Vascular Plant | <i>Packera cymbalaria</i> | Blue | S1S3 | G5 |
| | | Vascular Plant | <i>Poa abbreviata</i> ssp. <i>pattersonii</i> | Blue | S2S3 | G5T5 |
| | | Vascular Plant | <i>Antennaria</i> sp. nov. | Unranked | Unranked | Unranked |
| | | Vascular Plant | <i>Carex atrata</i> s. lat. | Unranked | Unranked | Unranked |
| | | Vascular Plant | <i>Ranunculus occidentalis</i> var. <i>hexasepalus</i> | Red | S1S3 | G1G3 |
| | | Lichen | <i>Allantoparmelia almquistii</i> | Blue | S3 | GNR |
| | | Lichen | <i>Cetraria nigricans</i> | Blue | S3 | GNR |
| | | Lichen | <i>Cladonia pseudalcicornis</i> | Blue | S2S3 | GNR |
| | | Lichen | <i>Psoroma tenue</i> var. <i>boreale</i> | Red | S2? | G3G5T2T4 |

(continued)

Table 16.10-6. Cumulative Alteration of Rare Plants and Lichens within the Cumulative Effects Assessment Boundary (continued)

| Project Name | Effect Type | Lifeform Type | Species Name | BC CDC Rank | NatureServe S Rank | NatureServe G Rank |
|--------------|-------------|----------------|---|---|--|--------------------|
| Brucejack | Alteration | Lichen | <i>Umbilicaria lambii</i> | Blue | S3 | G2G4 |
| | | Lichen | <i>Allantoparmelia almquistii</i> | Blue | S3 | GNR |
| | | Lichen | <i>Arctoparmelia incurva</i> | Blue | S2S3 | G5 |
| | | Lichen | <i>Bryocaulon hyperboreum</i> | NA | Unranked; previously undocumented in BC | NA |
| | | Lichen | <i>Sphaerophorus fragilis</i> | Blue | S2S3 | G4G5 |
| | | Lichen | <i>Bryoria nitidula</i> | Blue | S2S3 | G5 |
| | | Lichen | <i>Cetraria nigricans</i> | Blue | S3 | G5 |
| | | Lichen | <i>Cladonia subfurcata</i> | Blue | S2S3 | GNR |
| | | Lichen | <i>Cladonia pseudalcicornis</i> | Blue | S2S3 | GNR |
| | | Moss | <i>Psilopilum cavifolium</i> | Red | S1S2 | G4G5 |
| | | Vascular Plant | <i>Epilobium hornemannii</i> ssp. <i>Behringianum</i> | Blue | S2S3 | G5T4 |
| | | Lichen | <i>Placynthium asperellum</i> | Blue | S3 | G4G5 |
| | | Lichen | <i>Cladonia singularis</i> | Blue | S2S3 | GNR |
| | | Lichen | <i>Dermatocarpon leptophyllodes</i> | Blue | S2S4 | GNR |
| | | Lichen | <i>Cladonia coccifera</i> | Red-listed | S1 | G5 |
| | | Lichen | <i>Fuscopannaria cheiroloba</i> | NA | Unranked; documented in very few locations | NA |
| | | Lichen | <i>Collema cristatum</i> var. <i>marginale</i> | Blue | S2S3 | G3G5TNR |
| | | Lichen | <i>Collema</i> sp. nov. | Species new to science | Unranked | NA |
| | | Lichen | <i>Vahliella leucophaea</i> | Unranked; previously undocumented in BC | Unranked | NA |
| | | Lichen | <i>Collema crispum</i> | Red | S1 | GNR |
| | | Lichen | <i>Lempholemma intricatum</i> | Red | S1S2 | GNR |
| | | Lichen | <i>Leptogium cyanescens</i> | Red | S1 | G5 |
| | | Lichen | <i>Stereocaulon botryosum</i> | Red | S2 | G4 |
| | | Moss | <i>Miehlichhoferia elongata</i> | NA | Unranked; previously undocumented in BC | NA |
| | | Vascular Plant | <i>Carex rostrata</i> x <i>utriculata</i> | Blue | S2S3 | GNR |

(continued)

Table 16.10-6. Cumulative Alteration of Rare Plants and Lichens within the Cumulative Effects Assessment Boundary (completed)

| Project Name | Effect Type | Lifeform Type | Species Name | BC CDC Rank | NatureServe S Rank | NatureServe G Rank |
|-----------------------|--------------------------------|----------------|--|------------------------|--|--------------------|
| Brucejack (cont'd) | Alteration (cont'd) | Lichen | <i>Stereocaulon botryosum</i> | Red | S2 | G4 |
| | | Vascular Plant | <i>Draba glabella</i> | Blue | S2S3 | G4 |
| | | Vascular Plant | <i>Draba</i> sp. nov. | NA | Unranked; previously undocumented in BC | NA |
| | | Lichen | <i>Dermatocarpon leptophyllodes</i> | Blue | S2S4 | GNR |
| | | Lichen | <i>Cladonia singularis</i> | Blue | S3 | GNR |
| | | Lichen | <i>Peltigera gowardii</i> (<i>Hydrothyria venosa</i>) | Red: SARA candidate | S1S2 | GNR |
| | | Vascular Plant | <i>Gymnocarpium jessoense</i> ssp. <i>parvulum</i> | Blue | S3 | G5T4 |
| | | Vascular Plant | <i>Botrychium crenulatum</i> | Blue | S2S3 | G3 |
| | | Vascular Plant | <i>Carex enanderi</i> | Blue | S2S3 | GNR |
| Lichen | <i>Vestergrenopsis elaeina</i> | Blue | S2S3 | GNR | | |

16.10.6 Mitigation Measures to Address Cumulative Effects

Ecosystem management and mitigation plans are designed to avoid and minimize adverse effects to ecosystems and plants resulting from project activities within the feasible limits of project design and activities. Each past, present, and future project would have had or will have different mitigation and management for terrestrial ecosystems and plants; however, it is assumed any present and future projects will take into consideration the goals and objectives outlined in the CIS LRMP (BC ILMB 2000) and the Nass South SRMP (BC MFLNRO 2012). It is also assumed that the following general mitigation measures will be common amongst any present and future projects or activities:

- avoid and/or minimize detrimental effects to terrestrial ecosystems and wetlands through strategic planning;
- minimize all clearing dimensions during any construction activities;
- minimize soil loss and degradation (i.e., compaction, erosion, and soil horizon mixing);
- avoid the introduction and spread of invasive plants;
- avoid and minimize detrimental effects to rare plants and lichens, including rare plant and lichen habitat;
- avoid and/or minimize loss or alteration of ecosystem functions due to clearing activities, dust deposition, fragmentation, edge effects, windthrow, and altered hydrology;
- ensure clearing activities are coordinated with other management plans; and
- maintain natural levels of plant and lichen biodiversity through avoidance, offsetting, and other mitigation strategies.

