31 March 2017

PHASE 1 - PROJECT #10022017

Quintette Caribou Habitat Restoration Plan

Submitted to:
BC Ministry of Forests, Lands and Natural Resource Operations - Ecosystems Section
#400, 10003 110th Ave
Fort St. John, BC
V1J 6M7

REPORT

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Executive Summary

The Quintette caribou population is part of the Central Group subpopulation (Designatable Unit [DU8]; COSEWIC 2011) of the Southern Mountain caribou population (EC 2014). The Central Mountain (DU8) subpopulation have not yet been assessed under the *Species At Risk Act* (SARA) or by the Province of BC, but are listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014). The Southern Mountain population of woodland caribou is federally listed as Threatened and on Schedule 1 of SARA (Government of Canada 2017), and provincially, as part of the South Peace Northern Caribou population. The Quintette herd is listed as S3 ('Special concern') by the BC Conservation Data Center (CDC) and are on the provincial Blue list (BC CDC 2017). There is currently a combined estimate of 219 caribou in the six Central Mountain herds, which is a significant decrease over the past 20 years (Seip and Jones 2016). Population census surveys for the Quintette herd conducted in 2016 counted a total of 41 caribou in the core high elevation winter range, and the population size was estimated to be 62 animals. This represents a 50% decline since the census three years prior (Seip and Jones 2016).

The loss and fragmentation of caribou habitat resulting from anthropogenic disturbances, and the subsequent increase in predator and primary prey populations in early seral habitats, has been identified as the main limiting factor to woodland caribou populations (BC MoE 2014a; EC 2014). An analysis conducted as part of the 2017 joint federal-provincial study of the Central Mountain herds showed 57.6% of the non-high elevation portion of the Quintette range is disturbed (ECCC and MoE 2017). The overall objective of the Quintette Caribou Habitat Restoration Plan is to transition anthropogenically disturbed, low quality caribou habitat into higher quality habitat, with a particular focus on linear disturbances. Habitat restoration will reduce the benefits that predators and their primary prey gain through linear corridor use and movement from low to high elevations, and establish a vegetation trajectory on these corridors that will, in the long-term, increase caribou habitat intactness. Development of the Quintette Caribou Restoration Plan is in support of the Quintette Strategic Action Plan (BC MFLNRO 2017) (QSAP). The QSAP identifies as its goals the recovery of the Quintette caribou herd to a level that supports a sustainable Treaty 8 caribou harvest, and to meet the Government of Canada's recovery targets for woodland caribou.

The Quintette Caribou Habitat Restoration Plan (the Plan) presented here is Phase 1 of a multi-phase project. The Plan has been designed to be implemented over a multi-year period, with desktop disturbance mapping and implementation planning to be completed in 2017-2018, implementation of restoration treatments to occur beginning tentatively in 2017 and continuing for approximately 5 years, and post-treatment monitoring to be conducted following restoration implementation. Contained within this Phase 1 document is a review of current state of knowledge of habitat restoration in woodland caribou range, the details from the linear disturbance mapping, an overview of the restoration program approach including a preliminary tactical multi-year implementation plan, an outline of the authorization process and assessments required to conduct restoration activities within the Quintette Range, and a summary of restoration and wildlife monitoring. An outline of next steps that are required in Phase 2 of this plan, pending additional funding, is also included. These preliminary priority zones and decisions about elevations to treat require further refinement in Phase 2, preferably through a workshop discussion with government agencies, as alternate areas may be prioritized depending on FLNRO priorities.

Study Limitations

This project was initiated by the BC Government following the announcement in February 2017 of additional funding for caribou recovery actions in the province. Golder Associates was contracted on 2 March 2017 with a deadline of 31 March 2017 to meet fiscal timelines to develop Phase 1. Phase 1 of this project is a preliminary restoration plan, and requires feedback from BC Ministry of Forests, Lands, and Natural Resources on approach, additional information, data manipulation, and ground-truthing to complete the linear mapping and implementation planning.

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1.0 INTRODUCTION

Woodland caribou (*Rangifer tarandus caribou*) in British Columbia (BC) occur in 52[1] herds that have been classified into three ecotypes – Boreal, Mountain, and Northern – based primarily on feeding behaviour and habitat associations (BC MoE 2014a). The Quintette caribou population is part of the Central Group subpopulation (Designatable Unit [DU8]; COSEWIC 2011) of the Southern Mountain caribou population (EC 2014). The Central Mountain (DU8) subpopulation have not yet been assessed by the *Species at Risk Act* (SARA) or by the Province of BC, but are listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; COSEWIC 2014). The Southern Mountain population of woodland caribou is federally listed as Threatened and on Schedule 1 of SARA (Government of Canada 2017), and provincially as part of the South Peace Northern Caribou population. The Quintette herd is listed as S3 ('Special concern') by the BC Conservation Data Center (CDC) and are on the provincial Blue list (BC CDC 2017). There is currently a combined estimate of 219 caribou in the six Central Mountain herds including Quintette, which is a significant decrease over the past 20 years (Seip and Jones 2016) and well below the federal recovery plan's population objective of 2000 caribou in the Central Mountain population (EC 2014) and the provincial population objective of at least 1,200 caribou in the South Peace Northern Caribou population (BC MoE 2014a).

The loss and fragmentation of woodland caribou habitat resulting from anthropogenic disturbances, and the subsequent increase in predator and primary prey populations in early seral habitats, has been identified as the main limiting factor to woodland caribou populations (BC MoE 2014a; EC 2014). The South Peace region of Northeast BC has experienced rapid land-use change since the 1990s as a result of resource extraction activities such as oil and gas exploration and development, large-scale commercial forestry, agriculture, mining, and wind energy development (Schneider et al. 2003; Nitschke 2008; Williamson-Ehlers 2012). Within the Central Mountain local population unit ranges, 21% of the high-elevation habitat and 24% of the non-high elevation habitat is allocated to existing coal mining tenures, while 14% of the high elevation and 46% of the non-high elevation habitat is considered part of the Timber Harvesting Land Base, and therefore feasible for harvest (ECCC and MoE 2017). An analysis conducted as part of the 2017 joint federal-provincial study of the Central Mountain herds showed 57.6% of the non-high elevation portion of the Quintette range is disturbed (including seismic lines; 54.3% when seismic lines are excluded; ECCC and MoE 2017). Disturbances were mapped following methodology developed for the boreal caribou recovery strategy (EC 2012), which included anthropogenic disturbances with a 500 m buffer and fires < 40 years old (EC 2014). Another analysis conducted by Glencore, using 2015 Landsat imagery (compared to 2011 imagery used by ECCC and MoE 2017), identified 62% of the low elevation/matrix habitat as disturbed (2016). Both analyses demonstrate that the minimal threshold of 65% undisturbed in low elevation/matrix critical habitat (EC 2014) has been exceeded. High elevation critical habitat does not have an acceptable threshold for disturbance (ECCC and MoE 2017). Figure 1 depicts the linear disturbance footprint only within the Quintette Range.

The cumulative development of these activities threatens the integrity of forest ecosystems by producing forested landscapes that are younger and increasingly fragmented (Schneider et al. 2003; Williamson-Ehlers 2012). Land-use development in the Peace Region accounted for an 89% increase in edge habitats and a 67% increase in early seral habitat (Nitschke 2008). Early seral habitats support higher densities of moose (*Alces americanus*), elk (*Cervus elaphus*), and deer (*Odocoileus sp.*), which in turn support higher predator densities (particularly wolves [*Canis lupus*]), and lead to increased risk of predation on caribou (Wittmer et al. 2007; Nitschke 2008; Wilson 2009).

[1] This number of populations includes the Burnt Pine herd which is now considered functionally extirpated (Seip and Jones 2013a).

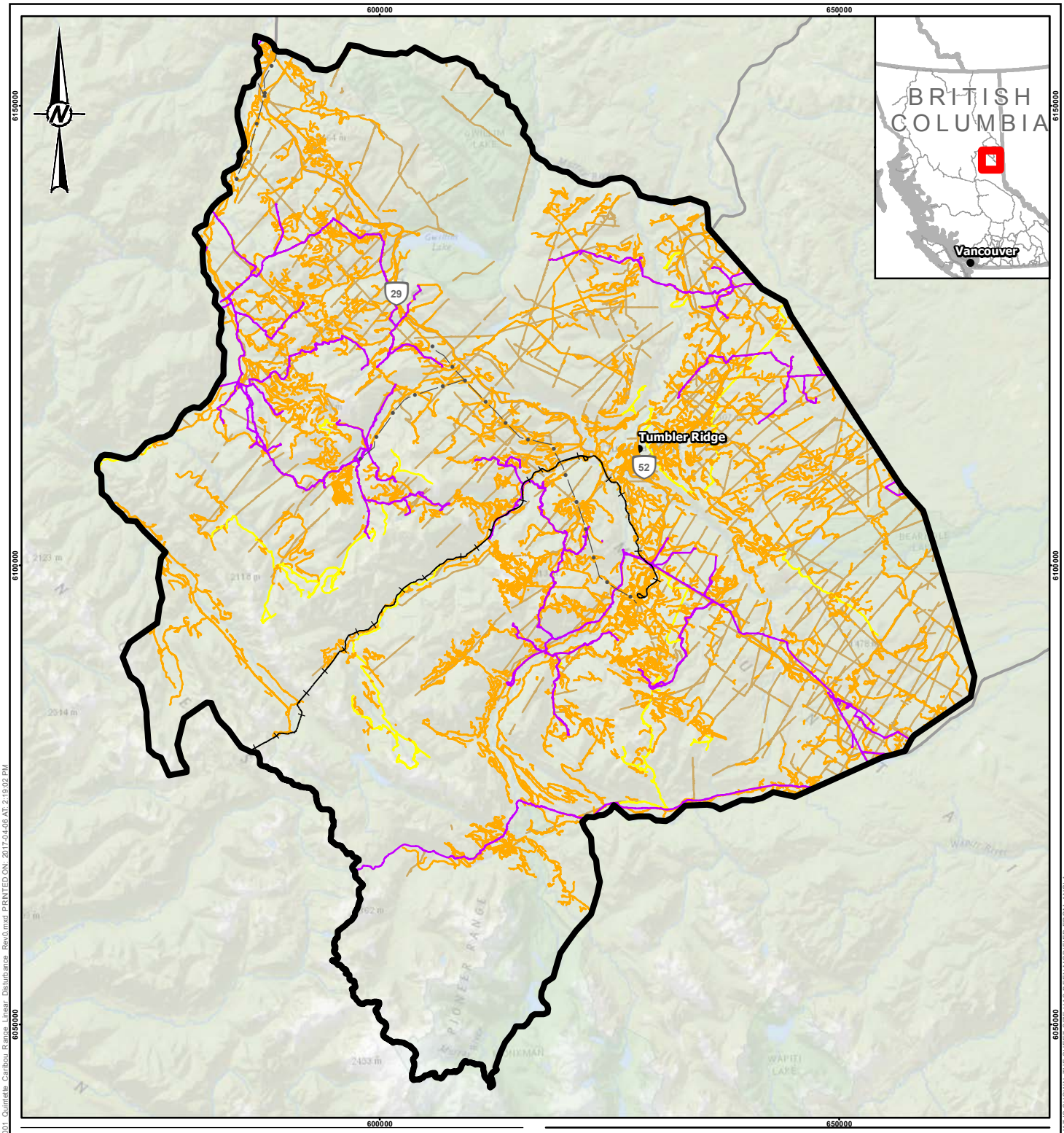
The Quintette Strategic Action Plan (QSAP) was developed in 2017 by the BC Government in response to the rapidly increasing rate of decline of the Quintette herd, and has two overarching goals: the recovery of the Quintette herd to a level that supports a sustainable Treaty 8 caribou harvest, and to meet the Government of Canada's Species at Risk recovery targets (BC MFLRNO 2017). The QSAP identifies three primary objectives to achieve these goals:

1) Grow the population of the Quintette herd at least 3% per year and preferably 6-9% per year.

2) Meet population targets of at least 200 and preferably 300 animals by 2048.

3) Restore and protect sufficient habitat to result in a self-sustaining Quintette caribou herd (BC MFLRNO 2017).

The development of the Quintette Caribou Restoration Plan (the Plan) is in support of Objective 3 of the QSAP (BC MFLNRO 2017). The overall objective of the Plan is to transition anthropogenically disturbed, low quality woodland caribou habitat into higher quality habitat, with a particular focus on linear disturbances. Habitat restoration will reduce the benefits that predators and their primary prey gain through linear corridor use, and establish a vegetation trajectory on these corridors that will in the long term increase woodland caribou habitat intactness. Habitat restoration of linear corridors should be implemented using methods that reduce wildlife and human use and promote late seral stage vegetation establishment, which will create larger contiguous patches of preferred caribou habitat than currently exist. Woodland caribou habitat restoration planning is needed to identify what habitat restoration activities should be undertaken, where they should be undertaken, and how to sequence restoration plans.



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY

LINEAR DISTURBANCE TYPE

- CUTLINE / TRAIL
- PIPELINE
- RAILWAY
- RECREATIONAL TRAIL
- ROAD
- TRANSMISSION LINE

- QUINTETTE CARIBOU RANGE BOUNDARY

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REFERENCE(S)

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CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
STUDY LOCATION AND LINEAR DISTURBANCE OVERVIEW

CONSULTANT
Golder Associates

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DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

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1.1 Ecological Setting

The Quintette herd range is 607,519 hectares (ha) in size, with the majority occurring in the Central Canadian Rocky Mountains ecoregion. The eastern extent of the herd range occurs in the Southern Alberta Upland ecoregion (Demarchi 2011).

The Central Canadian Rocky Mountains ecoregion consists of steep-sided, but round-topped mountains and foothills that are lower than ranges of the Rockies to either the south or the north, while the Southern Alberta Upland ecoregion is a rolling plateau that rises slowly to the north of the Peace River (Demarchi 2011). The boundary between the two is quite indistinct and dissected by eastward flowing rivers. The area is drained by the Moberly, Pine, Sukunka, Wolverine and Murray rivers which all ultimately drain into the Peace River in BC; and by Redwillow, Wapiti, Red Deer, and Belcourt rivers which all flow into Alberta before joining the Peace River (Demarchi 2011).

Pacific air spills over the mountains of the Hart Range, bringing moist, mild air to the eastern valleys, while Arctic air passes from east to west bringing very cold, dense air to the western valleys and lowlands. The Hart Foothills are in a rainshadow of easterly flowing Pacific air coming over the main Hart Ranges, however, when low-pressure systems build up in central Alberta moisture can be pushed westward into this area bringing considerable moisture. In the winter, cold dense Arctic air often stalls along the eastern margin or in the valleys, bringing periods of intense cold and considerable snowfall (Demarchi 2011).

The BC provincial Biogeoclimatic Ecosystem Classification (BEC) system groups together ecosystems into categories using a hierarchical classification system. Geographic areas influenced by similar climatic conditions are classified into BEC zones and subzones, defined by their stable “late-seral” or “near-climax” vegetation communities (Pojar et al. 1991). In the Quintette herd range, the Boreal White and Black Spruce (BWBS) zone occurs in the outer eastern valleys of the eastern boundary with the Alberta Plateau; the Sub-Boreal Spruce (SBS) zone occurs in the interior and western valleys, the Engelmann Spruce – Subalpine Fir (ESSF) zone occurs on all the middle and upper mountain slopes; and the Boreal Altai Fescue Alpine (BAFA) zone occurs on the mountain summits (Demarchi 2011). The Quintette herd range comprises nine different BEC subzones (Table 1; Figure 2).

Table 1: Proportion of BEC Subzones in the Quintette Herd Range

BEC Subzone	Subzone Name	Elevation Class[(a)]	Area (ha)	Proportion of Herd Range (%)
BWBSmw	Boreal Black and White Spruce Moist Warm	Low	88,819	14.6
BWBSwk1	Boreal Black and White Spruce Murray Wet Cool	Low	158,463	26.1
SBSwk2	Sub-Boreal Spruce Finlay-Peace Wet Cool	Low	52,677	8.7
ESSFmv2	Engelmann Spruce – Subalpine Fir Bullmoose Moist Very Cold	Low	162,721	26.8
ESSFwk2	Engelmann Spruce – Subalpine Fir Misinchinka Wet Cool	Low	53,260	8.8
ESSFwc3	Engelmann Spruce – Subalpine Fir Cariboo Wet Cold	Mid	34,028	5.6
ESSFmvp	Engelmann Spruce – Subalpine Fir Moist Very Cold Parkland	High	12,369	2.0
ESSFwcp	Engelmann Spruce – Subalpine Fir Wet Cold Parkland	High	20,419	3.4
BAFAun	Boreal Altai Fescue Alpine Undifferentiated	High	24,763	4.1
Total			**607,519**	**100**

(a) This elevational class is based on mountain caribou habitat elevations.

BWBSmw

The BWBSmw subzone occurs over 15% of the herd range in the Hart Foothills from approximately 750 to 1,050 metres above sea-level (masl) in elevation (DeLong et al. 2011). Zonal sites are typified by mature stands of white spruce (*Picea glauca*), with occasional trembling aspen (*Populus tremuloides*). However, due to its extensive history of fire and anthropogenic disturbance, seral stands dominated by trembling aspen, with occasional components of balsam poplar (*Populus balsamifera* ssp. *trichocarpa*) and lodgepole pine (*Pinus contorta*), often occur over large tracts of land in this subzone (Meidinger and Pojar 1991). Black spruce (*Picea mariana*) forests, often with a minor component of tamarack, are common on organic soils. Black spruce also occurs mixed with lodgepole pine on upland sites with cold soils or limited rooting availability (DeLong et al. 2011).

BWBSwk1

The BWBSwk1 subzone occurs over 26% of the herd range, on mid and upper slopes in the Hart Foothills above the BWBSmw. Elevation generally ranges from 1,050 to 1,200 masl (DeLong et al. 2011). Mature forests are dominated by white spruce, with black spruce occurring on wetter and poorer sites. Pure black spruce stands can occur on very wet sites on organic soils. Lodgepole pine and trembling aspen are dominant seral species, forming widespread forests along with minor amounts of white and/or black spruce. Trembling aspen is common as a seral species at lower elevations, especially on warm aspects (DeLong et. al. 2011).

SBSwk2

The SBSwk2 subzone occurs over 9% of the herd range in valley floors and lower slopes of the Hart Range and the southwestern Hart Foothills. Elevation generally ranges from 750 to 1,200 masl (DeLong 2004). Zonal sites are dominated by white spruce and subalpine fir (*Abies lasiocarpa*), with lodgepole pine commonly occurring on drier sites. Forests dominated by black spruce and lodgepole pine occur on gentle slopes with a cool aspect and in wetlands (DeLong 2004). Oak fern (*Gymnocarpium dryopteris*) commonly occurs in the understory.

ESSFmv2

The ESSFmv2 subzone occurs over 27% of the herd range. Is the driest and coldest of the lower elevation ESSF variants in the Prince George Forest Region, reflecting its northern position and its lee position with respect to the Rocky Mountains (DeLong et al. 1994). Elevations generally range from 1,000 to 1,400 masl (DeLong et al. 1994). Forest fires are more frequent relative to other variants of the ESSF, which has resulted in a larger portion of the landscape being dominated by seral lodgepole pine stands (DeLong et al. 1994). Zonal sites are dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir forests (Delong et al. 1994). Lodgepole pine occurs on dry sites and black spruce may occur on wet sites. White-flowered rhododendron (*Rhododendron albiflorum*), black huckleberry (*Vaccinium membranaceum*), and black gooseberry (*Ribes lacustre*) are common in the shrub understory.

ESSFmvp

The ESSFmvp subzone occurs over 2% of the herd range, above the ESSFmv2 in the southwestern Hart Foothills. It varies from open canopy parkland forest near the ESSFmv2 boundary to patches of krummholz interspersed with expanses of non-forested ecosystems (i.e., shrubby seepage areas, dwarf-shrub/herbaceous meadows), which in turn transition to alpine at approximately 1800 masl. Subalpine fir is the dominant tree species in the ESSFmvp parkland. White-flowered rhododendron, black huckleberry, scrub birch (*Betula nana*), crowberry (*Empetrum nigrum*), and mountain heathers (*Cassiope mertensiana, Phyllodoce empetriformis)* are common in the understory. Herbs and grasses such as mountain arnica (*Arnica latifolia)*, Sitka valerian (*Valerian sitchensis*), subalpine daisy (*Erigeron peregrinus*), pussytoes (*Antennaria* spp.), Altai fescue (*Festuca altaica*), and woodrushes *(Luzula* spp.) are common in the herb layer.

ESSFwk2

The ESSFwk2 subzone occurs over 9% of the herd range, on mid-slopes of steep valleys in the Hart Range above the SBSwk2 subzone. Elevation generally ranges from 900 to 1,300 masl (DeLong et. al. 1994). Very high snow accumulations (>3 m depth) occur in this subzone. Climax forests are dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir. Very few seral stands exist in this subzone because of the lack of fire history, although some sporadic lodgepole pine stands do exist. Sitka alder (*Alnus viridis* ssp. *sinuata*) swales are common, especially on north-facing slopes; these have been determined to be very (200+ years) old (DeLong et. al. 1994).

ESSFwc3

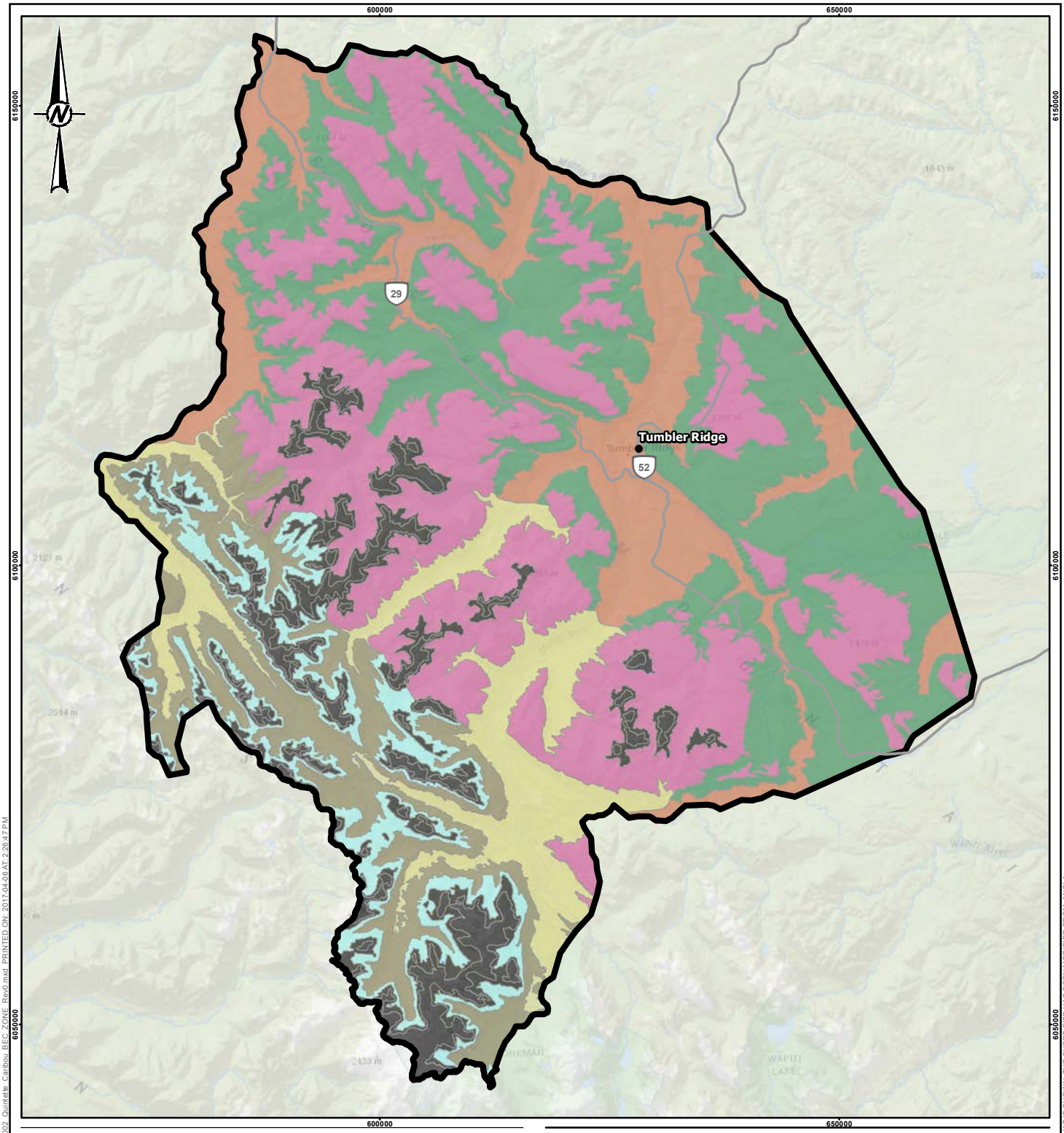
The ESSFwc3 subzone occurs over 6% of the herd range, on mid- and upper slopes in the Hart Range above the ESSFwk2 subzone. Elevation generally ranges from 1,300 to 1,550 masl (DeLong et. al. 1994). It is similar to the ESSFwk2 but is colder with more persistent snowpack and therefore a shorter growing season. Forest canopy tends to be widely spaced and clumpy, and are generally dominated by subalpine fir and/or Engelmann spruce (DeLong et. al. 1994). White-flowered rhododendron and black huckleberry are common in the shrub understory.

ESSFwcp

The ESSFwcp subzone occurs over 4% of the herd range, as the parkland transition zone between the ESSFwc3 subzone and true alpine at approximately 1,800 masl. The subzone varies from open canopy parkland forest near the ESSFwc3 boundary to patches of krummholz interspersed with expanses of non-forested ecosystems (i.e., shrubby seepage areas, dwarf-shrub/ herbaceous meadows). Subalpine fir is the dominant tree species in the ESSFmvp parkland.

BAFAun

The BAFAun subzone occurs over 4% of the herd range, at the highest elevations in the Hart Foothills and Hart Range above 1,800 masl. MacKenzie (2006) describes the harsh alpine climate of this zone as being cold, windy, and snowy with low growing season temperatures and a very short frost-free period. By definition, the alpine is treeless. The BAFAun subzone is dominated by rock, talus slopes, boulder fields, and sparsely to well-vegetated morainal and colluvial materials. Vegetation consists of heaths and other dwarf shrubs, graminoids (grasses, sedges and woodrushes), mosses, lichens and sporadic trees in krummholz form.



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

BEC SUBZONE

- BOREAL BLACK AND WHITE SPRUCE MURRAY WET COOL (BWBSwk1)
- BOREAL BLACK AND WHITE SPRUCE MOIST WARM (BWBSmw)
- ENGELMANN SPRUCE – SUBALPINE FIR BULLMOOSE MOIST VERY COLD (ESSFmv2)
- SUB-BOREAL SPRUCE FINLAY-PEACE WET COOL (SBSwk2)
- ENGELMANN SPRUCE – SUBALPINE FIR MISINCHINKA WET COOL (ESSFwk2)
- ENGELMANN SPRUCE – SUBALPINE FIR CARIBOO WET COLD (ESSFwc3)
- PARKLAND AND ALPINE (ESSFwcp, ESSFmvp & BAFAun)

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REFERENCE(S)

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PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
BEC SUBZONES IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

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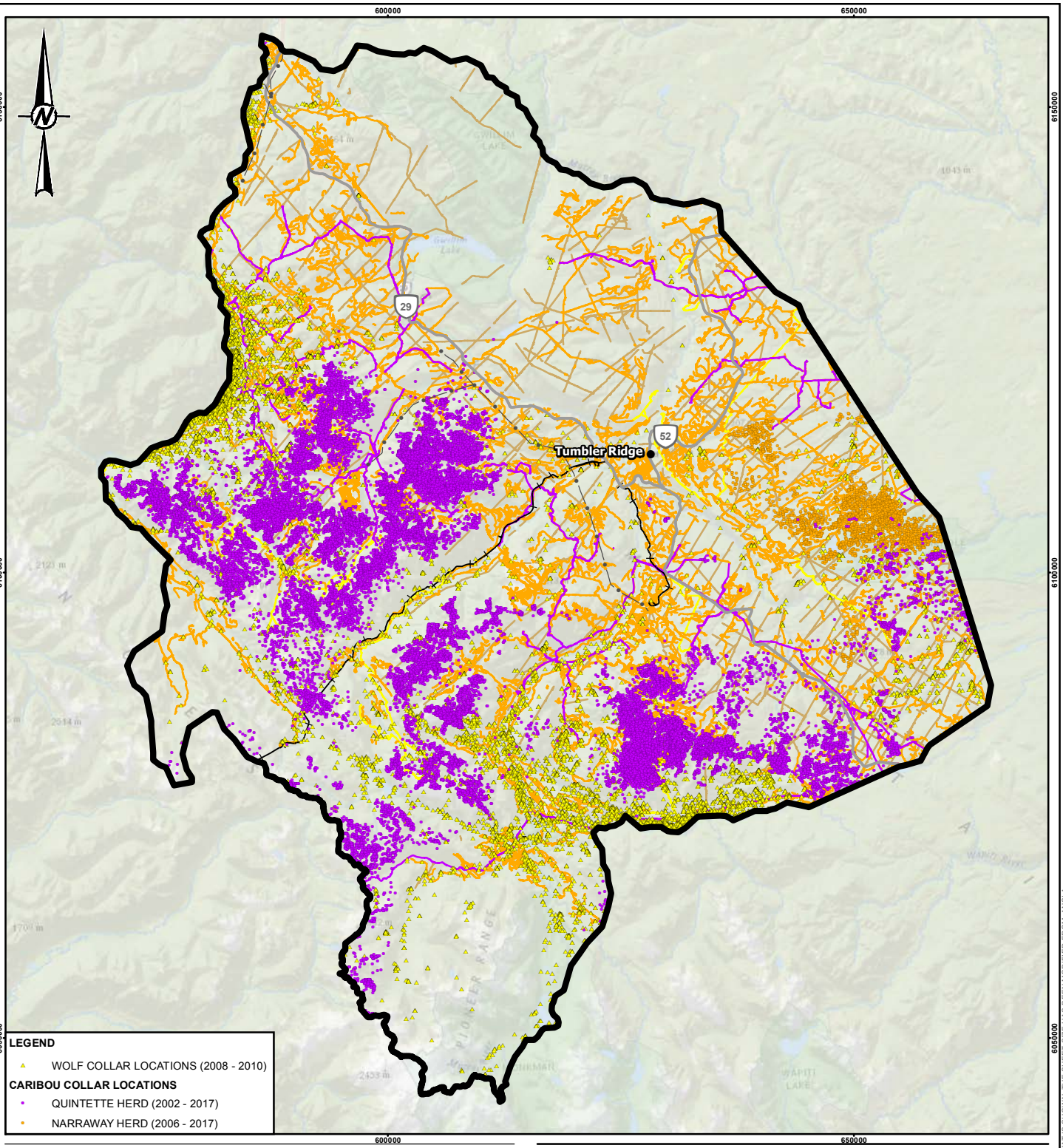
1.2 Quintette Caribou Population

The Quintette herd is associated with alpine and subalpine habitats of the eastern foothills of the Rocky Mountains south and west of the town of Tumbler Ridge (Seip and Jones 2011). Their range covers an area of 607,519 ha (DataBC 2017a). They typically spend spring, summer and fall in the alpine and winter in low elevation forests or wind-swept ridges where there is shallow snow (BC MoE 2014a). Many of the mountain complexes in this area have been designated as caribou and mountain goat Ungulate Winter Range (UWR) by the province (Goddard 2005; BC MoE 2014b). Several of these mountain complexes have also been designated as Wildlife Habitat Areas (WHA) for caribou calving and rutting (BC MoE 2014b). The Central Rocky Mountains Ecoregion caribou research program has collected telemetry data on the Quintette herd since 2002 (Jones et al. 2004). Both VHF and GPS radiocollar data indicates that the Quintette herd is typically located at elevations greater than 1,600 m and selects for alpine habitat and subalpine stands (fir and parkland) during all seasons (Jones 2007, 2008) (Figure 3). There is some evidence of caribou movement between the Quintette herd and the adjacent Bearhole-Redwillow herd to the east (Seip and Jones 2011), and also of range overlap with the Parsnip herd to the west (Jones 2007) (Figure 3).

High elevation habitat that is largely predator free has been identified as a key element to managing South Peace Northern Caribou (BC MoE 2013a). High elevation habitat provides a refuge from predators, as well as provides an accessible food source through winter, particularly lichen-bearing windswept ridges (BC MoE 2013b). Core habitat areas for the Quintette herd have been identified by the province based on habitat modeling in conjunction with telemetry and aerial survey data (Jones 2008; Seip and Jones 2012, 2014, 2015; Williamson-Ehlers et al. 2013). Approximately 71,276 ha of the Peace Forest District have been identified as core high-elevation winter habitat for the Quintette herd (Seip and Jones 2012). Historically, the Quintette herd used two areas for high-elevation winter habitat, one in the Mt. Spieker area and the other in the Quintette Mountain area. However, impacts to high elevation habitats have compromised the behaviour of the Quintette caribou. The expansion of TREND's coal mine from Roman Mountain to Quintette Mountain in 2010 shifted caribou habitat use significantly, and the Quintette Mountain group now use low-elevation forested habitat in the winter where predation risk is higher. This shift resulted in additional modeling to identify and protect low-elevation core winter habitat used by the displaced Quintette caribou (Seip and Jones 2014). High-elevation summer range has also been modeled using telemetry locations; approximately 112,694 hectares of high-elevation habitat in the Peace Forest District is identified as highly and very highly selected in the summer (Seip and Jones 2015) (Figure 4).