Collaborative approaches to address cumulative effects to the terrestrial ecology receptor VC should primarily involve the following:

- o continuation of existing data sharing agreements, including identification of any emerging negative population and biodiversity trends likely attributable to the relevant project.

16.10.7 Cumulative Residual Effects for Terrestrial Ecology

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent, as well as to rare plants and lichens, resulting from the activities of the present and future projects. Nevertheless, residual effects are expected due to historic activities or due to present and/or future planned activities where residual effects persist. Thus, residual effects are anticipated for alpine, forested, and riparian ecosystems, as well as for rare plants and lichens.

Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 16.10-7.

Table 16.10-7. Summary of Cumulative Residual Effects on Terrestrial Ecology Receptor Valued Components

| Receptor Valued Component | Timing of Cumulative Residual Effect ¹ | Description of Cause-Effect | Description of Additional Mitigation (if any) | Description of Cumulative Residual Effect |
|---------------------------|--|--|---|---|
| Alpine Ecosystems | Construction -beyond Post-closure | Surface clearing activities and continued use; reclamation disturbance | None anticipated | Loss and alteration of ecosystem function and/or extent |
| Forested Ecosystems | Construction and Operation | Surface clearing activities and continued use | None anticipated | Loss and alteration of ecosystem function and/or extent |
| Floodplain Ecosystems | Construction -Post-closure (depending on the type of riparian ecosystem) | Surface clearing activities and continued use | None anticipated | Loss and alteration of ecosystem function and/or extent |
| Rare Plants and Lichens | Construction -beyond Post-closure | Surface clearing activities and continued use; reclamation disturbance | None anticipated | Loss of rare plants and lichens; loss and alteration of rare plant and lichen habitat |

¹ Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component or receptor VC.

16.10.7.1 Residual Effects on Alpine Ecosystems

Loss of alpine ecosystems is expected to be a residual effect because reclamation efforts within the Sulphurets Project, Snowfield Project, Granduc Mine, Goldwedge Project, and KSM Project footprints were either limited, or there is low confidence that reclamation efforts will restore ecosystem function and extent to a level similar to that of baseline conditions. The restoration success of each alpine ecosystem is influenced by the level of effort invested in the reclamation initiatives, as well as the scale, frequency, and intensity of the disturbance, together with the local edaphic conditions (Chapin III and Shaver 1985; Forbes, Ebersole, and Strandberg 2001; Urbanska and Chambers 2002), which in alpine environments is a limiting factor.

16.10.7.2 Residual Effects on Forested Ecosystems

Alteration of forested ecosystem function and extent is expected to be a residual effect because windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. Mitigation measures to avoid the potential introduction and spread of invasive plants will help reduce potential introductions but may not avoid this effect altogether.

16.10.7.3 Residual Effects on Floodplain Ecosystems

Loss and alteration of floodplain ecosystem function and extent is expected to be a residual effect because windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. Mitigation measures to avoid the potential introduction and spread of invasive plants will help reduce the potential introductions but may not avoid this effect altogether.

16.10.7.4 Residual Effects on Rare Plants and Lichens

Loss of rare plant and lichen species is expected to be a residual effect because surface clearing activities at the KSM Project are expected to result in removal of rare plants/lichens and associated critical habitat. Furthermore, the Brucejack Gold Mine Project could result in alteration of rare plant/lichens or habitat.

Rare plants and lichens are habitat-specific and the unique combinations of environmental conditions that characterize their habitats are also rare and cannot be easily reproduced, if at all. Alteration of rare plant and/or lichen habitat is also considered a residual effect because indirect effects, such as deposition of fugitive dust and changes to hydrology, can be minimized but not avoided entirely.

16.10.8 Characterizing Cumulative Residual Effects, Significance, Likelihood, and Confidence

The cumulative residual effects for the relevant terrestrial ecology VCs were characterized by considering the Project’s incremental contribution to the cumulative residual effect under two scenarios:

- Future case without the Project: a consideration of residual effects from all other past, existing, and future projects and activities on receptor VCs without the Project.
- Future case with the Project: a consideration of all residual effects from past, existing, and future projects and activities on receptor VCs with the Project.

This approach helps predict the relative influence of the Project on the residual cumulative effect for each relevant receptor VC, while also considering the role of other projects and activities in causing that effect.

16.10.8.1 Characterizing Cumulative Residual Effects

The residual cumulative effects on the receptor valued components in question were characterized in terms of magnitude, geographic extent, duration, frequency, reversibility, and resiliency, according to the definitions in Table 16.10-8.

Table 16.10-8. Magnitude Threshold for each Terrestrial Ecology Receptor Valued Components

| Definition of Magnitude for Terrestrial Ecology Sub-components | Magnitude of Effect |
|--|---------------------|
| < 1% loss of amount of habitat available in the CEA boundary | None |
| 1-10% loss of amount of habitat available in the CEA boundary | Low |
| 11-25% loss of amount of habitat available in the CEA boundary | Moderate |
| > 25% loss of amount of habitat available in the CEA boundary | High |

It is difficult to accurately determine the magnitude of loss and alteration of terrestrial ecosystems within a cumulative context due to data limitations, disparate methodologies between projects, and an overall absence of measurable criteria and indicators. Nevertheless, there is some empirical information on amount of habitat loss (i.e., ecosystems) beyond which effects to wildlife species is predicted to be unacceptably high. Therefore, the magnitude of loss and alteration of terrestrial ecosystems was based on threshold levels for habitat loss.

The magnitude threshold takes into consideration the amounts of landscape disturbance beyond which measures of ecological degradation increase in intensity. This idea has been supported empirically, and has been useful in determining risks to wildlife species from landscape disturbance, which include not only habitat loss but also other ecological changes that negatively affect species (Scrimgeour, Hvenegaard, and Tchir 2008). Habitat thresholds also can be defined based on perceived risk. For example, habitat loss thresholds for the Great Bear Rainforest in BC were defined based on expert opinion: greater than 30% habitat loss was identified as a threshold amount representing a transition from low risk to higher risk of uncertain magnitude (Price, Roburn, and MacKinnon 2009). Combining these two approaches (i.e., landscape disturbance thresholds and expert-derived risk thresholds), thresholds for habitat loss of greater than 30 to 40% can be defined as amounts of habitat loss predicted to cause unacceptable risks to species (Scrimgeour, Hvenegaard, and Tchir 2008; Price, Roburn, and MacKinnon 2009).

Applying a precautionary approach, a high magnitude effect was designated at 25% loss of the total amount of habitat available. The magnitude of the effect on relevant terrestrial ecology receptor VC within the CEA was calculated relative to the amount of each VC available within the CEA boundary. Magnitude for the effects of ecosystem loss was quantified as follows:

The magnitude of an effect on rare plants and lichens or associated habitat was determined based on the BC CDC and the NatureServe Ranks (MOF 1992; NatureServe 2012), which provide definitions on the level of rarity of a species. This information was used to determine severity of residual effects to rare plants and lichens (Table 16.7-3).

The duration, frequency, reversibility, resiliency, and context of Project-related effects were determined based on reviews of other similar projects' monitoring results, relevant scientific literature information attained through community consultation, and professional judgement.

16.10.8.2 Likelihood

The likelihood or probability that a Project activity (mine construction, road use, transmission tower installation, etc.) will result in an effect on ecosystem function or extent was determined through reviews of relevant literature, proposed Project activities, baseline information, and/or professional judgement.

16.10.8.3 Significance

The significance of an effect on a terrestrial ecology receptor valued component was based on the characterization criteria outlined in Table 16.7-1.

16.10.8.4 Confidence

The confidence regarding how well residual effects are understood, which includes a consideration of the acceptability of the data inputs and analytical methods used to predict and assess project effects, was taken into consideration when characterizing residual effects.

16.10.9 Evaluation of Cumulative Residual Effects and Significance

16.10.9.1 *Alpine Ecosystems*

Characterization

Cumulative effects represent a low magnitude effect to alpine ecosystems. Loss and alteration of ecosystem function and/or extent will occur at a regional level as the effects within each project footprint along with the associated disturbance footprint span across multiple valleys and will contribute to the cumulative loss of terrestrial ecosystems within the regional area (i.e., CEA boundary; Table 16.10-9).

These effects will be sporadic-regular depending on the effect and will last into the far future. As a conservative approach, effects to alpine ecosystems are considered irreversible due largely to their low resiliency. The effects to alpine ecosystems will be distinguishable from background conditions (i.e., the effects do not occur within the range of natural variation as influenced by physical, chemical, and biological processes). Project effects do not pose a risk to the viability of this resource in the region.

Probability

There is a high probability that effects to alpine ecosystems will occur as many of the projects within the CEA boundary will result in the removal of alpine ecosystems. Furthermore, there is a high likelihood that dust will be deposited on alpine ecosystems. Effects due specifically to dust deposition and subsequent chemical transformations in soil and uptake by vegetation are well understood; however, due to the number of possible pathways and the interference between many factors, the probability of acidification on alpine ecosystems is considered medium.

Significance

The cumulative loss and alteration of alpine ecosystem function and/or extent are considered not significant.

Confidence

There is a medium level of confidence in the analyses because mining-related direct effects to alpine areas are relatively well understood; however, there is uncertainty regarding the ability to reclaim these sites over the long term and the full extent of the loss or alteration.

16.10.9.2 *Forested Ecosystems*

Characterization

Loss of forested ecosystems due to surface clearing activities at the KSM Project and Brucejack Gold Mine Project, and to a lesser degree at the Granduc Mine, are considered minor in magnitude largely due to the available amount of this resource within the CEA boundary. Indirect effects, including windthrow, invasive plant introduction, fragmentation, edge effects, and changes to hydrology are considered medium magnitude, regional in extent, long term in duration, and may occur regularly. Effects are considered reversible in the long term from the point at which the activity causing the loss or alteration ceases. Forested ecosystems are considered to have neutral resiliency. In an ecological context, forested ecosystems have some unique attributes within the region and are considered neutral according to the definitions in Table 16.7-1.

Table 16.10-9. Significance Determination of Cumulative Residual Effects for Terrestrial Ecology: Future Case with the Project

| Residual Effects | Evaluation Criteria | | | | | | | Likelihood (low, medium, high) | Significance of Adverse Residual Effects (not significant; significant) | Confidence (low, medium, high) |
|--|------------------------------------|---|--|--|--|------------------------------------|--|-----------------------------------|--|-----------------------------------|
| | Magnitude (low, moderate, high) | Duration (short, medium, long, far future) | Frequency (once, sporadic, regular, continuous) | Geographic Extent (local, landscape, regional, beyond regional) | Reversibility (reversible short-term; reversible long-term; irreversible) | Resiliency (low, neutral, high) | Ecological Context (low, neutral, high) | | | |
| Loss and alteration of ecosystem function and/or extent on alpine ecosystems | Low | Far future | Regular | Regional | Irreversible | Low | Neutral | Medium | Not significant | Medium |
| Loss and alteration of ecosystem function and/or extent on forested ecosystems | Low | Long | Regular | Regional | Reversible medium term | Neutral | Neutral | Medium | Not significant | Medium |
| Loss and alteration of ecosystem function and/or extent on floodplain ecosystems | Low | Medium | Regular | Regional | Reversible medium term to long term | Neutral | High | High | Not significant | Medium |
| Loss and/or alteration of rare plant and lichen habitat | Moderate | Far future | Once | Beyond Regional | Irreversible | Low | High | High | Not determined | Medium |

Probability

There is a medium level of probability that effects to forested ecosystems will occur. The majority of the effects to forested ecosystems, including fragmentation, windthrow, and edge effects are expected to occur as a result of clearing activities related to mine development or forest harvesting. Most of the effects to forested ecosystems are well understood and well documented in the scientific literature; however, uncertainty exists with respect to the specific location of forest removal and alteration.

Significance

Loss and alteration of forested ecosystem function and/or extent are considered not significant.

Confidence

There is a medium level of confidence in the data sources as examples of information classes, collected at the site level, were used to guide mapping but this information was not available for the full extent of the CEA boundary. Furthermore, uncertainty exists with respect to where and to what degree alteration of functions may occur.

16.10.9.3 Floodplain Ecosystems

Characterization

The majority of the loss of floodplain ecosystems is expected to occur along Treaty Creek, Todedada Creek, Scott Creek, Bowser River, and at high elevations in the headwaters of Sulphurets Creek as a result of the KSM Project. Within a regional context, effects to floodplain ecosystems are considered minor in magnitude. The effects are not expected to affect the viability of this resource in the long term. Loss of floodplain ecosystems due to surface clearing activities is considered both reversible medium to long term depending on the ecosystems affected. For example, affected floodplain ecosystems at the Project consist of regosolic gravelly soils, which can recover from disturbance whereas some floodplains along the confluence of Upper Treaty Creek and Treaty Creek represent highly productive low bench ecosystems, which may not have the same ability to recover. Furthermore, the ability of a floodplain to recover from effects is also influenced by its associated ecological processes, determined in part by the relative bench position. Additionally, the effects of windthrow, fragmentation, edge effects, and changes to hydrology are landscape in extent, medium term in duration, and will occur regularly. In an ecological context, floodplain ecosystems have unique attributes and are considered high according to the definitions in Table 16.7-1.

Probability

There is a high level of probability that effects to floodplains ecosystems will occur because some of the Project infrastructure, including the Bowser Aerodrome on a known floodplain. Nutrient addition sustained throughout the Project life may affect floristic composition and diversity of floodplain ecosystems and affect abundance of rare vegetation species due to the use of the Bowser Aerodrome. Uncertainty exists with regards to location and severity of the effects due to the number of possible pathways and the ecological processes between components.