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

LINEAR DISTURBANCE TYPE

- CUTLINE / TRAIL
- PIPELINE
- RAILWAY
- RECREATIONAL TRAIL
- ROAD
- TRANSMISSION LINE

0 10 20

1:600,000 KILOMETERS

REFERENCE(S)

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
LINEAR DISTURBANCES AND GPS RADIOCOLLAR LOCATIONS FOR CARIBOU (2002 - 2016) AND WOLVES (2008 - 2010) IN THE QUINTETTE RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	3

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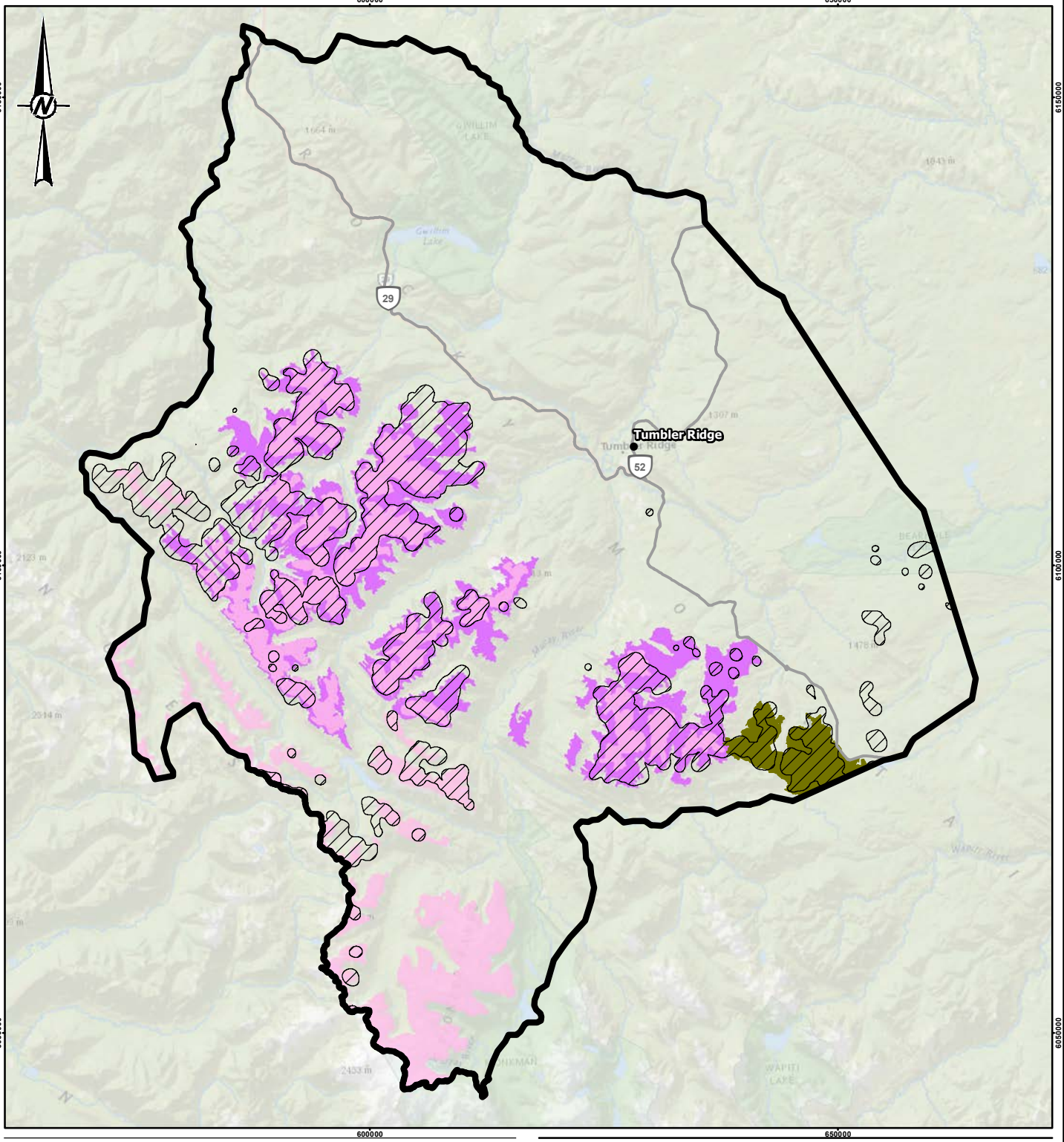

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- HIGH ELEVATION WINTER RANGE (BEC)
- HIGH ELEVATION WINTER RANGE (HEWR)
- KERNEL DENSITY 90%
- LOW ELEVATION WINTER RANGE (LEWR)
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20

1:600,000 KILOMETERS

REFERENCE(S)

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
QUINTETTE HIGH ELEVATION WINTER RANGE (HEWR), LOW ELEVATION WINTER RANGE (LEWR), AND 90% KERNEL DENSITY ESTIMATORS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	JE
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
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Population census surveys for the Quintette herd were conducted in 2008, 2013 and 2016. In 2008, a total of 173 caribou were counted in the census area and the population size was estimated between 173 and 208 animals (Seip and Jones 2011). In 2013, a total of 100 caribou were counted in the census area, resulting in a population estimate between 114 and 129 animals (Seip and Jones 2013a). A comparison between the population census data from 2008 and 2013 showed a notable decrease in the minimum count and population estimate for the Quintette herd, which is indicative of a declining population (Seip and Jones 2013a). In 2016, a population census survey counted a total of 41 caribou in the core high elevation winter range, and the population size was estimated to be 62 animals. This represents a 50% decline in numbers since the census three years prior (Seip and Jones 2016).

Calf recruitment and adult mortality surveys have also been conducted annually for the Quintette herd since 2002. In general, to ensure persistence or growth of a population, recruitment must be equal to or greater than adult mortality. In 2011, Seip and Jones classified the Quintette herd as increasing due to a low annual adult mortality rate (9%) and high calf recruitment (20%) between 2003 and 2011. However, calf recruitment rates in 2012 and 2013 were below the average adult mortality rate of 9%, which may reflect the observed population decline between 2008 and 2013 (Seip and Jones 2013a). In 2016, the annual adult mortality rate was 35% and calf recruitment was estimated to be 20%. Calf recruitment may have increased in conjunction with the wolf control program initiated in 2015, however the adult mortality rate was significantly higher than is sustainable (Seip and Jones 2016).

Wolf and grizzly bear predation are the suspected causes of low calf survival and high adult mortality (Seip and Jones 2013a, 2016). In northern BC, wolves are most commonly associated with the distribution of moose, and the most current (2014) estimate for the moose population in the Peace region is between 50,000 and 80,000 animals (BC MoE 2014c). Estimated wolf densities measured in northern BC have ranged from 10 to 44 wolves per 1,000 km^2 (Hatler et al. 2008), and the most recent (2014) estimate for the wolf population in the Peace region is between 1,300 to 3,000 wolves (BC MFLNRO 2014a). Telemetry data indicate that wolves are infrequently located in Quintette core high-elevation winter habitat (Williamson-Ehlers 2012) (Figure 3) and only two of eight known caribou mortalities recorded between 2002 and 2013 were attributed to wolves (Seip and Jones 2013a). However, any amount of adult or calf mortality from predation can have severe impacts on herd stability due to the small size and isolation of caribou herds in the South Peace region (Wittmer et al. 2005; Williamson-Ehlers 2012), as is apparent from the recent population surveys (Seip and Jones 2016).

1.3 Peace Northern Caribou Recovery Efforts

1.3.1 Peace Northern Caribou Committee (PNCC)

The Peace Northern Caribou Committee (PNCC) is a collaborative regional forum, established in 2011, and includes representatives from government agencies, industry, First Nations (West Moberly First Nation [WMFN], Saulteau First Nation [SFN]), McLeod Lake Indian Band (MLIB), and recreation and community groups. The forum focuses on the recovery of the South Peace Region's at-risk caribou herds through the development of local initiatives (WMFN and SFN 2014).

1.3.2 Klinse-Za Herd Recovery Action Plan

On 10 June 2013, the WMFN released a draft action plan for the Klinse-Za herd of woodland caribou (McNay et al 2013). The draft action plan follows the requirements of the federal SARA. It includes the goal of restoring a stable or increasing population of at least 654 caribou within 21 years (McNay et al 2013). A long-term outcome of the draft action plan is to allow sustainable First Nation harvest of caribou to resume, following a decades-long self-imposed moratorium on woodland caribou hunting by WMFN (CNW 2014). Actions under the action plan which have been implemented include maternal penning and predator control to reduce caribou mortality (McNay et al. 2016).

1.3.3 Klinse-Za Maternal Penning Program

Maternal penning as a strategy to reduce predation on newborn caribou in the South Peace area was recommended by First Nations, and provincial and federal governments (BC MoE 2013b; McNay et al 2013; Environment Canada 2014). The Klinse-Za maternal penning program, led by WMFN, SFN and the Province of BC, is currently in its fourth year of implementation (PNCC 2014). The program is an emergency measure to slow the decline of the Klinse-Za herd and prevent their extirpation, and is run coincident with a predator removal program (McNay et al 2013; WMFN undated). Between 2014 and 2016, 34 pregnant cows have been captured, transported and isolated from wolves at the penning site (FWCP 2015). In each year, cows and their calves were released after spending up to 4 months at the penning site. A total of 20 calves were added to the population from the pen program between 2014 and 2016 (McNay et al. 2016).

1.3.4 Predator-Prey Management Program

The extent of wolf predation on caribou has been unsustainable over the last few decades (BC MoE 2014d). During this time industrial exploration and development, forest harvesting, and road building has altered the landscape (BC MoE 2014d). The corresponding increase in the extent and distribution of early-seral habitat has benefited other ungulates and resulted in an increase in wolf number and distribution across caribou ranges (BC MoE 2014d). Predator management is deemed a necessity in the recovery efforts of the southern mountain caribou population (BC MoE 2014d; Environment Canada 2014), and wolf control programs are designed to achieve a wolf density below 3 wolves/1000km^2, which is believed to be the threshold for self-sustaining caribou populations (BC MFLNRO 2017). In response to the continued decline of the caribou herds in the South Peace, a wolf control program was initiated in 2015 in Moberly, Kennedy/Scott, and Quintette ranges (Seip and Jones 2016). Approximately 41-68% of the estimated wolf population in Quintette was removed in 2015, and 100% of the estimated wolf population in Quintette was removed in 2016 (Seip and Jones 2016). Other management tools for managing predator populations include reducing ungulate prey populations through increased hunting quotas and restoring habitat with limited ungulate forage plants (EC 2014), but direct predator management is currently the primary focus of the Province (BC MFLRNO 2017).

1.3.5 Twin Sisters Native Plants Nursery

The Twin Sisters Native Plants Nursery (TSNPN) is located in Moberly Lake, BC, and joint owned by WMFN and SFN (Twin Sisters Native Plants Nursery 2017). The nursery was originally established to provide a source of seedlings to reclaim Walter Energy's mine sites (Davis pers comm. 2017). The Twin Sisters Native Plants Nursery now services other mine companies, as well as oil and gas, forestry, hydro-electrical, and landscaping companies (Government of BC 2015; Davis pers comm. 2017). The work undertaken at the TSNPN is helping to address the shortage of local plant stock in northern BC required for use in reclamation (Royal Roads University 2013; Government of BC 2015).

The nursery has two 7,000 square foot greenhouses, each with a capacity of 234,000 seedlings if cropped only once per year (Davis pers comm. 2017). By taking advantage of varying growth rates of various species, over 500,000 seedlings can be produced per season (Davis pers comm. 2017). Staff at the nursery collect, dry, clean and cold store native seeds (including cold storing since 2014), facilitate the germination of seeds, tend to seedlings, and ship plants (TSNPN 2017). In 2014, the nursery provided seedlings to the Willow Mine site. In 2016, staff at the nursery were invited to visit the site and see successful establishment of the nursery's seedlings (Davis pers comm. 2017).

In 2016, TSNPN began collecting seed for the High Pine Pipeline Project for Spectra Energy (Enbridge). This pipeline will cross through caribou habitat, and so staff at the nursery are selecting the most appropriate species of seed to collect, clean, store, stratify and grow to restore this caribou habitat (Davis pers comm. 2017). The TSNPN are also collecting seed specific to caribou dietary requirements and has participated in the collection and storage of lichens for the Klinse-Za Maternal Penning Program (Davis pers comm. 2017).

The Native Plant Propagation Program (NPPP) runs out of the TSNPN. Royal Roads University developed the NPPP, in partnership with WMFN and SFN, native plant horticulture and reclamation experts, and mining companies. The NPPP is a training program aimed at teaching WMFN and SFN members how to raise native plants for the purposes of reclamation (Royal Roads University 2013).

1.4 Habitat Restoration: Current State of Knowledge

The federal Recovery Strategy for Southern Mountain caribou (EC 2014) identifies maintaining 65% undisturbed habitat in low elevation and Type 1 matrix range as an important threshold to providing a 60% chance that a local population will be self-sustaining; there should be minimal disturbance in high-elevation winter range (EC 2014). Coordinated actions to reclaim woodland caribou habitat is a key step to meeting current and future caribou population and habitat objectives.

"Restored habitat" for caribou has not been clearly defined in either provincial or federal caribou recovery strategies. As caribou habitat restoration initiatives have become more widespread in the last decade, there has been much debate regarding what treatment types are appropriate for habitat restoration, and how to measure success. In response to research suggesting predators and primary prey are increasing their use of linear features, one focus for restoration treatments has been to establish treatments that will provide an immediate removal of the benefits that linear disturbances provide to predators (referred to as Functional Restoration) (e.g., Cody 2013; Cenovus 2013; Saxena 2014; Golder 2015a). In addition, controlling off-road access which compacts soil and inhibits revegetation recovery has been identified as an equally important focus for restoration treatments.

1.4.1 Caribou Habitat Restoration in Boreal Ranges

Boreal caribou habitat restoration projects have been on-going within boreal caribou ranges since 2001 in Alberta and since 2015 in BC (Golder 2015a). The Caribou Range Restoration Project (CRRP) was implemented between 2001 to 2007 in west-central Alberta (Szkorupa 2002), and explored the use of silviculture methods to restore linear features, including tree/shrub seedling planting, seeding of tree species, tree/shrub transplanting, mounding and soil de-compaction (CRRP 2006, 2007a,b). Several other initiatives and trials in Alberta boreal caribou ranges have been completed (e.g. DES 2004; Golder 2005, 2009, 2011, 2012; Enbridge 2010; Osko and Glasgow 2010) or are ongoing (Golder 2010; OSLI 2012) to effectively restore linear disturbances and polygon features resulting from the oil and gas industry activity. The focus of most initiatives has been on establishing vegetation along pipelines or seismic lines, with the combined goals of creating line-of-sight breaks, directly restoring habitat with transplanted vegetation, planting shrub and tree seedlings, sowing native shrub and tree seed, reducing human access to reclaimed areas to allow undisturbed natural vegetation growth, and reducing wildlife usage to reduce or eliminate the benefits wildlife obtain from linear corridor usage. Appendix A summarizes boreal caribou habitat restoration techniques developed from previous research and monitoring projects.

Tree regeneration on seismic lines within treed areas is considered a key determinant of recovery success (MacFarlane 2003). Vegetation re-growth on seismic lines is mainly influenced by the moisture and nutrient regime, the method of clearing used, and the level of human use (e.g., Golder 2009; van Rensen et al. 2015). Natural vegetation regeneration does occur, with linear disturbances in mesic sites the most likely to regenerate naturally without restoration treatments implemented (all things being equal), whereas a linear disturbance in a bog or fen is least likely to regenerate naturally (van Rensen et al. 2015). Natural regeneration to 3 m vegetation height within 30 years is inversely related to terrain wetness, line width, proximity to roads as a proxy for human use of lines, and lowland ecosites such as fens and bogs (van Rensen et al. 2015). Areas adjacent to major rivers illustrate high probability of regeneration. Overall, terrain wetness and the presence of fens have the strongest negative effect on natural regeneration (van Rensen et al. 2015).

Natural regeneration can be hindered, however, depending on the level of disturbance both during construction of the feature, and use by humans on Off Highway Vehicles (OHVs). Conventional seismic lines cleared by bulldozer may take as long as 112 years to reach 95% recovery to woody vegetation in the absence of restoration efforts (Lee and Boutin 2006). This slow tree regeneration has been attributed to root damage from the original disturbance, compaction of the soil in tire ruts, insufficient light reaching the forest floor, maintenance of apical dominance from surrounding stands, introduction of competitive species (i.e., planted seed mixes), drainage of sites (i.e., regeneration slowest on poorly drained sites with low nutrient availability such as bogs) and repeated disturbances (e.g., OHVs, animal browsing, repeated exploration) (Revel et al. 1984; MacFarlane 1999, 2003; Sherrington 2003).

Seismic lines in west-central Alberta that were allowed to regenerate naturally, without any significant human activity (e.g., re-cleared to ground level for winter access or seismic program use), achieved an average height of 2 m across all ecosite types within 20 to 25 years (Golder 2009). Restoration efforts have also been negatively compromised when OHVs destroyed seedlings after planting (Enbridge 2010; Golder 2011, 2012).

1.4.2 Caribou Habitat Restoration in Mountain Ranges

In 2013, the BC Government released two documents: the Planning and Approval of Development Activities in the Peace Northern Caribou Plan Area (BC MoE 2013c) and the Guidelines for Development of Caribou Mitigation and Monitoring Plans for South Peace Northern Caribou (BC MoE 2013a). These guidance documents informed proponents that development activities being proposed in high elevation winter range would require Caribou Mitigation and Monitoring Plans (CMMP) as a permit condition.

The habitat restoration initiatives thus far in mountain ranges have been tied to restoration of mining sites, with some research focused initiatives occurring on linear corridors (Appendix B). Mine CMMPs developed in the South Peace region include:

- Roman Mine (including a revision to the revegetation plan on the adjacent Trend Mine; Stantec 2012)
- Quintette Mine (Teck Coal Ltd. 2013)
- Sukunka Mine (Stantec 2015)
- Bonanza Ledge Mine (not yet finalized; Golder 2017)

Habitat restoration initiatives proposed in CMMPs have included minimizing the use of seed mixes and forage species that attract moose and deer; seeding spoil slopes with tree/shrub mix that is predominately coniferous species; planting moderate tree densities to discourage browse species; inoculating arboreal lichen onto conifer species; spreading logs, stumps, rocks and woody debris piles; and deactivating and restoring roads to impede predator movement (Stantec 2012, 2015; Teck Coal Ltd. 2013; Golder 2017). These CMMP initiatives have yet to be implemented or are still in early stages, therefore the efficacy of these techniques in mountain ranges is unknown. There remains considerable uncertainty with efficacy of caribou habitat restoration in high elevation, mountainous areas.

2.0 RESTORATION PROGRAM APPROACH

2.1 Approach

The overall objective of the Quintette caribou habitat restoration project is to transition low quality caribou habitat into higher quality habitat by reducing the benefits predators and their primary prey gain through linear corridor use, reduce predator access and movement from low elevation to high elevation caribou habitat, and establish and/or promote a vegetation trajectory on these corridors that will increase caribou habitat intactness in the long-term.

This project is designed to be implemented over a multi-year period given the size of the Quintette range and amount of disturbance. The preliminary plan developed here for Phase 1 includes desktop disturbance mapping and implementation planning. Phase 2 will include desktop and field validation of the linear disturbance inventory and vegetation regrowth to quantify restoration candidate areas, and pre-treatment monitoring proposed for 2017 to 2018. Depending on funding, implementation of restoration treatments is proposed for 2018 to 2023, followed by post-treatment vegetation and wildlife monitoring.