Significance

Loss and alteration of floodplain/riparian ecosystem function and/or extent are considered not significant.

Confidence

There is a medium level of confidence in the analyses because uncertainty exists with respect to where and to what degree alteration of functions may occur and the specific floodplains that may be affected.

*16.10.9.4 Rare Plants and Lichens*Characterization

Rare plants and lichens represent at-risk components of regional, provincial, federal, or global biodiversity. These species are often highly habitat-specific with low resiliency to habitat loss or degradation, invasive alien species, changes in ecological dynamics or natural processes, and disturbance (BC MOE 2008). The magnitude of the removal or alteration of rare plants and lichens or their associated habitat will vary from minor to major depending on the species affected and their associated conservation rank. The effect is beyond regional, will occur once, and will last into the far future. Loss of rare plants and lichens is considered an irreversible effect as transplantation is usually ineffective (Schemske et al. 1994; Howald 1996; Hubbard et al. 2001; Fahselt 2007). Furthermore, rare plants and lichens can have limited dispersal ability, poor recruitment or reproduction, population fluctuations, inbreeding, and/or restricted ranges. In an ecological context, rare plants and lichens (depending on their conservation rank) are considered unique attributes according to the definitions in Table 16.7-1.

Probability

Within the CEA study area, the primary effect to rare plants and lichens, via a direct loss pathway, would result from construction of the KSM Project. According to the current design for the KSM Project up to 65 rare plants or lichens will be directly impacted by surface clearing activities. Thus, assuming that the KSM Project is constructed, there is a high level of probability that effects to rare plants and lichens will occur.

Significance

Within the CEA study area, the primary cumulative effect to rare plants and lichen, via a direct loss pathway, would result from construction of the KSM Project. A determination of significance of project specific effects from the KSM Project could not be made in Seabridge Gold Inc.'s Application/EIS (Rescan 2013c). Thus, the significance of potential cumulative residual effects to rare plants and lichens cannot be made here. In the absence of the KSM Project, cumulative residual effects to rare plants and lichens would be not significant.

Confidence

There is a high level of confidence in the location and identification of the species but uncertainty exists with respect to where and to what degree loss or alteration of rare plant and lichen populations may occur. Furthermore, uncertainty exists with regards to the rarity of each species due to the limited knowledge of local and regional floral biodiversity.

16.11 EFFECTS ASSESSMENT CONCLUSIONS FOR TERRESTRIAL ECOLOGY

In summary, the Project-related residual effects of loss and/or alteration of ecosystem function or extent will result in not significant effects on alpine, parkland, forested, and floodplain ecosystems and culturally/economically important plant habitat. The Project-related residual effects of loss and/or alteration of rare plant and lichen species or associated habitat will result in a not significant effect. The residual effects, mitigation, and significance on terrestrial ecology receptor VC are summarized in Table 16.11-1.

The cumulative loss of terrestrial ecosystems within the CEA boundary—excluding the Project—is 5,358 ha (1.7 %). The Project may result in the loss of 217 ha (0.1%) of alpine ecosystems, 178 ha (0.1%) of forested ecosystems, and 15 ha (0.2%) of floodplain ecosystems. The cumulative loss of terrestrial ecosystems within the CEA boundary—including the Project—is 5,769 ha (1.9%), including 1,706 ha (1.1%) of alpine ecosystems; 4,051 ha (2.8%) of forested ecosystems, and 225 ha (2.8%) of floodplain ecosystems. The Brucejack Gold Mine Project contributes approximately 7.1% of the total cumulative loss of ecosystems expected within the CEA boundary.

The cumulative alteration of terrestrial ecosystems within the CEA boundary—excluding the Project—is 20,582 ha (6.6 %). The Project may result in the alteration of 196 ha (0.1%) of alpine ecosystems, 983 ha (0.7%) of forested ecosystems, and 102 ha (1.3%) of floodplain ecosystems. The cumulative alteration of terrestrial ecosystems within the CEA boundary—including the Project is 21,806 ha (7.0%), including 3,442 ha (2.1%) of alpine ecosystems; 17,654 ha (12.2%) of forested ecosystems, and 710 ha (8.7%) of floodplain ecosystems. The Brucejack Gold Mine Project contributes approximately 5.9% of the total cumulative alteration of ecosystems expected within the CEA boundary.

The Project's residual effects, in combination with the residual effects of past, present, and future projects, will result in not significant effects on alpine, forested, and floodplain ecosystems. Parkland ecosystems and culturally/economically important plant habitat were not included in the CEA because effects to these receptor VCs are expected to be undetectable. The Project's residual effect on rare plants and lichens is expected to result in not significant effects on rare plants and lichens. The significance of cumulative residual effects of loss and/or alteration of rare plant and lichen species or associated habitat cannot be determined based on currently available information. The Project and cumulative residual effects, mitigation, and significance on relevant terrestrial ecology receptor VCs are summarized in Table 16.11-1.

Table 16.11-1. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Terrestrial Ecology

| Residual Effect and Terrestrial Ecology Receptor VC | Project Phase(s) | Mitigation Measures | Significance of Residual Effects | |
|---|-------------------------------|--|----------------------------------|-----------------|
| | | | Project | Cumulative |
| <i>Alpine Ecosystems</i> Loss and/or alteration of ecosystem function and extent | Construction and Operation | Minimize loss; restoration | Not significant | Not significant |
| <i>Forested Ecosystems</i> Alteration of ecosystem function and extent | Construction and Operation | Minimize loss and adaptively manage effects through an ecosystem based approach | Not significant | Not significant |
| <i>Floodplain Ecosystems</i> Alteration of ecosystem function and extent | Construction and Operation | Minimize loss and adaptively manage effects through an ecosystem based approach | Not significant | Not significant |
| <i>Rare Plants and Lichen</i> Loss of species and/or loss or alteration of habitat | Construction and/or Operation | Avoidance and minimize clearing areas, relevant data sharing with other proponents | Not Significant | Not determined |