The overall approach for developing the Restoration Project includes:

- Reviewing the current state of knowledge regarding caribou habitat restoration, with a particular focus on habitat restoration in mountainous regions (Phase 1).
- Compiling landscape data and completing an initial linear disturbance inventory (Phase 1).
- Manually interpreting through desktop means vegetation regrowth in order to map the current vegetation status of disturbance areas to identify potential treatable sites (Phase 2).
- Ground-truthing potential treatment sites and obtaining site level data required to select restoration treatment, as well as data regarding field equipment accessibility and other field considerations for treatment implementation (Phase 2).
- Identifying regulatory requirements, obtaining appropriate authorizations to access and implement habitat restoration measures, and identifying Indigenous community opportunities for participation and engagement (Phase 2).
- Developing a tactical plan to treat (actively and/or passively) the identified treatable sites within the Quintette range over a multi-year time period beginning in 2018 (Phase 1 and 2).
- Implementation of a vegetation and wildlife monitoring program to determine restoration effectiveness (Phase 2).

2.2 Scope

This restoration project focuses on restoring low and mid elevation BEC units in the Quintette caribou range. Restoration is focused on low and mid elevation for several reasons, including:

- The majority of linear disturbance lies in low and mid elevation.
- Restoration can only be implemented on linear features that are not under disposition, and are therefore on crown land.

- Mines in high elevation habitat have their own restoration and reclamation regulatory requirements including restoring to caribou habitat within individual CMMPs.
- Restoration of lichen in alpine and subalpine ecosystems would take too long for the rapidly declining Quintette caribou population.
- Efforts will be more feasible and reasonable in cost given the accessibility of low and mid elevation.
- Ongoing wolf control efforts in low and mid elevation will work in conjunction with habitat restoration to have a combined positive effect on the recovery of the Quintette caribou population.

2.3 Conservation Targets

Conservation targets are species, ecological communities, and ecological systems that are the focus of the restoration work (CMP 2013). The conservation targets for this restoration project are:

- **Quintette caribou (woodland caribou– northern ecotype - central mountain population –– Quintette herd).** Southern mountain caribou have been harvested by First Nations for centuries, and so have great cultural significance (EC 2014). Owing to their dwindling numbers, many First Nations have self-imposed moratoriums on subsistence hunting of southern mountain caribou in an effort to curb the decline (EC 2014).
- **Coniferous forest.** Northern ecotype caribou rely on late successional and old-growth coniferous forest for their primary winter habitat (Stevenson et al. 2001; Cichowski et al. 2004; Apps and McLellan 2006; Serrouya et al. 2008; COSEWIC 2014).

2.4 Goals

Goals are the desired state or conditions to be achieved (CMP 2013). The goals for this restoration project will be SMART goals: Specific, Measurable, Appropriate, Realistic and Time-limited (CMP 2013).

A short-term goal will be to block linear corridors in a manner that prevents motorized access by humans, and restricts their usage as travel corridors by wolves and other ungulates. The number of linear corridors to be blocked, and the time-frame for this to be achieved, will be determined during a workshop attended by qualified MFLNRO staff.

A long-term goal will be to restore linear corridors to mature coniferous forest suitable as low- and mid-elevation northern mountain caribou habitat. The precise length of linear corridors to be restored, and the time-frame for this to be achieved, will be determined during a workshop attended by qualified MFLNRO staff. Suitable caribou habitat is habitat with the necessary biophysical attributes to support sustainable caribou populations. Biophysical attributes include little to no sensory disturbance, access to ice-free water, snow-free or low snow areas, minimum physical obstructions, low predation risk, access to lichen, emergent vegetation, mineralize soils, and wetlands, and canopy snow interceptions (EC 2014). The Project goals and measurable targets will be refined in Phase 2 upon further discussion between government and stakeholders.

2.5 KEAs and Indicators

Key ecological attributes (KEAs) are aspects of a conservation target's biology or ecology that, if present, define a "healthy" target, and if missing or altered, would lead to the loss or extreme degradation of that target over time (CMP 2013). Indicators are measurable entities that document changes in KEAs over time (CMP 2013); restoration projects should have both short and long term indicators and measurable targets (Golder 2015b) to take into account the short term goal of reducing predator movement into caribou habitat and the long term goal of achieving functional habitat.

Indicators to assess revegetation following restoration treatment are outlined in the Habitat Restoration Monitoring Framework (Golder 2015b) and include:

- density and percent cover of targeted tree species
- leader growth
- growth and vigour of targeted vegetation
- presence of invasive species
- presence and level of ATV tracks and game trails (to assess access control)

The indicators (i.e., % of surviving planted seedlings, percent cover, density of targeted vegetation, evidence of chlorosis, evidence of access) will be measured during vegetation monitoring surveys at pre-determined intervals during the restoration project timeline (Golder 2015b).

2.6 Human Well-being Targets

A key component to achieving a successful restoration project is stakeholder engagement (CMP 2013). The primary interests of the key stakeholder groups will be critical to integrate into restoration planning. The key stakeholders, and their primary interests are:

- **Indigenous Communities**: opportunities for traditional use activities (e.g., gathering food and medicinal plants, trapping, hunting) and to participate in and lead restoration efforts.
- **Ministry of Environment (MoE) and MFLNRO**: resilient, self-sustaining northern mountain caribou populations (MCST 2006).
- **Lease or Tenure Holders**: opportunities for exploration and development of resources including forestry.
- **Snowmobile Groups and other Recreational Users**: opportunities for recreational use activities within designated trail systems.

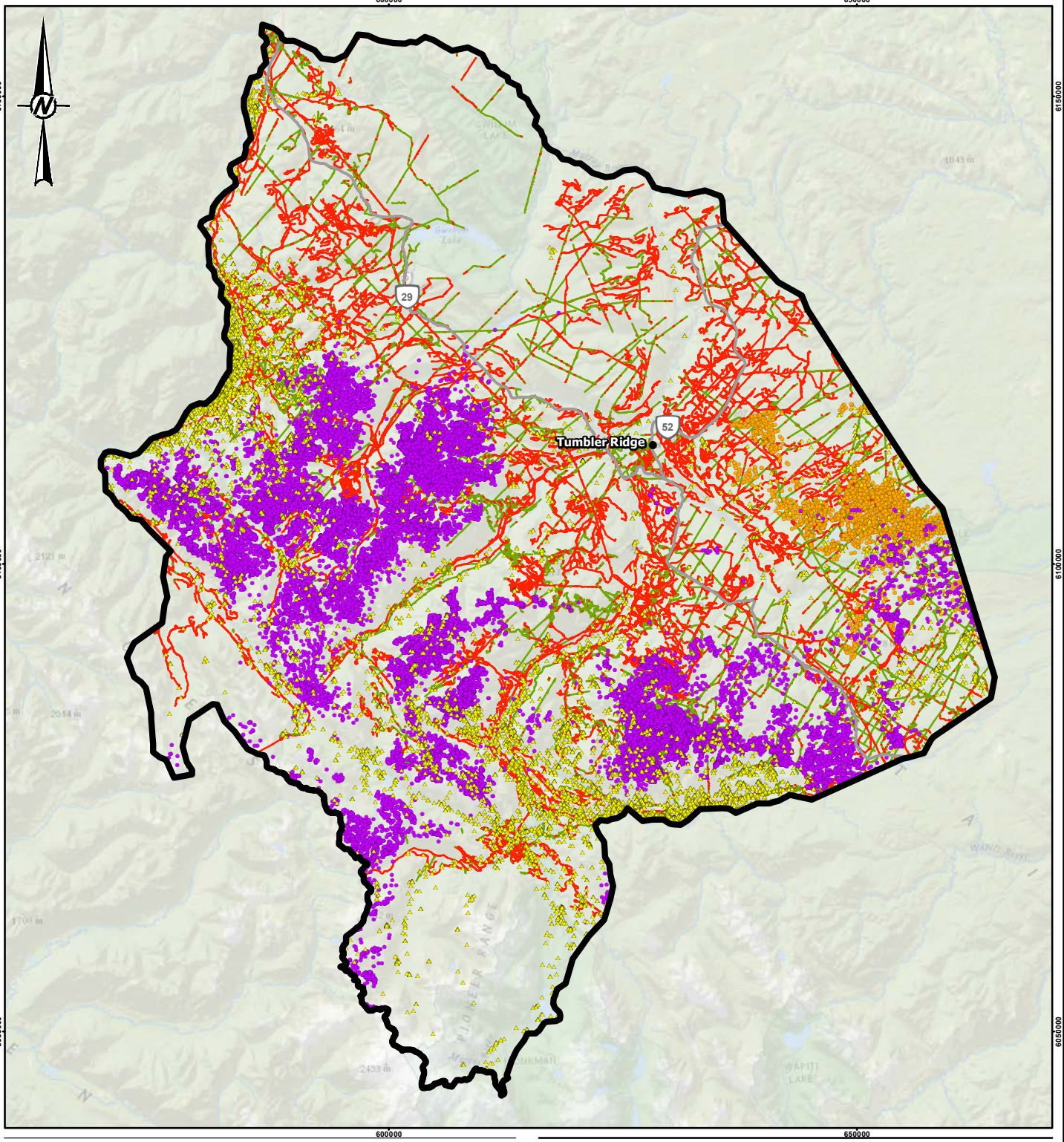
3.0 LINEAR DISTURBANCE MAPPING

3.1 Imagery and Spatial Feature Acquisition

Existing linear disturbance information for the Quintette Range was obtained from government sources, with documented metadata. These included:

- Confirmed 2D seismic survey corridors, sourced from the BC Oil and Gas Commission (1996 to 28 May 2015) (BC OGC).
- Confirmed 2D seismic survey corridors from CANVEC datasets (2013), sourced from Natural Resources Canada.
- Possible or probable 2D corridors from CANVEC (2013) datasets and the Digital Road Atlas (2016), sourced from GeoBC.
- Unclassified linear disturbance corridors obtained from the BC OGC (2016) and Digital Road Atlas (2016) (GeoBC).

Aerial imagery (SPOT 1.5m, 2013-2014) for the Quintette Range was used to digitise any additional linear disturbances absent from the available government data sources. Roads and pipeline access roads, other than those defined as unclassified, were excluded from the linear disturbance dataset. Roads and pipelines are considered active dispositions and therefore are not currently candidate areas for restoration treatments in this Plan (Figure 5). Access management is also a component of the QSAP. Candidate roads for restoration will be identified through Province-led access management planning at a later date.



LEGEND

- POPULATED PLACE
- WOLF COLLAR LOCATIONS (2008 - 2010)

CARIBOU COLLAR LOCATIONS

- QUINTETTE HERD (2002 - 2017)
- NARRAWAY HERD (2006 - 2017)
- PRIMARY HIGHWAY

LINEAR DISTURBANCE

- NOT TREATMENT CANDIDATE
- TREATMENT CANDIDATE
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20
1:600,000 KILOMETERS

REFERENCE(S)

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
LINEAR DISTURBANCE CANDIDATES FOR RESTORATION TREATMENT AND GPS RADIOCOLLAR LOCATIONS FOR CARIBOU (2002 - 2017) AND WOLVES (2008 - 2010) IN THE QUINTETTE RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
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3.2 Mapping Interpretation Process, Quality Assurance, Quality Control, and Field Verification

Phase 1 time and data/imagery constraints only allowed for the development of a preliminary linear disturbance inventory. In Phase 2, the linear disturbance layers will need to be internally reviewed, and remote sensing data compiled and interpreted to assess natural regrowth on some of the linear disturbances initially identified for treatment, in an effort to exclude some linear segments as treatment candidates where significant vegetation regrowth has occurred naturally. Remote sensing options and costs are presented in Appendix C, and assume coverage of the entire Quintette range. Costs will decrease if remote sensing was restricted to priority areas for restoration identified by government experts. A quality assurance and quality control assessment should be completed following the analysis of remote sensing data. Lessons learned from remote sensing and linear mapping interpretation for the Parker Caribou Habitat Restoration Plan (Golder 2015a) demonstrated that there are limitations for assessing vegetation heights up to 50 cm using remote sensing; therefore, it is recommended that all treatment candidate lines (i.e., sites with less than 50 cm height classification) require field verification (ground-truthing).

4.0 PRELIMINARY IMPLEMENTATION TACTICAL PLAN

The preliminary tactical plan has been developed to guide the implementation of habitat restoration treatments along candidate treatment areas identified during the desktop linear classification exercise. Additional disturbance data needs to be acquired and interpreted from remote sensing (Appendix C) and treatment areas need to be ground-truthed to refine the tactical plan.

4.1 Quintette Caribou Range: Understanding the Context

The Quintette caribou range encompasses a large area (607,519 ha) with land management measures and policies that both assist and conflict with caribou habitat needs. The land base is being managed by several government agencies and under numerous provincial Acts (Section 4.2).

In British Columbia, specific amounts of habitats important for the winter survival of ungulates are maintained under the Forest and Range Practices Act (FRPA) and protected under the Government Actions Regulation (GAR) as Ungulate Winter Range (UWR) and Wildlife Habitat Areas (WHAs). Since 2011, UWRs and WHAs are also addressed within the provincial Oil and Gas Activities Act (OGAA). Ungulate Winter Range is defined as an area that contains habitat that is necessary to meet the winter habitat requirements of an ungulate species. Ungulate Winter Range are based on ungulate habitat requirements in winter, as interpreted by the BC Ministry of Environment regional staff from current scientific and management literature, local knowledge, and other expertise (BC MoE 2017). In the Quintette caribou range, UWRs cover approximately 223,417 ha (37%) of the range (Figure 6). Wildlife habitat areas are smaller discrete mapped areas that are necessary to meet the habitat requirements of a Species at Risk or regionally important wildlife species (BC MoE 2017). Currently, WHAs cover approximately 58,028 ha (9.5%) of the Quintette range landbase; approximately 53,122 ha of WHA overlaps with UWRs (Figure 6). The UWR and WHA's current protection status makes these areas a priority for caribou restoration efforts to be applied, as restoration efforts will not be impacted by future land uses.

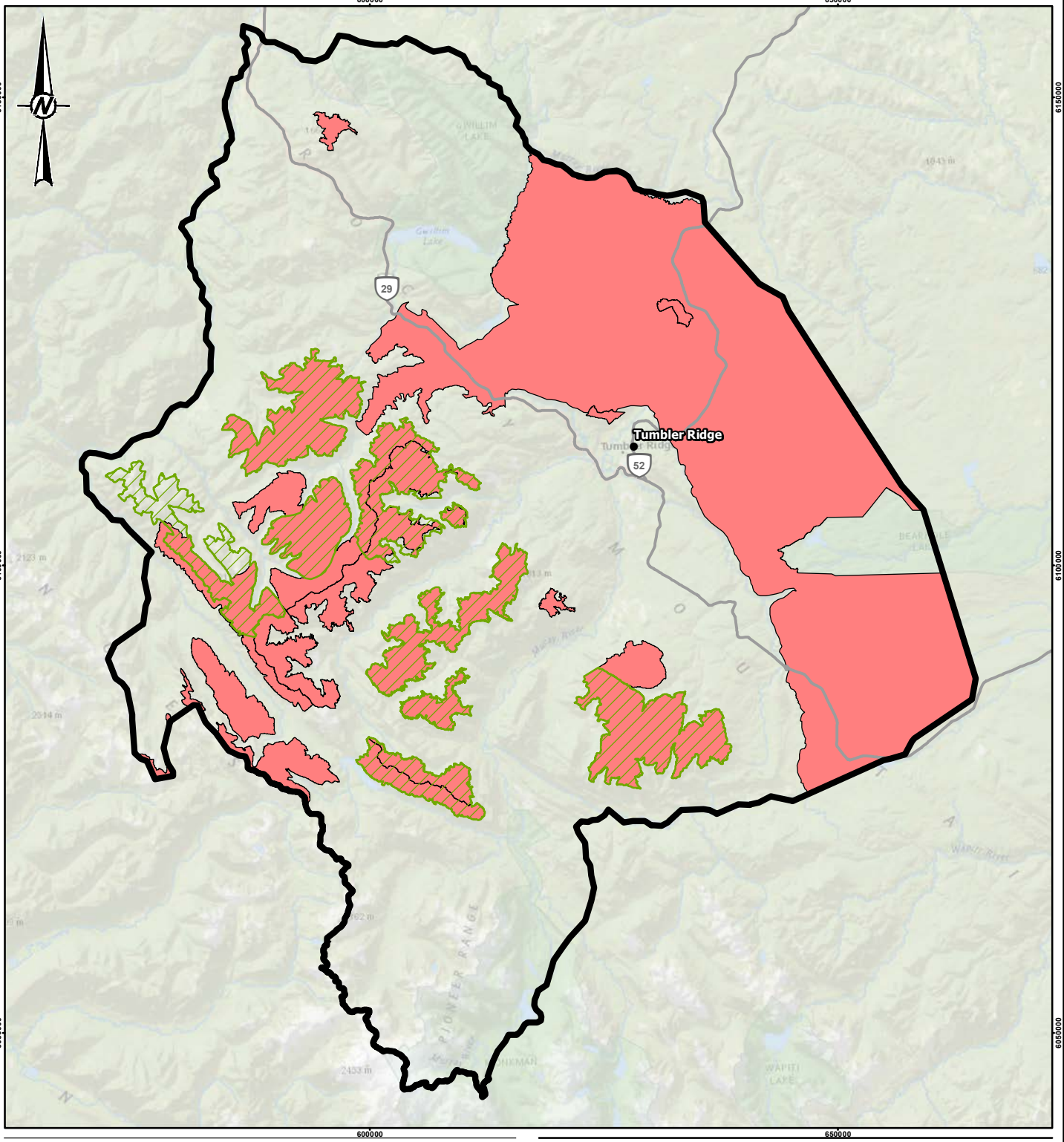
Other habitat protection measures in the Quintette range include provincial parks and Old Growth Management Areas (OGMA). Five provincial parks (Gwillim Lake, Bearhole Lake, Monkman Park, Sukunka Falls, and Hole in the Wall) make up approximately 60,154 ha (10%) of the landbase in the Quintette caribou range. OGMAs are legally established areas of old growth forest where forestry is prevented or constrained; 8% (49,740 ha) of the Quintette range is managed as OGMAs (Figure 7).