REFERENCES

1985. *Fisheries Act*, RS. C. F-14. s. 1.
- 1996a. *Environment Management Act*, RSBC. C. 118 (Repealed or spent).
- 1996b. *Waste Management Act*, RSBC. C. 382 (Repealed or spent).
- 1996c. *Water Act*, RSBC. C. 483.
- 1996d. *Weed Control Act*, RSBC. C. 487.
- 1996e. *Wildlife Act*, RSBC. C. 488. s. 1.1.
1997. *Fish Protection Act*, SBC. C. 25.
- 2002a. *Environmental Assessment Act*, SBC. C. 43.
- 2002b. *Forest and Range Practices Act*, SBC. C. 69. s. 149.1.
- 2002c. *Species at Risk Act*, SC. C. 29. s. 15.3.
2004. *Environmental Management Act*, SBC. C. 53.
2012. *Canadian Environmental Assessment Act, 2012*, SC. C. 19. s. 52.
- Forest Service Road Use Regulation, BC Reg. 70/2004.
- Contaminated Sites Regulation, BC Reg. 375/96.
- Anthony, P. 2001. *Dust from walking tracks: Impacts on rainforest leaves and epiphylls*. Australia: Cooperative Research Centre for Tropical Rainforest Ecology and Management. http://www.jcu.edu.au/rainforest/infosheets/dust_walkingtracks.pdf (accessed October 2008).
- Arienti, M. C., A. D. Steven, G. B. Cumming, M. A. Krawchuk, and C. S. Boutin. 2009. Road network density correlated with increased lightning fire incidence in the Canadian western boreal forest. *International Journal of Wildland Fire*, 18 (8): 970-82.
- Auerbach, N. A., M. D. Walker, and D. A. Walker. 1997. Effects of roadside disturbance on substrate and vegetation properties in arctic tundra. *Ecological Applications*, 7 (1): 218-35.
- Azous, A. and R. R. Horner. 2010. *Wetlands and urbanization: Implications for the future*. CRC Press.
- Banner, A., W. H. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. L. Trowbridge. 1993. *A Field Guide to Site Identification and Interpretation for the Prince Rupert Forest Region Land Management Handbook Number 26*. BC Ministry of Forests and Range Research Branch: Victoria, BC.
- Baron, J. S., H. M. Rueth, A. M. Wolfe, K. R. Nydick, E. J. Allstott, J. T. Minear, and B. Moraska. 2000. Ecosystem Responses to Nitrogen Deposition in the Colorado Front Range. *Ecosystems*, 3 (4): 352-68.
- Barrick Gold Inc. 2004. *Eskay Creek Mine Responsibility Report*. http://www.barrick.com/Theme/Barrick/files/docs_performance/PerfReport_03_EskayCreek.pdf. (accessed April 2010).
- BC EAO. 2013. *Guidelines for the Selection of Valued Components and Assessment of Potential Effects*. British Columbia Environmental Assessment Office: Victoria, BC.
- BC ILMB. 2000. *Cassiar Iskut-Stikine Land and Resource Management Plan*. British Columbia Integrated Land Management Bureau. <http://ilmbwww.gov.bc.ca/slrp/lrmp/smithers/cassiar/index.html> (accessed June 2013).

- BC ILMB and Ministry of Agriculture and Lands. 2006. *A New Direction for Strategic Land Use Planning in BC: Synopsis*. Government of British Columbia: Victoria, BC.
- BC MEMPR. 2008. *Health, Safety and Reclamation Code for Mines in British Columbia*. Prepared by the Ministry of Energy, Mines and Petroleum Resources, Mining and Minerals Division: Victoria, BC.
- BC MFLNRO. 2012. *Nass South Sustainable Resource Management Plan*.
<http://www.ilmb.gov.bc.ca/slrp/srmp/south/nass/index.html> (accessed November 2012).
- BC MFLNRO. n.d. *Freshwater Atlas*. <http://ilmbwww.gov.bc.ca/geobc/FWA> (accessed October 2013).
- BC Ministry of Environment Lands and Parks and BC Ministry of Forests Research Branch. 1998. *Field Manual for Describing Terrestrial Ecosystems*. Land Management Handbook No. 25: Victoria, BC.
- BC MOE. 2007a. *BC Conservation Data Centre Home Page*. <http://www.env.gov.bc.ca/cdc/index.html> (accessed May 2010).
- BC MOE. 2007b. *Sensitive Ecosystems Inventory*. <http://www.env.gov.bc.ca/sei/> (accessed November 2010).
- BC MOE. 2008. *Multi-species Recovery Strategy for the Princeton Landscape, Including Dwarf Woolly-heads (*Psilocarphus brevissimus* var. *brevissimus*), Slender Collomia (*Collomia tenella*), and Stoloniferous Pussytoes (*Antennaria flagellaris*) in British Columbia*. Prepared by the Southern Interior Rare Plants Recovery Implementation Group DRAFT.
<http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do;jsessionid=589852f9620e4868d871de6ad2322ed03723d9622c532208f62c0dd457c49fe9.e3uMah8KbhmLe3mMbN8Pa3uPbi1ynknvrkLOlQzNp65ln0?subdocumentId=4873> (accessed October 2013).
- BC MOE. 2012. *BC Conservation Data Centre Home* <http://www.env.gov.bc.ca/cdc/index.html>. (accessed June 2013).
- BC MOFR. 2006. *The Ecology of the Alpine Zones*. Brochure 83. BC Ministry of Forests and Range Research Branch: Victoria, BC.
- Berch, S. M. and W. Cocksedge. 2003. *Commercially Important Wild Mushrooms and Fungi of British Columbia What the Buyers Are Buying*. October 2013. B.C. Min. For., Res. Br., Victoria, B.C. Tech. Rep. 006: Victoria.
- Berryman, S., J. Straker, and D. Straker. 2009. Using lichens as bioindicators of air pollution deposition near remote mining operations.
- Bittman, K. K. 1995. *Innovative reclamation at Quintette: high elevation/high altitude challenges*. T. T. a. R. C. o. Reclamation, Ed. 19th Annual British Columbia Mine Reclamation Symposium Dawson Creek, BC.
- Blackwell, B. A., G. Shrimpton, F. Steele, D. W. Ohlson, and A. Needoba. 2004. *Development of a Wildfire Risk Management System for BC Transmission Corporation Rights-of-Way*. Prepared for British Columbia Transmission Corporation: n.p.
- Blaser, P., M. Zysset, S. Zimmermann, and J. Luster. 1999. Soil Acidification in Southern Switzerland between 1987 and 1997: A Case Study Based on the Critical Load Concept. *Environmental Science and Technology*, 33 (14): 2383-89.
- Bobbink, R., K. Hicks, J. Galloway, T. Spranger, R. Alkemade, M. Ashmore, M. Bustamante, S. Cinderby, E. Davidson, F. Dentener, B. Emmett, J.-W. Erismann, M. Fenn, F. Gilliam, A. Nordin, L. Pardo, and W. De Vries. 2010. Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. *Ecological Applications* 20: 30-59.
- Bobbink, R. and L. Lamers. 2002. Effects of increased nitrogen deposition. *Air pollution and plant life*, 2: 201-35.

- Bowman, W. D. and H. Steltzer. 1998. Positive Feedbacks to Anthropogenic Nitrogen Deposition in Rocky Mountain Alpine Tundra. *Ambio*, 27 (7): 514-17.
- Brown, R. W. and R. S. Johnston. 1976. *Revegetation of an alpine mine disturbance: Beartooth Plateau, Montana*. Presented at USDA Forest Service Intermountain Forest and Range Experiment Station, Ogden Utah.
- Brown, S. C., K. Smith, and D. Batzer. 1997. Macroinvertebrate responses to wetland restoration in northern New York. *Environmental Entomology*, 26 (5): 1016-24.
- Burton, P. J. 1991. Windthrow patterns on cutblock edges and in retention patches in the SBSmc. In *Windthrow Assessment and Management in British Columbia*. Eds. S. J. Mitchell and J. Rodney. Richmond, BC: Proceedings of the Windthrow Researchers Workshop.
- Cambria Gordon. 2013. *Brucejack Access Road: Environmental Monitoring of Road Construction*. Cambria Gordon Ref. #497.200. Pretium Resources Inc.: Vancouver, BC (ongoing reporting).
- Canadian Food Inspection Agency. 2008. *Invasive Alien Plants In Canada: Summary Report*. Canadian Food Inspection Agency: Ottawa, ON.
- CCME. 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*. In *Canadian Environmental Quality Guidelines, 1999*. Canadian Council of Ministers of the Environment: Winnipeg, MB.
- CEA Agency. 2013. *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* Prepared by the Canadian Environmental Assessment Agency. <https://www.ceaa-acee.gc.ca/default.asp?lang=En&n=1DA9E048-1> (accessed January 2014).
- CEPA/FPAC Working Group. 1998. National ambient air quality objectives for particulate matter - Part 1. In *CEPA/FPAC Working Group on Air Quality Objectives and Guidelines Report*. Cat. No. H26-2/98-220. Minister, Public Works, and Government Services, Canada: n.p.
- Chapin III, F. S. and G. R. Shaver. 1985. Individualistic growth response of tundra plant species to manipulation in the field. *Ecology* 66 (2):
- Coast Mountain Hydro Corp. 2002. *Forrest Kerr Hydroelectric Project: Project Approval Certificate Application, Volume 1*. Prepared for AltaGas Renewable Energy Inc. by Coast Mountain Hydro Corp.: Vancouver, BC.
- Coupe, R., A. C. Stewart, and B. M. Wikeem. 1991. Engelmann Spruce Subalpine Fir Zone. In *Ecosystems of British Columbia*. Eds. D. V. Meidinger and J. Pojar. Victoria, BC: Special Report Series 6, British Columbia Ministry of Forests and Range, Research Branch.
- Cowling, E. B. 1982. Acid precipitation in historical perspective. *Environmental Science and Technology* 16: 110-23.
- Cowling, E. B. and J. Nilsson. 1995. Acidification research: lessons from history and visions of possible futures. *Water, Air, and Soil Pollution* 85 (1): 279-92.
- Creed, I. F., Gabor Z. Sass, Jim M. Buttle, and J. A. Jones. 2011. Hydrological principles for sustainable management of forest ecosystems. *HYDROLOGICAL PROCESSES*, (10.1002/hyp.8056): http://geo.oregonstate.edu/files/geo/creed_et_al_hp_11.pdf (accessed October, 2013).
- Cypress Forest Consultants Ltd. 2013. *Wildfire Road As Built July 2013.dxf*. B. C. Prepared for Pretium Resources Inc. by Cypress Forest Consultants Ltd.: Vancouver, CAD File.
- De Schrijver, A., P. De Frenne, E. Ampoorter, L. Van Nevel, A. Demey, K. Wuyts, and K. Verheyen. 2011. Cumulative nitrogen input drives species loss in terrestrial ecosystems. *Global Ecology and Biogeography*, 20 (6): 803-16.

- Demarchi, D. A. 1996. *An Introduction to the Ecoregions of British Columbia*. Wildlife Branch, Ministry of Environment, Lands and Parks: Victoria, BC.
- Demarchi, D. A. 2011. *The British Columbia Ecoregion Classification*. <http://www.env.gov.bc.ca/ecology/ecoregions/> (accessed May 2013).
- Eller, B. M. 1977. Road dust induces increase of leaf temperature. *Environmental Pollution*, 13: 99-107.
- Fahselt, D. 2007. Is transplanting an effective means of preserving vegetation. *Canadian Journal of Botany* 85: 1007-17.
- Farmer, A. M. 1993. The Effects of Dust on Vegetation: A Review. *Environmental Pollution*, 79: 63-75.
- Federal-Provincial-Territorial Biodiversity Working Group. 1995. *Canadian Biodiversity Strategy: Canada's Response to the Convention on Biological Diversity, 1995*. Biodiversity Convention Office, Environment Canada: Hull, QC. <http://www.biodivcanada.ca/default.asp?lang=En&n=560ED58E-1&offset=1&toc=show> (accessed November 2011).
- Fenger, M. A. and R. C. Kowall. 1992. *Biophysical Soil Landscapes Inventory of the Stikine-Iskut Area*. BC Ministry of Environment, Lands and Parks: Victoria, British Columbia.
- Fenn, M. E., J. S. Baron, A. E. B., H. M. Rueth, K. R. Nydick, L. Geiser, W. D. Bowman, J. O. Sickman, T. Meixner, D. W. Johnson, and P. Neitlich. 2003. Ecological Effects of Nitrogen Deposition in the Western United States. *BioScience*, 53 (4): 404-20.
- Fernandez, I. J., L. E. Rustad, S. A. Norton, J. S. Kahl, and B. J. Cosby. 2003. Experimental Acidification Causes Soil Base-Cation Depletion at the Bear Brook Watershed in Maine. *Soil Science Society of America Journal*, 67 (6): 1909-19.
- Forbes, B. C. 1995. Tundra disturbance studies, III: short-term effects of Aeolian sand and dust, Yamal Region, Northwest Siberia. *Environmental Conservation*, 22 (04): 335-44.
- Forbes, B. C., J. J. Ebersole, and B. Strandberg. 2001. Anthropogenic Disturbance and Patch Dynamics in Circumpolar Arctic Ecosystems. *Conservation Biology*, 15 (4): 954-69.
- Frank, D. A. and R. del Moral. 1986. Thirty-five years of secondary succession in a *Festuca viridula* - *Lupinus latifolius* dominated meadow at Sunrise, Mount Rainier National Park, Washington. *Canadian Journal of Botany*, 64: 1232-36.
- Galloway, J. N. 1995. Acid deposition: Perspectives in time and space. *Water, Air, and Soil Pollution* 85 (1): 15-24.
- Gamiet, S., H. Ridenour, and F. Philpot. 1998. *An Overview of Pine Mushrooms in the Skeena-Bulkley Region*. Prepared for the Northwest Institute for Bioregional Research Institute for Bioregional Research: Smithers, BC.
- Gitxsan Chiefs' Office. 2010. *Gitxsan Chiefs' Office Home Page*. www.gitxsan.com (accessed April 2010).
- Gordon, C., J. M. Wynn, and S. J. Woodin. 2001. Impacts of increased nitrogen supply on high Arctic heath: the importance of bryophytes and phosphorus availability. *New Phytologist*, 149 (3): 461-71.
- Gorham, E. 1992. Atmospheric deposition to lakes and its ecological effects: A retrospective and prospective view of research. *Japanese Journal of Limnology* 53: 231-48.
- Government of Canada. 2010. *Species at Risk Public Registry*. <http://www.sararegistry.gc.ca> (accessed December 2012).
- Greaver, T. L., T. J. Sullivan, J. D. Herrick, M. C. Barber, J. S. Baron, B. J. Cosby, M. E. Deerhake, R. L. Dennis, J.-J. B. Dubois, C. L. Goodale, A. T. Herlihy, G. B. Lawrence, L. Liu, J. A. Lynch, and K. J. Novak. 2012. Ecological effects of nitrogen and sulfur air pollution in the US: what do we know? *Frontiers in Ecology and the Environment*, 10 (7): 365-72.