Anthropogenic disturbances in the Quintette range include forestry, mining, oil and gas developments, and recreational trails (Figure 8). According to the 2017 joint federal-provincial study of the Central Mountain herds, nearly 58% of the mid and low elevation portion of the Quintettte range is disturbed by anthropogenic (with the addition of a 500 m buffer) or natural disturbances, which exceeds the minimum 65% undisturbed habitat that has been identified as a threshold for self-sustaining populations (EC 2014; ECCC and MoE 2017).

Mountain pine beetle (MPB) has been a major source of natural disturbance in the Quintette herd range. The MPB was first confirmed in the Dawson Creek area in February 2004. The main provincial outbreak expanded rapidly, but it was thought at the time the terrain of the Rocky Mountains and relative scarcity of host material (i.e. lodgepole pine) at heights of land would prevent its spread east (Duthie-Holt et. al. 2007). This was not the case, as scattered infestations were observed on eastern slopes of the Hart Range which likely originated from the main outbreak. Initial spread rates were low from 2004 to 2006; however conditions were optimal in 2006 and the outbreak spread significantly into the Peace Forest District, north into the Fort St. John Timber Supply Area and east into Alberta (Duthie-Holt et. al. 2007). According to provincial Vegetation Resource Inventory (VRI) data, 179,539 ha (30%) of the Quintette range has been affected by MBP infestation (Figure 9).

In addition to existing infestation areas, the FLNRO Forest Health Program maintains a spatial database of bark beetle susceptibility ratings, created by Geospatial Services Group in 2014 (DataBC 2017b). The hazard rating is calculated based on the proportion of pine basal area per hectare, stand age, stand density, and proximity to existing infestation (BC MFLNRO 2014b). Approximately 95,762 ha (15.7%) of the Quintette range is rated medium or high susceptibility to MBP infestation (DataBC 2017b; Figure 10). Areas susceptible to MPB should be considered within a prioritization process for where to focus restoration efforts. It may be more ideal to focus restoration efforts outside of medium to high susceptibility to MBP infestation.

Habitat restoration activities have the potential to impact historic and archeological sites during physical reclamation means. The Plan would consider mitigations to avoid damage or impact to these sites. There are 677 historic and archeological sites in the Quintette caribou range (Cooper pers. comm. 2017), and approximately 62,360 ha (10%) of the Quintette range has been identified as having archaeological potential (Figure 11).



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY
- UNGULATE WINTER RANGE
- WILDLIFE HABITAT AREA

0 10 20

1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
WILDLIFE HABITAT AREAS (WHA) AND UNGULATE WINTER RANGES (UWR) IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-04
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
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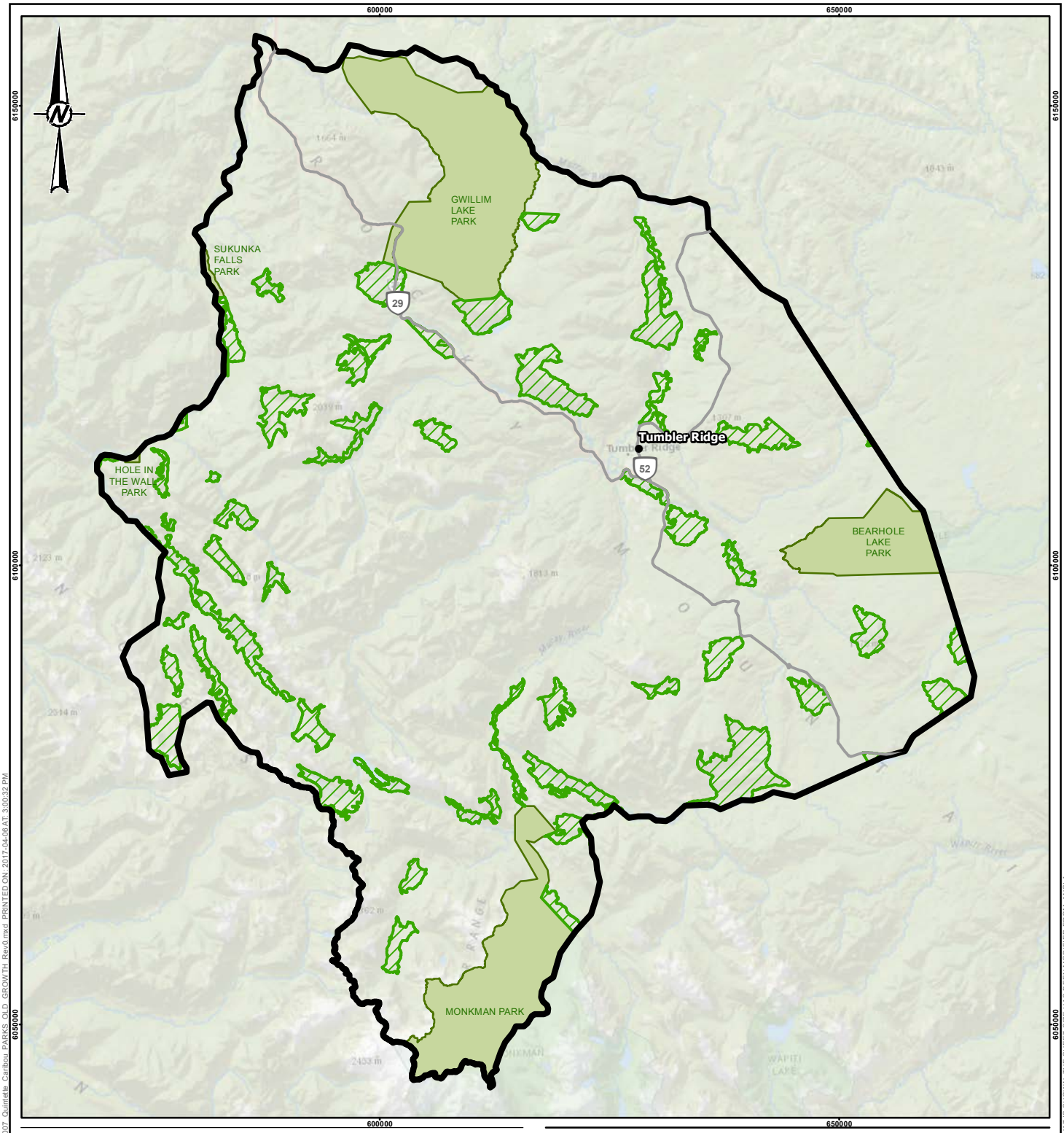

LEGEND

- POPULATED PLACE
- OLD GROWTH MANAGEMENT ZONES
- PARKS AND PROTECTED AREAS
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20

1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
PROVINCIAL PARKS AND OLD GROWTH FOREST MANAGEMENT AREAS IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	7

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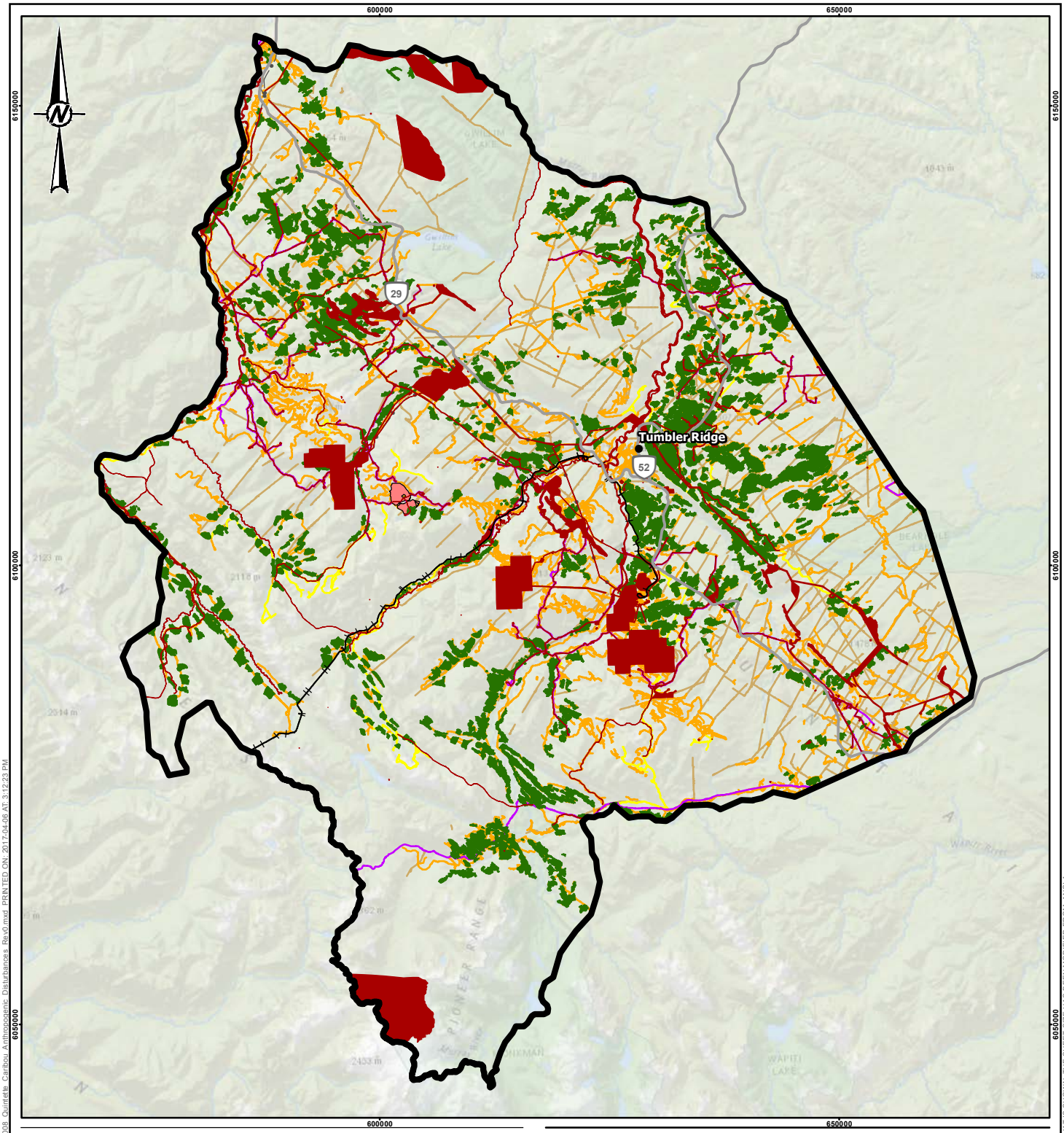

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY

LINEAR DISTURBANCE TYPE

- CUTLINE / TRAIL
- PIPELINE
- RAILWAY
- RECREATIONAL TRAIL
- ROAD
- TRANSMISSION LINE

- CUTBLOCK
- MINE SITE
- CROWN TENURE
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20
1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
ANTHROPOGENIC DISTURBANCES IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	8

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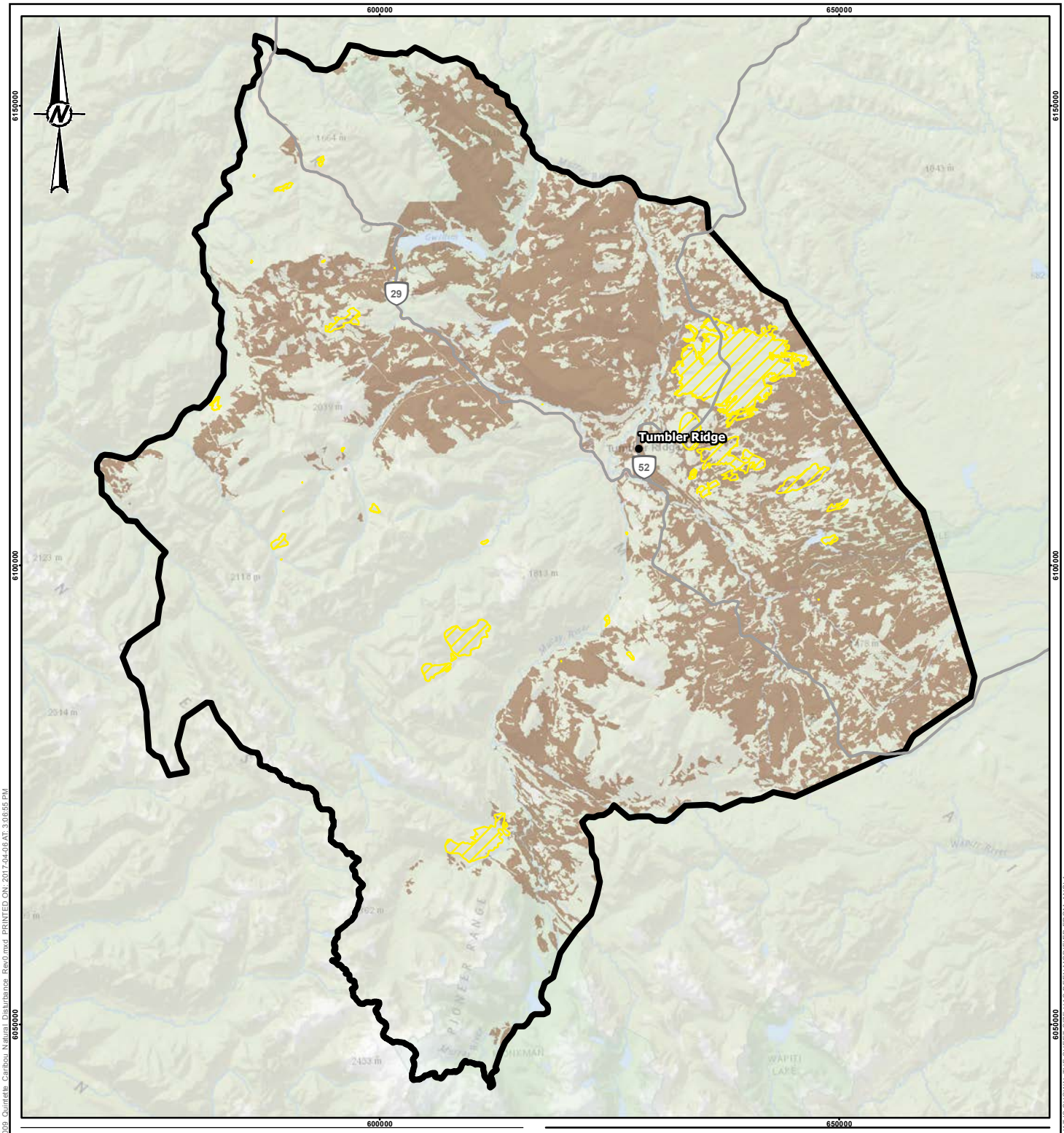

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- MOUNTAIN PINE BEETLE AFFECTED AREA
- WILDFIRES (1977 - 2016)
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20

1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
NATURAL DISTURBANCES IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	JE
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	9

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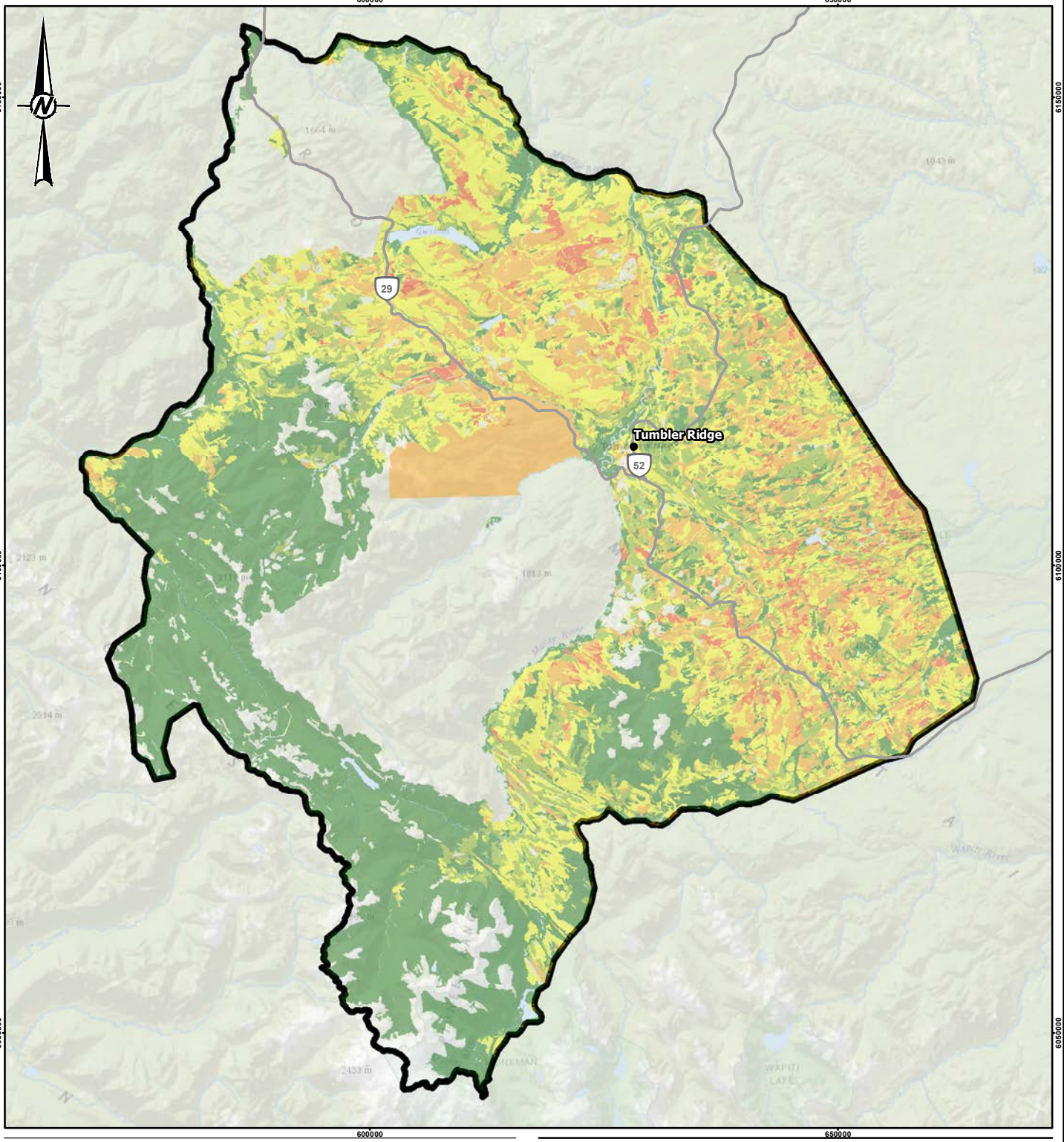