- Gunn, S. 2009. *Ecological Effects of Forest Roads*. <http://www.wildlandscpr.org/ecological-effects-forest-roads> (accessed December 2010).
- Gwaans. 2007. *Gitxsan Houses of Nii Kyap & Miluulak: Submission to joint panel review May 14-17, 2007, Wet'sutwet'en Territories*. Prepared by Office of Gitxsan Hereditary Chiefs: n.p. http://www.ceaa.gc.ca/050/documents_staticpost/cearef_3394/hearings/SM25.pdf (accessed April 2010).
- Haber, E. 1997. *Guide to Monitoring Exotic and Invasive Plants*. Prepared for Ecological Monitoring and Assessment Network Environment Canada by National Botanical Services, Ontario: ON.
- Hanson, A. R., L. Swanson, D. Ewing, G. Grabas, S. Meyer, L. Ross, M. Watmough, and J. Kirkby. 2008. *Wetland ecological functions assessment: An overview of approaches*. Canadian Wildlife Service.
- Harris, L. D. 1988. The nature of cumulative impacts on biotic diversity of wetland vertebrates. *Environmental Management*, 12 (5): 675-93.
- Heij, G. J. and T. Schneider. 1991. *Acidification Research in The Netherlands*. Amsterdam: Elsevier.
- Howald, A. M. 1996. Translocation as a mitigation strategy: lessons from California. . 293-329 in D.A. Falk, C.I. Millar & M. Oldwell, eds. *Restoring diversity: strategies for reintroduction of endangered plants*. Island Press, Washington, D.C.
- Howes, D. E. and E. Kenk. 1997. *Terrain Classification System for British Columbia*. Version 2. BC Ministry of Environment: Victoria, BC.
- Hubbard, L. B., A. Ertter, Dennis, and C. Baskin. 2001. Statement Oposing Transplantation as Mitigation for Impacts to Rare Plants. *Fremontia* 29: 66-67.
- Huggard, D. J., W. Klenner, and A. Vyse. 1999. Windthrow Following Four Harvest Treatments in an Engelmann Spruce - Subalpine Fir Forest in Southern Interior British Columbia, Canada. *Canadian Journal of Forestry Research*, 29: 1547-56.
- Interagency Conservation Strategy Team. 2007. *Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area*. Interagency Conservation Strategy Team: Missoula, MT.
- Ketcheson, M. V., T. F. Braumandl, D. Meidinger, G. Utzig, D. A. Demarchci, and B. M. Wikeem. 1991. Interior Cedar Hemlock Zone. In *Ecosystems of British Columbia*. Eds. D. V. Meidinger and J. Pojar. Victoria, B.C.: B.C. Ministry of Forests and Range Research Branch.
- Kremsater, L. L. and F. L. Bunnell. 1999. Edges: Theory, Evidence, and Implications to Management of Western Forests. In *Forest Fragmentation: Wildlife and Management Implications*. Eds. J. A. Rochelle, L. A. Lehmann, and J. Wisniewski. 117-53. Leiden, Netherlands: Brill.
- Liu, Y., G. Shi, L. Mao, G. Cheng, S. Jiang, X. Ma, L. An, G. Du, N. Collins Johnson, and H. Feng. 2012. Direct and indirect influences of 8 yr of nitrogen and phosphorus fertilization on Glomeromycota in an alpine meadow ecosystem. *New Phytologist* 194 (2): 523-35.
- Mace, R. D. 2004. Integrating science and road access management: lessons from the Northern Continental Divide Ecosystem. *Ursus*, 15: 129-36.
- Mace, R. D. and J. S. Waller. 1997. *Final Report: Grizzly Bear ecology in the Swan Mountains*. Montana Department of Fish, Wildlife, and Parks: Helena, MT.
- Mace, R. D., J. S. Waller, T. L. Manley, L. J. Lyon, and H. Zuring. 1996. Relationships among grizzly bears, roads, and habitat use in the Swan Mountains, Montana. *Journal of Applied Ecology*, 33: 1395-404.

- MacKenzie, W. 2012. *Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia*. Technical report ; 068. Ministry of Forests, Lands and Natural Resource Operations: Smithers, British Columbia.
- MacKenzie, W. H. and J. R. Shaw. 2000. *Wetland classification and habitats at risk in British Columbia*. Proceedings of a conference on the biology and management of species and habitats at risk.
- McCune, D. C. 1991. Effects of airborne saline particles on vegetation in relation to other variables of exposure and other factors. *Environmental Pollution*, 74: 176-203.
- McElhanney. 2011. *Wildlife assessment and management plan Silver Standard - Bowers Lake Road*. Prepared for Cypress Forest Consultants Ltd. by McElhanney Consulting Services Ltd.: Terrace, BC.
- McPhee, M., P. Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N. Dawe, and I. Nykwist. 2000. *Sensitive ecosystems inventory: East Vancouver Island and Gulf Islands, 1993-1997*. Vol. 2: Conservation Manual of Pacific and Yukon Region: Technical Report Series No. 345. Canadian Wildlife Service, Environmental Conservation Branch.
- Mingyu, Y., L. Hens, O. Xiaokun, and R. D. Wulf. 2009. Impacts of recreational trampling on sub-alpine vegetation and soils in Northwest Yunnan, China. *Acta Ecologica Sinica*, 29 (3): 171-75.
- Mitsch, W. and J. Gosselink. 2000. *Wetlands* (3rd edn).
- MOF, B. 1992. *British Columbia's Forests: Monocultures or Mixed Forests?*
- Murphy, F. M. and W. A. Napier. 1996. *Eskay Creek Access Road - a Case Study*. Paper presented at 20th Annual British Columbia Mine Reclamation Symposium, Kamloops, BC.
- Murphy, H. T. and J. Lovett-Doust. 2004. Context and connectivity in plant metapopulations and landscape mosaics: Does the matrix matter? *Oikos*, 105: 3-14.
- NatureServe. 2012. *A Network Connecting Science With Conservation*. <http://www.natureserve.org/> (accessed March 2013).
- Noss, R. F. 1995. *The Ecological Effects of Roads*. <http://www.wildlandscpr.org/ecological-effects-roads> (accessed November 2010).
- NWIPC. 2012. *Welcome to the NWIPC*. <http://www.nwipc.org> (accessed October 2012).
- Ohlson, D., B. Blackwell, B. Hawkes, and D. Bonin. 2003. *A wildfire risk management system—an evolution of the wildfire threat rating system*. 3rd International Wildland Fire Conference and Exhibition.
- Olivier Honnay, Hans Jacquemyn, Beatrijs Bossuyt, and M. Hermy. 2005. Forest fragmentation effects on patch occupancy and population viability of herbaceous plant species. *New Phytologist*, Volume 166 (Issue 3): pages 723-36.
- Pojar, J., K. Klinka, and D. A. Demarchi. 1991. Mountain Hemlock Zone. In *Ecosystems of British Columbia*. Eds. D. V. Meidinger and J. Pojar. Victoria, BC: BC Ministry of Forests and Range Research Branch.
- Polster, D. F. 2005. The Role of Invasive Plant Species Management in Mined Land Reclamation. *Canadian Reclamation*, Summer/Fall 2005: 24-32.
- Price, K., R. Holt, and L. Kremsater. 2007. *Representative Forest Targets: Informing Threshold Refinement with Science*. Review paper for Raincoast Solutions Project and Coast Forest Conservation Initiative. http://www.forrex.org/program/con_bio/PDF/Workshops/Forest_Workshop/representation_per.pdf (accessed December 2010).