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

MOUNTAIN PINE BEETLE SUSCEPTIBILITY

- HIGH
- MEDIUM
- LOW
- VERY LOW
- NONE

0 10 20

1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
MOUNTAIN PINE BEETLE SUSCEPTIBILITY RATING IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	JE
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	9

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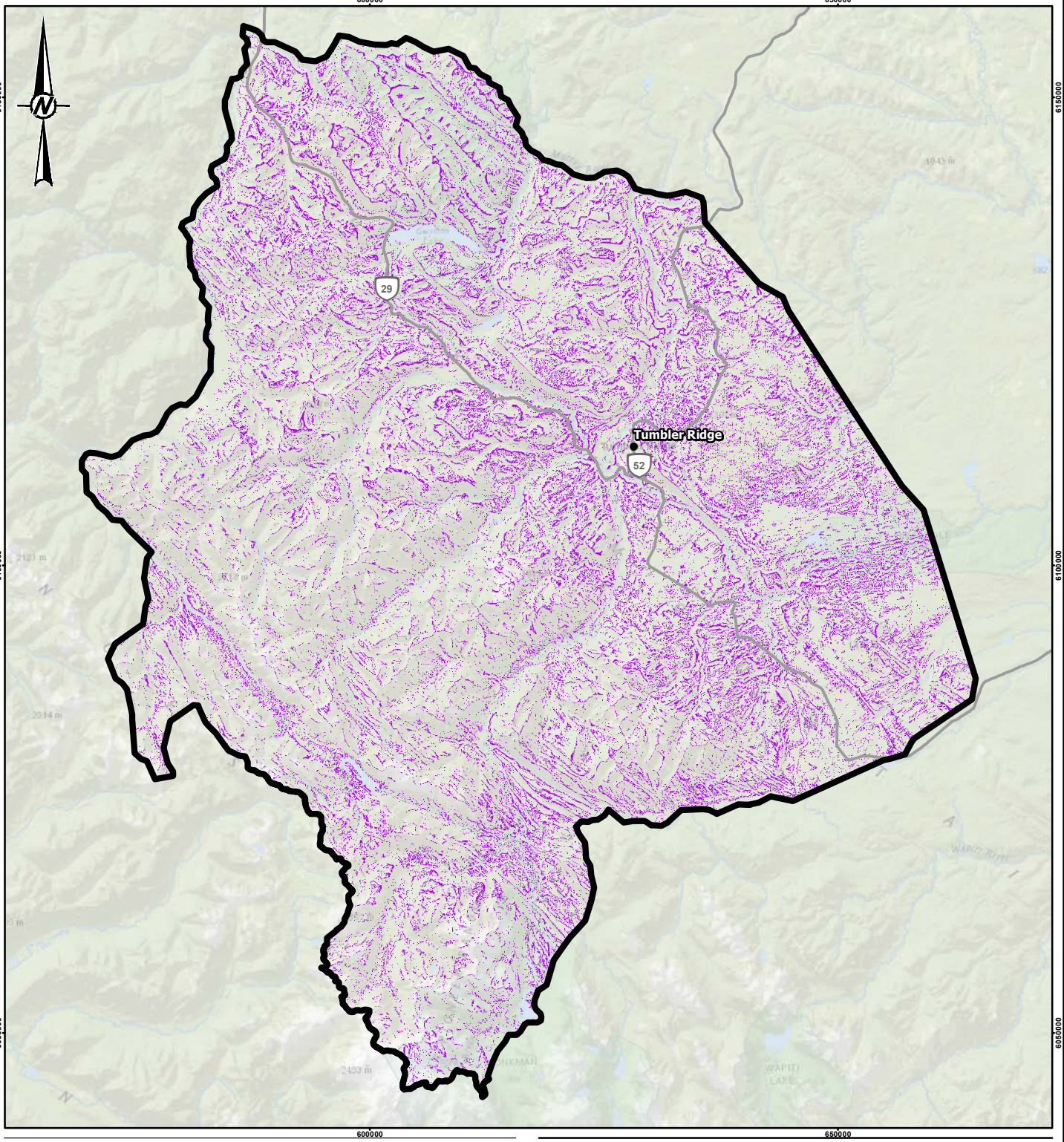

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- ARCHAEOLOGICAL POTENTIAL
- QUINTETTE CARIBOU RANGE BOUNDARY

0 10 20

1:600,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
ARCHAEOLOGICAL AND CULTURALLY IMPORTANT SITES AS RECORDED IN THE QUINTETTE CARIBOU RANGE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	JE
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	11

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4.2 Relevant Provincial Legislation

The Quintette caribou range has overlapping land uses overseen by several provincial ministries. This section summarizes the most relevant provincial legislation which either pertains to, or should be considered during the planning process of, a range specific caribou habitat restoration plan (Campbell pers. comm. 2017). Ideally, habitat restoration efforts should be focused in areas where caribou habitat protection is the priority.

4.2.1 Designating Areas of Wildlife Habitat

The following provincial legislation pertains to the designation of land for the protection of wildlife habitat, and potentially to habitat restoration implementation areas.

- ***Forest and Range Practices Act*** **(Part 9 Section 149.1(1)(a)(i) and (ii)):** The Lieutenant Governor in Council (LGC) can establish UWR and WHAs, and set objectives for them. These UWRs and WHAs can be designated to protect caribou ranges and habitat.
- ***Land Act*** **(Part 2 Statute 15(2)):** The LGC can create Crown land reserves. A reserve can be established for the purposes of protecting caribou habitat, if the LGC considers it advisable in the public interest.
- ***Land Act*** **(Part 2 Statute 17):** The minister can designate a portion of Crown land for the conservation of caribou habitat, if the minister considers it advisable in the public interest.
- ***Wildlife Act*** **(Part 1 Section 4(2)):** The minister can designate a wildlife management area. This can be applied to critical habitat for caribou.
- ***Wildlife Act*** **(Section 109(1)(b)):** The minister may regulate access to designated areas for the purposes of wildlife management. This can be applied to the prohibition or restriction of access to designated areas of caribou habitat.
- ***Forest Act*** **(Part 13 Sections 169(1), 170(2)(a) 171(1)):** The LGC can establish designated areas within which, forestry can be temporarily suspended, harvest levels adjusted, and the allowable annual cut be reduced. Caribou habitat in or adjacent to designated areas would benefit from reduced forestry activity.

4.2.2 Managing Public Recreation

The following provincial legislation relates to the management of public recreation.

- ***Forest and Range Practices Act*** **(Part 5 Section 58(1) and (2)):** The Minister can establish an order to restrict or prohibit public recreation in order to protect a range resource on Crown land. This can be applied to protect caribou habitat within Crown land.
- **Forest Recreation Regulation (Sections 6 and 20):** Recreational use can be managed at interpretive forest sites, recreation sites and recreation trails established under Section 56 of the *Forest and Range Practices Act.* This can be applied to limit recreation where a Section 56 interpretive forest site, recreation site or recreation trail exists in caribou habitat.

- ***Land Act* (Part 6 Statute 66(1)):** The LGC can prohibit a specific recreational activity in a designated area. This can be applied to close off vehicle access to caribou habitat.
- ***Motor Vehicle Act*, Motor Vehicle Act Regulations:** There are limitations on the use of motor vehicles in a manner that will destroy planting stock or disturb wildlife. This includes the use of ATVs and snowmobiles in the back-country, and prohibitions of motor vehicles within designated areas.

4.2.3 Industrial-use Conditions in Caribou Habitat

The following provincial legislation relate to the issuance of environmental licences, leases and permits, and their conditions that pertain to caribou habitat.

- ***Land Act* (Statute 11):** Permits are required for investigative work. Conditions relating to the protection and/or restoration of caribou habitat may be attached to permits.
- ***Coal Act* (Sections 12 (3) and (4), 18(3)):** The minister can make approval of license or lease subject to conditions. One or more of these conditions may relate to the protection and/or restoration of caribou habitat.
- ***Mines Act* (Section 10):** Permit conditions may be included during the issuance of notice of work or on major mine permits that pertain to the protection and/or restoration of caribou habitat.
- ***Petroleum and Natural Gas Act* (Sections 41(1)):** The minster may refuse to grant a development permit, and this may be for reasons including the preservation of caribou habitat.

4.3 Restoration Candidacy Decision Support Process

Several key assumptions, determined through discussions with FLNRO and experience from previous restoration projects, were made to inform decisions for focusing priority areas, develop preliminary treatment zones and assess potential treatment type. These assumptions should be further discussed and modified in Phase 2 with a workshop of provincial experts, given the specific range conditions within the Quintette Range.

- Low and mid elevation caribou habitat are a greater priority for restoration than high elevation (although the priority of low vs mid is not yet determined from a habitat restoration perspective).
- Areas with Provincially-designated protections (WHA, UWR, Parks, OGMA) are high priority because it is assumed these areas will not be impacted by future industrial land uses (Figures 6-7).
- Areas with high caribou use, determined from radiocollar data and kernel density estimators (Figures 3-4), are high priority.
- Linear features that overlap with current mine and cutblock footprints were not taken into consideration because it was assumed they would be restored under permit conditions.
- Future approved harvest management plans were not taken into consideration, but should be discussed in Phase 2.
- Mountain pine beetle current distribution (Figure 9) and susceptibility ranking (Figure 10) were not taken into consideration, but should be discussed in Phase 2.

To determine habitat restoration treatment candidate line segments (Phase 2), a decision support flow chart was modified from boreal caribou restoration programs and ongoing monitoring (Figure 12). The flow chart currently only applies to low elevation habitat though likely is also applicable to mid elevation; as described above, high elevation was not considered for restoration treatment in this Plan. Following further discussion with FLNRO, the flow chart will be applied in Phase 2 to the linear disturbance inventory post imagery analysis and ground-truthing.

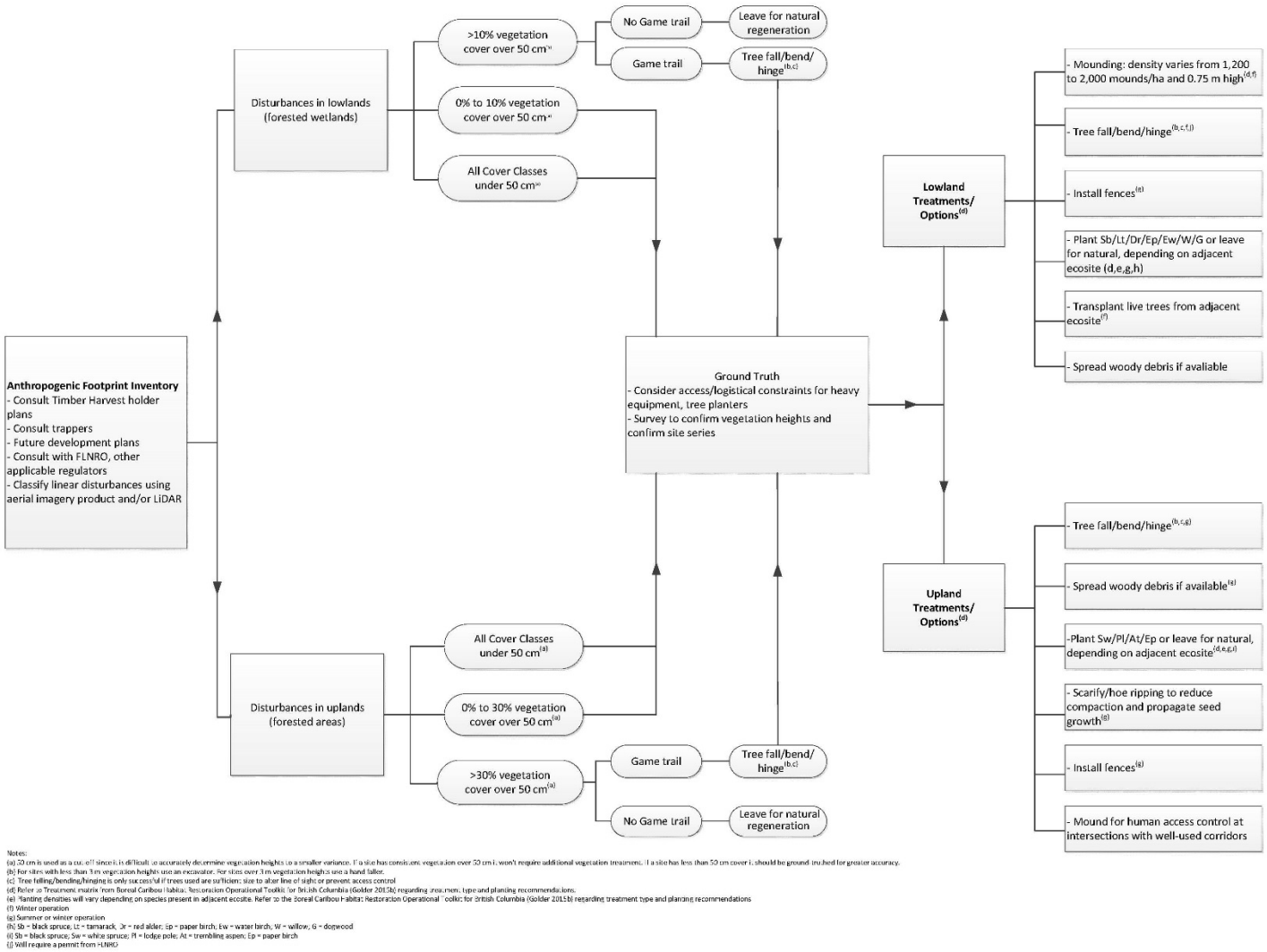


Figure 12: Low Elevation Treatment Decision-Making Flow Chart (may apply to mid elevation)

4.4 Active vs Passive Restoration

The majority of knowledge related to caribou habitat restoration tools and techniques comes from projects implemented in boreal caribou ranges (see Section 1.3 and Appendix A, B). Vegetation recovery in the medium and long-term following the creation of linear disturbances has not been extensively documented in mountain regions, however, the attributes of naturally revegetated linear features have been documented in boreal and foothill regions by the Caribou Range Restoration Project (CRRP 2007a, b), the Foothills Research Institute (Finnegan et al. 2014), and van Rensen et al. (2015). While there are expected to be many similarities in the vegetation recovery in low and mid elevation mountain caribou ranges compared to boreal caribou ranges, there is a degree of uncertainty in the applicability and anticipated results of the current restoration techniques in the South Peace Northern caribou ranges.

In boreal habitats, natural regeneration does occur, with linear development features in mesic sites the most likely to regenerate naturally without restoration treatments implemented (all things being equal), whereas a linear development feature in a bog or fen is least likely to regenerate naturally (van Rensen et al. 2015). Natural regeneration to 3 m vegetation height within 30 years is inversely related to terrain wetness, line width, proximity to roads as a proxy for human use of lines, and lowland ecosites such as fens and bogs (van Rensen et al. 2015). Areas adjacent to major rivers illustrate high probability of regeneration. Overall, terrain wetness and the presence of fens have the strongest negative effect on natural regeneration in boreal systems (van Rensen et al. 2015). Passive restoration can be defined as leaving a treatment candidate site to vegetate naturally to 3 m vegetation height within 30 years without implementing revegetation techniques such as planting seedlings or using a seed product (van Rensen et al. 2015).

To help determine whether silviculture-type treatments are necessary for Phase 2, preliminary treatment matrix tables for low and medium elevation BEC subzones of the Quintette caribou range have been developed (Appendix D). These tables were originally created by Tim Vinge of Alberta Environment and Sustainable Resource Development Land Management Branch for use in Alberta boreal caribou habitats, and modified by Golder for the *Boreal Caribou Restoration Toolkit* to apply to the BEC subzones present in boreal caribou habitat range (Golder 2015c); they have now been updated to address conditions in the Quintette central mountain caribou range. The preliminary treatment matrix tables include details on limiting factors to tree establishment, management considerations, mechanical site preparation, and vegetation treatments (if required) based on site characteristics such as site type, moisture/nutrient regime, and degree of prior disturbance. Restoration prescription types will be implemented in consideration of the measures in Appendix D, with modifications where additional feedback and considerations are made during Phase 2.

Following imagery analysis/interpretation and ground-truthing (Phase 2), for the Quintette habitat restoration project, candidate treatment sites classified as leave for passive restoration may still be treated if the existing vegetation is less than 3 m in height and there is a game trail, with the treatment method focused on protecting the site from human disturbance and wildlife use by implementing access control techniques such as mounding, spreading of coarse woody debris, and/or tree-felling (Golder 2015c). The decision to recommend treatment, either through vegetation enhancements such as seedling planting, or implementing access controls such as tree-felling, will consider both van Rensen's research on attributes of linear disturbances with natural vegetation recovery in boreal caribou ranges, and Dickie's (2015) suggestions that wolves changed their movement on linear features with increasing vegetation height, with a breakpoint of 1 m in summer and 2.7 m in winter. Boreal caribou population decline is linked to declining calf recruitment rates and female mortality, with the summer months

considered the most vulnerable time for caribou, as calves are born and experience high predation mortality in the first few weeks of life and the highest amount of female mortality occurs during that summer (Latham et al. 2013; Smith 2004). This relationship is expected to be similar for the South Peace Northern Caribou populations (but there is still uncertainty), so habitat restoration treatment of linear corridors is suggested to target sites with less than 1 m consistent vegetation height, after which treatment is no longer required. This would be contingent upon a consistent >10% cover class in wetlands, and >30% cover class in uplands. Although Dickie's research suggests 1 m is the target height after which wolves will no longer select for the feature during the summer, Finnegan et al. (2014) suggests where vegetation heights were greater than 1.4 m, movement rates of both wolves and adult grizzly bears decreased by 70%. To account for the presence of a well-worn game trail on features with > 1 m or 1.4 m vegetation height during the treatment recommendation stage, these sites may be recommended for access control treatment up to 3 m in vegetation height. Treatment application to a feature which has already achieved the status of a 'free growing stand' (BC MFLNRO 2015) would likely cause considerable damage to the existing vegetation.