- Price, K., A. Roburn, and A. MacKinnon. 2009. Ecosystem-based management in the Great Bear Rainforest. *Forest Ecology and Management*, 258 (4): 495-503.
- Rao, D. N. 1982. Responses of Bryophytes to Air Pollution. In *Bryophyte ecology*. Ed. A. J. E. Smith. 445-71. London, UK: Chapman and Hall.
- Rescan 2013. *Brucejack Gold Mine Project: Country Foods Baseline Assessment* Prepared for Pretium Resources Inc. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.
- Rescan. 2013a. *Brucejack Gold Mine Project Skii km Lax Ha Traditional Knowledge and Traditional Use Report*. Prepared for Pretivm Resources by Rescan Environmental Services Ltd.: Vancouver, BC.
- Rescan. 2013b. *Brucejack Gold Mine Project: 2012-2013 Rare Plant and Lichen Report*. Prepared for Pretium Resources Inc. by Enlivened Consulting and Rescan Environmental Services Ltd.: Vancouver, British Columbia.
- Rescan Environmental Services Ltd. 2013. *Application of an Environmental Assessment Certificate/ Environmental Impact Statement*. Prepared for Seabridge Gold Inc.: Vancouver, BC.
- Reuss, J. O., B. J. Cosby, and R. F. Wright. 1987. Chemical processes governing soil and water acidification. *Nature*, 329: 27-32.
- RIC. 1998. *Standard for Terrestrial Ecosystem Mapping in British Columbia*. Terrestrial Ecosystems Taskforce, Ecosystems Working Group, Resources Inventory Committee: Victoria, BC.
- Sayers, P., J. Hall, and I. Meadowcroft. 2002. Towards risk-based flood hazard management in the UK. *Proceedings of the Institution of Civil Engineers: Civil Engineering*, 150: 36-42.
- Schack-Kirchner, H., P. T. Fenner, and E. E. Hildebrand. 2007. Different responses in bulk density and saturated hydraulic conductivity to soil deformation by logging machinery on a Ferralsol under native forest. *Soil Use and Management*, 23 (3): 286-93.
- Schemske, D. W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating Approaches to the Conservation of Rare and Endangered Plants. *Ecology* 75: 584-606.
- Schwartz, C. C., M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the greater yellowstone ecosystem. *Wildlife Monographs*, 161: 1-68.
- Scrimgeour, G. J., P. J. Hvenegaard, and J. Tchir. 2008. Cumulative industrial activity alters lotic fish assemblages in two boreal forest watersheds of Alberta, Canada. *Environmental management*, 42 (6): 957-70.
- Sharmin, G., Holly Ridenour, and F. Philpot. 1998. *An Overview of Pine Mushrooms in the Skeena-Bulkley Region*.
- Sheldon, D. 2005. *Wetlands in Washington State: Volume 1: A Synthesis of the Science*. Washington State Department of Ecology.
- Society for Ecological Restoration. 2013. *A Project of the Society for Ecological Restoration International*. <http://www.globalrestorationnetwork.org/degredation/fragmentation/> (accessed August, 2013).
- Soil Classification Working Group. 1998. *The Canadian System of Soil Classification*. 3rd ed. Publication 1646. Research Branch, Agriculture and Agri-Food Canada. Ottawa, ON: NRC Research Press.
- Stathers, R. J., T. P. Rollerson, and S. J. Mitchell. 1994. *Windthrow Handbook for British Columbia Forests*. Working Paper 9401. BC Ministry of Forests Research Program: Victoria, BC.
- Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology*, 14 (1): 18-30.

- Trowbridge, R., A. MacAdam, and M. Kranabetter. 1999. *Ecological description and classification of highly productive pine mushroom sites in northwestern British Columbia*. Northwest Institute for Bioregional Research: Smithers, BC.
- Urbanska, K. M. and J. Chambers. 2002. *Handbook of Ecological Restoration: Restoration in Practice High-elevation ecosystems*. Cambridge, United Kingdom: Cambridge University Press.
<http://books.google.ca/books?id=dJpa74ubOKQC&pg=PA376&dq=Urbanska+%26+Chambers+2002+wind&hl=en&sa=X&ei=X6LZUqCMJozzoASMqIDYCA&ved=0CDkQ6AEwAA#v=onepage&q=Urbanska%20%26%20Chambers%202002%20wind&f=false> (accessed November 2013).
- US EPA. 1995. Compilation of Air Pollutant Emission Factors. In *Stationary Point and Area Sources*. Fifth Ed. n.p.: US EPA.
- Walker, D. A. and K. R. Everett. 1991. Loess ecosystems of northern alaska: regional gradient and toposequence at Prudhoe Bay. *Ecological Monographs*, 61 (4): 437-64.
- Watmough S.A. . 2002. A dendrochemical survey of sugar maple in south-central Ontario. *Water, Air and Soil Pollution*, 136 (165-187):
- WHO. 2000. *Air Quality Guidelines for Europe, Second edition*. World Health Organization Regional Publications, European Series No. 91:
- Wiensczyk, A. and S. Berch. 2001. Ecological description and classification of some pine mushroom habitat in British Columbia. *BC Journal of Ecosystems and Management*, 1 (2): 119-25.
- Zhao, Y., L. Duan, J. Xing, T. Larssen, C. P. Nielsen, and J. Hao. 2009. Soil Acidification in China: Is Controlling SO₂ Emissions Enough? *Environmental Science and Technology* 43 (21): 8021-26.

Personal Communications

- Kranabetter, M. 2010. Prince Rupert Forest Region Soil Scientist. Personal Communication: 2010.