4.5 Restoration Candidacy Preliminary Results

Linear disturbances with potential for treatment candidacy were identified based on the preliminary disturbance mapping of the Quintette range. A summary of treatment candidacy for all linear disturbances within the Quintette caribou range is presented in Table 4. As per direction from BC MFLRNO, linear disturbances in high elevation parkland and alpine BEC subzones (Figure 2) were excluded from treatment candidacy as this plan is to focus on disturbances in low and mid elevation. Summaries are provided by preliminary priority zones, which are discussed further in Section 4.6.

Table 2: Summary of Treatment Candidacy in Preliminary Priority Zones

	Length of Restoration Candidacy (km)[(a)]	No-treatment (km)[(a)]	Total (km)[(a)]
Priority Zone 1	892	1065	1958
Priority Zone 2	307	435	742
Priority Zone 3	289	580	868
No Priority[(b)]	n/a	4104	4104
High Elevation[(b)]	n/a	269	269
Total	**1487**	**6454**	**7941**

(a) Cutblocks, wildfires <40 years old, and roads were overlapped when making these calculations. Unclassified roads with no other designation/disposition were left as potential candidates. Only the Walter Energy mine footprint was available at the time; that footprint was excluded from treatment candidacy. Other mine footprints were not available at the time and will be added during Phase 2. Future planned cutblocks have not yet been added. Overlap of linear disturbance within future cutblock areas should be removed from planning candidate areas as long term habitat securement is unlikely.

(b) Linear disturbances were not considered candidates for treatment in No Priority zones and in the Parkland and Alpine high elevation BEC subzones.

Treatment Candidate

Based on preliminary disturbance mapping, a total of 1,487 km (19%) of linear disturbances within the Quintette Range are considered as restoration candidates, prior to fine scale vegetation and attribute data collection (Table 5, Figure 13). Remote sensing and ground-truthing is necessary to verify site specific treatment recommendations. Following field verification, treatment candidacy can be further refined to upland sites meeting the following criteria:

- < 30% vegetation cover and < 100 cm in height.
- > 30% vegetation cover, but < 50 cm in height.
- A game trail exists.

Table 3: Linear disturbance lengths by disturbance types in Treatment Zones

Priority Zone	Disturbance Type	Disturbance Length (km) – high elevation BEC zones excluded
Zone 1	Cutline	522
	Recreation Trail	11
	Resource Road	62
	Road/ROW [(a)]	297
	Zone 1 Subtotal	*892*
Zone 2	Cutline	110
	Recreation Trail	14
	Resource Road	9
	Road/ROW [(a)]	168
	Trail	6
	Zone 2 Subtotal	*307*
Zone 3	Cutline	219
	Recreation Trail	2
	Resource Road	13
	Road/ROW [(a)]	53
	Trail	2
	Zone 3 Subtotal	*289*
Total		**1,487**

(a) Unclassified roads with no other designation/disposition were left as potential candidates.

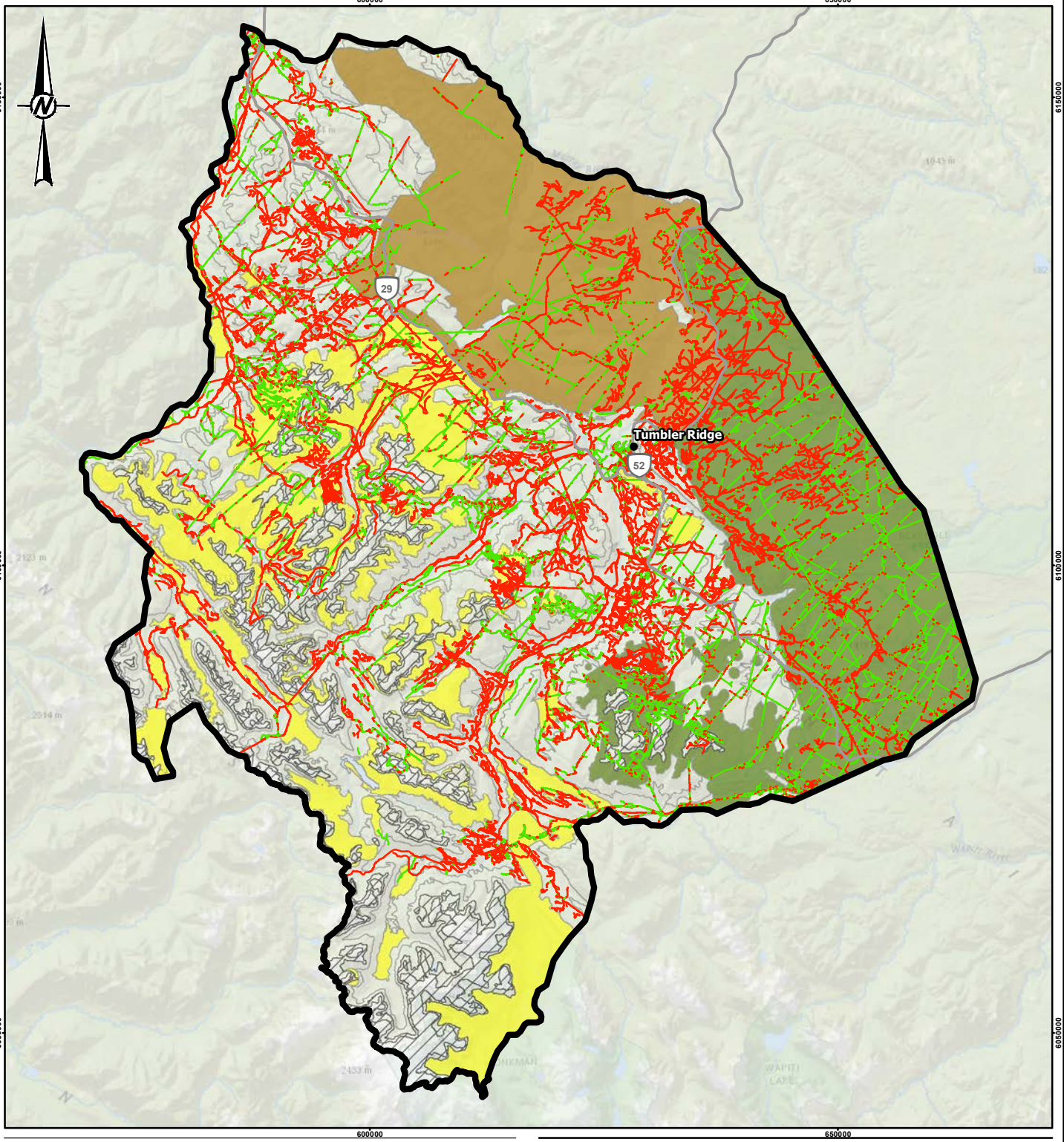
No-Treatment

No-Treatment linear disturbances constitute any linear disturbance that may have an active disposition or protective notation, such as a pipeline, lease road, recreational trail, or ecological reserve. Linear disturbances associated with cutblocks, and fire events within the last 40 years were also excluded as treatment candidates. Where the locations of these access corridors were certain, they were excluded from the linear disturbance inventory treatment options summary. In total, 6,454 km (81%) of the mapped and classified linear disturbances within three Priority Zones excluding high elevation BEC subzones are considered No-treatment disturbances (Table 4, Figure 13).

Leave for Natural

Linear disturbances will be recommended to Leave for Natural when percent cover and height classification of vegetation along a linear disturbance are above the threshold for recommending vegetation introduction or access control, and there is no game trail. A recommendation of Leave for Natural will be determined if:

- A wetland has > 10% vegetation cover, consistently equal to or over 50 cm in height, and no game trail is present.
- An upland has over 30% vegetation cover, consistently equal to or over 50 cm in height and no game trail present.



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

LINEAR DISTURBANCE

- NOT TREATMENT CANDIDATE
- TREATMENT CANDIDATE

BEC PRIORITY ZONE

- NO PRIORITY
- NO PRIORITY - HIGH ELEVATION
- PRIORITY ZONE 1
- PRIORITY ZONE 2
- PRIORITY ZONE 3

0 10 20
1:600,000 KILOMETERS

REFERENCE(S)

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
TACTICAL PLAN ZONES - PROPOSED HIERARCHY OF TREATMENT ZONES AND PRIORITY CLASSES (BEC ZONE BAFA EXCLUDED)

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	13

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4.6 Treatment Zones

In order to create a logistical timeline to access treatment areas, treatments for each implementation year will be focused in a specific treatment zone, within a certain geographical area, for logistical implementation efficiency. A treatment zone hierarchy will be developed in Phase 2 of the Plan, based on a number of ecological, logistical and economic criteria, including but not limited to:

- Elevational considerations to prevent predation and movement of predators from low elevation to caribou occurring within high and mid elevational zones.
- Treatment Priority Class Optimization, calculated by ranking treatment segment sites based on a combination of weighted variables outlined in Section 6.2.
- Specific implementation period treatment area/amount or budget objectives.
- Access into the zone area(s), which will reflect overall economic and logistical considerations.

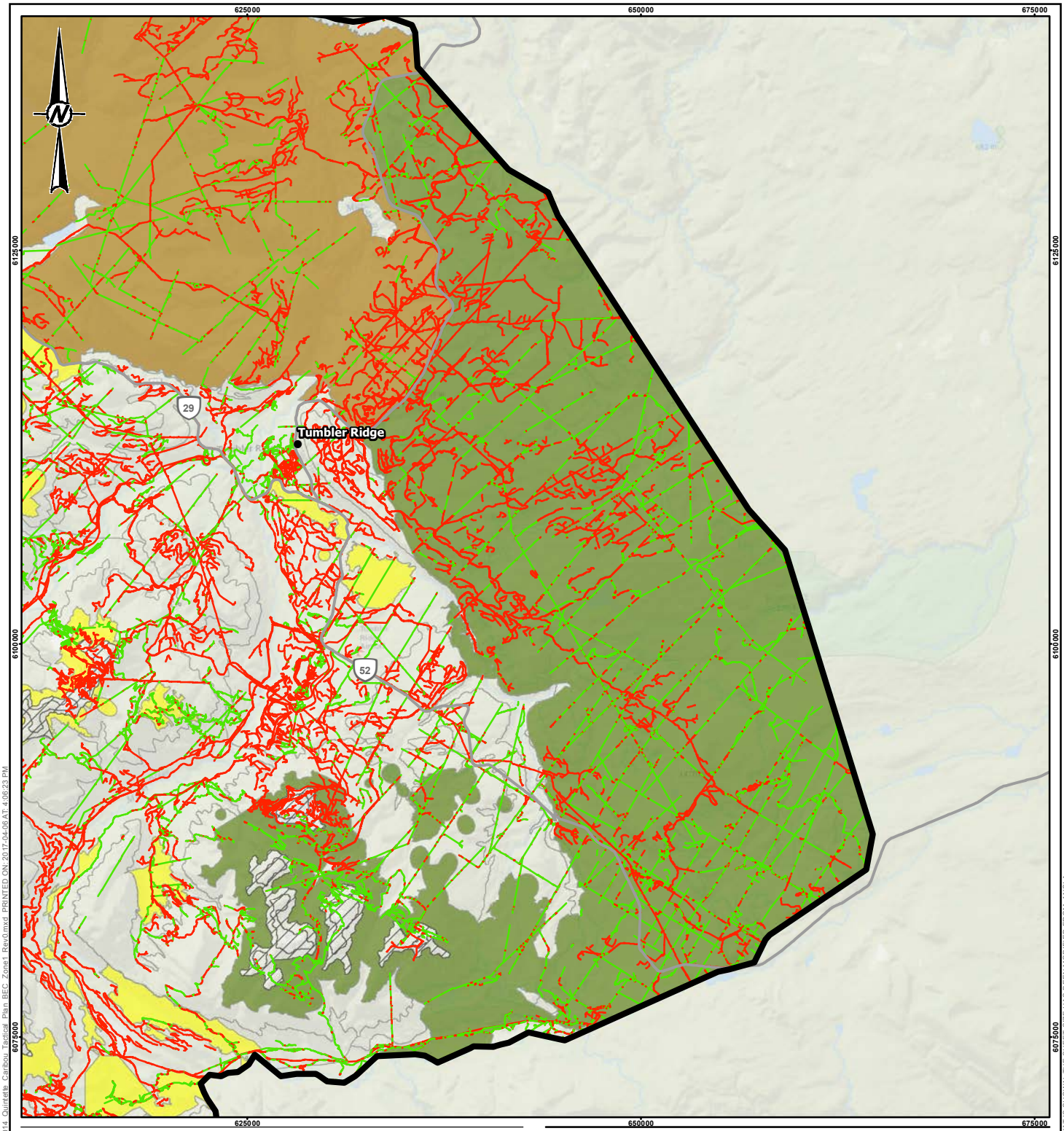
Figures 14 to 16 illustrates the proposed treatment zones to be treated, by Zone number, with BEC high elevation zones excluded. Until the ground-truthing has taken place and stakeholder consultation has been conducted to have a thorough understanding of criteria to consider and FLNRO priorities, it is unknown which zone will be treated first. However, preliminary recommendations are to treat Zone 1 and 2 first, followed by Zone 3. Zone 1 encompasses the low elevation winter range that has been identified as important habitat by provincial radiocollaring efforts (Seip and Jones 2014). In addition, kernel density estimators developed from provincial radiocollar data show there is high use by both the Quintette and Narraway/Bearhole caribou herds in Zone 1 (Figure 3). Zone 2 includes the majority of the high use elevation habitat, which will not be treated as part of this restoration project; but linear features in this zone that lead from the low and mid elevations to the high elevation are important to restore to block predator access into high elevation winter caribou habitat. Wildlife Habitat Areas and Ungulate Winter Ranges have “no harvest” designations and are thus protected from a certain amount of disturbance (ECCC and MoE 2017) (See Section 4.2); those areas are also included in Zones 1 and 2. Zone 3 has very few recent caribou telemetry locations (Figure 3) and therefore is considered less of a priority for restoring based on recent caribou habitat use. These preliminary priority zones require further refinement in Phase 2 following discussion with government agencies; as alternate areas may be prioritized depending on FLNRO priorities. For example, the preference may be to treat mid elevation linear disturbances in the short term, to functionally block predator movements into the high elevation areas. These mid elevation areas also afford an increased distance from cutblocks and other sources of high early seral habitats and associated prey populations. Other land management and natural disturbances will also need to be more thoroughly considered when prioritizing areas; for example, the proportion of zones affected by mountain pine beetle (Table 4).

Table 4: Areas of MPB Disturbance in the Quintette Caribou Range

Priority Zone	Total Zone Area (ha)	Area of MBP Disturbance (ha)	Proportion of Zone Damaged by MPB (%)
Priority Zone 1	113,772	58,947	51.8
Priority Zone 2	91,317	18,063	19.8
Priority Zone 3	87,297	55,252	63.3
No Priority [(a)]	257,583	47,272	18.4
High Elevation [(b)]	57,551	6	<0.1
Total	**607,519**	**179,539**	**29.6**

(a) Cutblocks, wildfires <40 years old, and roads were overlapped when making these calculations. Unclassified roads with no other designation/disposition were left as potential candidates. Only the Walter Energy mine footprint was available at the time; that footprint was excluded from treatment candidacy. Other mine footprints were not available at the time and will be added during Phase 2. Future planned cutblocks have not yet been added. Overlap of linear disturbance within future cutblock areas should be removed from planning candidate areas as long term habitat securement is unlikely.

(b) Linear disturbances were not considered candidates for treatment in No Priority zones and in the Parkland and Alpine high elevation BEC subzones.



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY

LINEAR DISTURBANCE

- NOT TREATMENT CANDIDATE
- TREATMENT CANDIDATE

BEC PRIORITY ZONE

- NO PRIORITY
- NO PRIORITY - HIGH ELEVATION
- PRIORITY ZONE 1
- PRIORITY ZONE 2
- PRIORITY ZONE 3

- QUINTETTE CARIBOU RANGE BOUNDARY

0 5 10

1:350,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

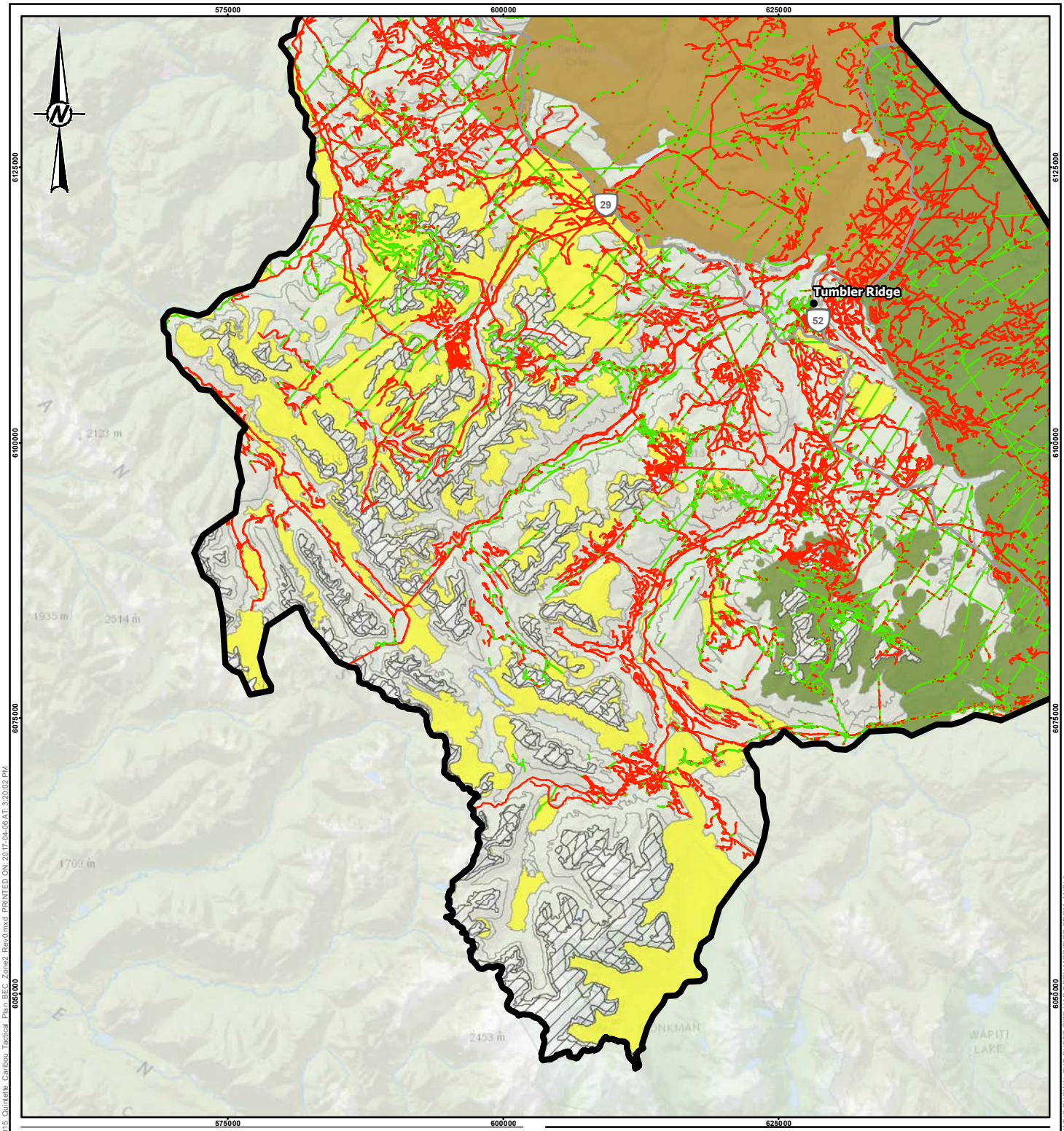
PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
TACTICAL PLAN TREATMENT ZONE 1 (BEC ZONES BAFA EXCLUDED FROM TREATMENT)

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	14



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

LINEAR DISTURBANCE

- NOT TREATMENT CANDIDATE
- TREATMENT CANDIDATE

BEC PRIORITY ZONE

- NO PRIORITY
- NO PRIORITY - HIGH ELEVATION
- PRIORITY ZONE 1
- PRIORITY ZONE 2
- PRIORITY ZONE 3

0 10 20

1:500,000 KILOMETERS

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
TACTICAL PLAN TREATMENT ZONE 2 (BEC ZONES BAFA EXCLUDED FROM TREATMENT)

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
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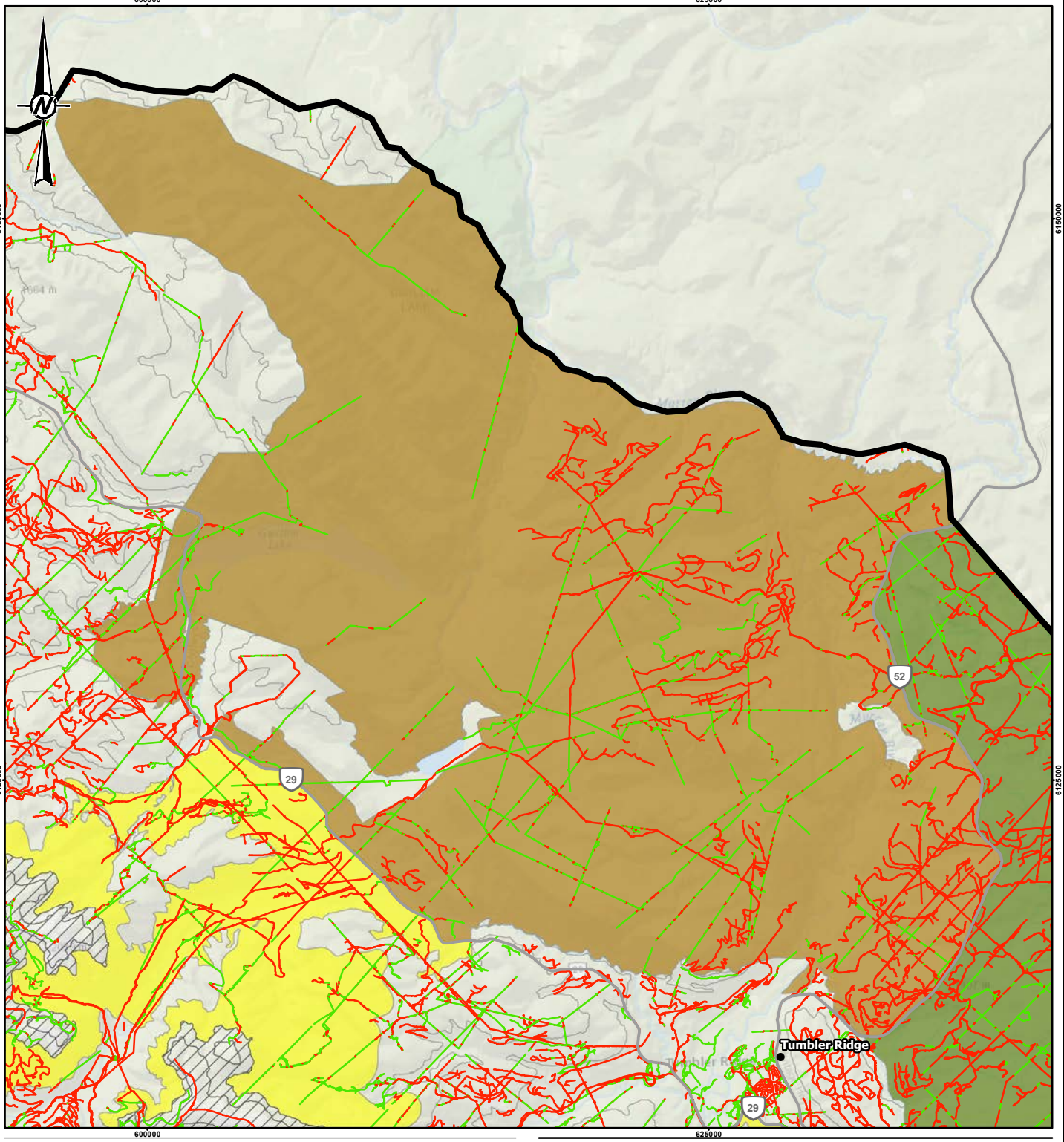

LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- QUINTETTE CARIBOU RANGE BOUNDARY

LINEAR DISTURBANCE

- NOT TREATMENT CANDIDATE
- TREATMENT CANDIDATE

BEC PRIORITY ZONE

- NO PRIORITY
- NO PRIORITY - HIGH ELEVATION
- PRIORITY ZONE 1
- PRIORITY ZONE 2
- PRIORITY ZONE 3

0 5 10

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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

PROJECT
QUINTETTE HABITAT RESTORATION

TITLE
TACTICAL PLAN TREATMENT ZONE 3 (BEC ZONES BAFA EXCLUDED FROM TREATMENT)

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-06
DESIGNED	MB
PREPARED	HR
REVIEWED	MB
APPROVED	PB

PROJECT NO.	CONTROL	REV.	FIGURE
1775025		0	16

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4.7 Data Management

Data for this multi-year habitat restoration project should be managed within a framework that effectively facilitates the compilation, analysis, manipulation and communication of large and complex spatial data sets for the purpose of landscape management planning. In Phase 2, Golder will setup the project in Orientis, a web mapping viewer designed to allow users to view, explore and examine project data on an interactive map. The Orientis program has tools for tracking development and revisions of data, with documented standards for procedures, metadata, accuracy and quality.

5.0 MONITORING

5.1 Vegetation and Treatment Response

The vegetation response to the restoration treatments will be monitored following guidelines in the Boreal Caribou Habitat Restoration Monitoring Framework (Golder 2015b). Monitoring for compliance (where applicable, if restoration implementation is conducted by third parties or by industrial proponents; or if implementation is conducted by Government of British Columbia, as-built maps and tracking should be completed), effectiveness, and validation will be incorporated into the study design, and monitoring will occur after the first, fifth, tenth, and fifteenth growing seasons after treatment. Reference plots will be established during treatment periods on untreated gaps of linear features (reference plots- disturbed) and on linear features that are already on a successional vegetation trajectory (reference plots- natural revegetation). These reference plots will be compared to the treatment plots to evaluate the effectiveness of the treatments at achieving the overall objectives of the program, which is to reduce predator and primary prey access and establish a vegetation trajectory that will increase boreal caribou habitat intactness.

5.2 Wildlife Response Monitoring

The wildlife response to the habitat restoration treatments will be monitored using data collected from motion activated remote cameras established by FLNRO (Watters 2017 pers. comm.). Cameras will be placed on disturbed (linear features) and undisturbed (game trails) lines in Quintette caribou range prior to treatment implementation (approximately June 2017 to November 2018, depending on initiation of restoration treatments, as a means of collecting baseline wildlife use on the two types of features. Cameras will continue to be deployed after treatments are implemented to assess the impacts of treatments on wildlife use (i.e., a before-after-control-impact (BACI) study), and will be closely tied to the restoration planning in that monitoring will occur on lines planned for restoration, as much as possible.

6.0 PROPOSED NEXT STEPS

Phase 2 of the Plan will expand and refine the work in the preliminary Plan presented here, including addressing data and information gaps (i.e., current vegetation status on linear disturbance inventory), identifying treatment on specific lines, obtaining the appropriate authorizations, investigating seed and seedling sources, and consulting with stakeholders. In addition, the preliminary treatment matrix tables (Appendix D) may need to be revised once more detailed vegetation information is acquired.

6.1 Data and Information Gaps

6.1.1 Acquiring Detailed Remote Sensing Data

Detailed spatial imagery from remote sensing needs to be acquired, interpreted and verified in the field prior to determining areas where natural vegetation recovery and areas where restoration treatment candidacy occur within the Quintette range. On previous restoration projects, this remote sensing process has determined that up to 60% of existing linear disturbances are naturally on a path to recovery (Golder 2015a). Details of the remote sensing mapping options and costs are presented in Appendix C. Given the high costs of remote sensing options, an option for Phase 2 may be to focus the detailed mapping to priority areas for restoration which are identified based on current land use and protection measures, as well as caribou and predator known use.

6.1.2 Correcting the Linear Disturbance Dataset

Overlapping Data

As no one spatial dataset contained all linear disturbances exists in the range, several data sources were required to complete the linear disturbance mapping. This resulted in numerous overlaps in the linear disturbance dataset. Most of these have been removed, however there remain some areas where the start and end of separate linear features have a slight overlap. The overall effect on the length of restoration candidacy lines is minimal, but if required these remaining overlaps can be removed with additional manual effort in Phase 2.

Mine Disturbances

Mine footprint data was not available for Phase 1. Current and approved mine footprints are recommended to be excluded as treatment candidate areas, as these project footprints are expected to have project specific CMMPs to address the footprint. Mine footprint data will need to be overlaid with existing linear disturbances and removed from the treatment areas as part of Phase 2.

Data Gaps

Due the size of the range and the time required to review and digitize linear features that were not displaying on the various available datasets, we were not able to fully complete digitizing of missing linear disturbances from imagery. We have captured most of the missing features but a more thorough review is recommended for Phase 2, at least within the priority areas.

Source Data Updates

Some of the datasets used to identify areas of exclusion are updated on a regular basis. Depending on the timing of Phase 2, updates to wildfires and cutblocks (including proposed future harvest plans) may be available and should be included. Crown tenures are also updated frequently and exclusions should be re-assessed if updated data is available for Phase 2. The exclusionary criteria of crown tenures could also be assessed in more depth by reviewing individual tenures rather than applying blanket exclusions according to the more general subtype classification.

Cutline Offset

The Canvec cutlines are offset from the imagery. The offset is inconsistent and ranges from a few metres up to 100 metres. Further data processing will be required in Phase 2.

6.2 Treatment Priority Class Optimization Process

The treatment priority class optimization process will be completed once remote sensing and ground-truthing of linear disturbance vegetation and attribute cover has been collected, and will involve assigning a relative treatment priority value to each line segment based on the following preliminary criteria:

- Probability of regeneration (considers a combination of vegetation cover, vegetation height, and soil moisture)
- Presence/absence of game trail
- Presence/absence of ATV trail
- Distance to high grade road
- Distance to polygonal disturbance (cutblock, mine footprints)
- Areas with overlapping legislative protections, for example overlap with Provincially protected areas (WHA, UWR, OGFM, Parks) which will afford immediate protection to restoration efforts
- Areas with high caribou usage (from kernel density estimators developed by Seip and Jones 2013b)
- Areas with high overlapping use by wolves and caribou
- Linear disturbances under an existing permit of the Ministry or the Oil and Gas Commission (OGC), whereby the permit may be altered to add habitat restoration specifications
- Areas with high/low mountain pine beetle hazard
- Percentage change of habitat intactness expected following restoration treatments

Preliminary criteria will be discussed with FLNRO and habitat restoration experts to determine if additional criteria should be included in the prioritization process. Costs of treatment applications will not be factored into the Treatment Priority Value equation, but will have a direct relationship to the Treatment Priority Class, with the higher priority class costing more per kilometer to treat.

6.3 Refine Tactical Plan

6.3.1 Obtain Authorizations

Restoration treatments on legacy disturbance footprint within the Quintette Range not under an existing permit of another Ministry or the Oil and Gas Commission (OGC) will require authorization by the Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) under the *Forest and Range Practices Act*. The restoration treatments, and associated obligation to the treatment activities, will be identified and tracked by FLNRO as a Forestry Licence to Cut. Identification of a 'licensee' who will be carrying out the on the ground activities must be provided. It is expected that authorization will be on a yearly basis during the multi-year Plan, specific to the area of restoration treatment. This allows consultation to be led by FLRNO on the specific treatment area, activities and access. Authorization will also be needed for any cutting of Crown timber for the use of tree-felling treatments (will need to report number and location).

Authorization applications should be submitted at least 6 months prior to targeted treatment start dates. This authorization timeline will allow for Indigenous community consultation led by FLNRO; feedback received during the consultation phase and from the FLNRO will be incorporated into future implementation plans.

Discussions will be required in Phase 2 between MoE, FLNRO, and OGC to confirm the authorizations and timeline for restoration treatments.

6.3.2 Archeological Desktop Review

An archaeological desktop review of the Plan should be completed in Phase 2 to determine whether any recorded archaeological sites are located within the Quintette Range, and if they may be impacted by the Plan. According to the BC Archaeological Impact Assessment Guidelines (Archaeology Branch 1998), an archaeological study is initiated when a proposed development or activity will possibly disturb or alter the landscape, thereby endangering archaeological sites. Although the activities associated with the Quintette restoration project are anticipated to be carried out during the winter months, under frozen ground conditions to mitigate impacts to the ground, with flexibility to move treatments to avoid areas of high potential for archaeological sites; some of the proposed treatment methods may be considered land-altering, specifically microsite preparation using mounding techniques or tree-felling, and as such, further archaeological assessment may be required. The process to be following during the planning and implementation of the restoration project should be determined in Phase 2.

6.3.3 Watercourse Crossing Requirements

During the implementation of the restoration treatments, access will be required into the Quintette caribou range during the winter in areas without high grade roads or bridges. Main access routes required for each implementation year will need to be frozen-in prior to bringing heavy machinery into the area. For these main access routes, when watercourses are present, crossings will need to be established in the form of either temporary bridges or ice bridges/snow fills. Once machinery has been transported into a treatment zone, watercourse crossings will also need to be established where heavy machinery needs to cross a watercourse to access treatment areas, again in the form of either temporary bridges or ice bridges/snow fills. The type of crossing structure required will depend on the size of the watercourse and presence/absence of flowing water.

At least four months prior to mobilizing heavy machinery required for the field implementation component for each field implementation year, access routes will be assessed using spatial imagery to determine the presence and number of potential watercourse crossings, and a watercourse crossing plan will be developed as part of the yearly implementation plan. The watercourse crossing plan will indicate where there are watercourses and wetlands that may require crossing structures, and what type of structure will be used to cross each watercourse. During the ground-truthing component required as part of each yearly implementation plan, the access routes will be visited to field verify the watercourse crossing plan and any watercourses identified in the field that were not identified during the review of the imagery will be added to the watercourse crossing plan.

The watercourse crossing plan will form the basis for a notification package that must be sent to FrontCounterBC at least 45 days prior to the establishment of any required crossing structures, as required under the BC *Water Act*. Field watercourse crossing assessments are not anticipated to be required prior to establishing a crossing structure if there will be no disturbance to the watercourse or the riparian area. Due to the nature of establishing crossing structures in the winter using temporary bridges or ice bridges/snow-fills, it is not anticipated there will be disturbance to any of the watercourses or riparian areas.

A water source and associated water use permit will need to be submitted to FrontCounterBC at least 60 days prior to the start of access preparation, to secure water resources necessary for freezing in of access.

6.3.4 Seed and Seedling Sourcing

Sources for seeds and seedlings, as well as the timeline for treatments and planting, needs to be further investigated in Phase 2. Winter planting is not an option for upland sites in Quintette caribou range; planting should be conducted from mid-July to early August. When possible, seedlings will be sourced from Twin Sisters Native Plant Nursery.

Seed encapsulated products should also be considered for this project, since they could be placed at the time of treatment as opposed to coming back in the summer.

6.3.5 First Nations Engagement and Aboriginal Inclusion Plan

In Phase 2, engagement with First Nations should be initiated to provide the opportunity for early input on the early restoration planning and prioritization process as well as to incorporate Traditional Ecological Knowledge into the restoration planning and treatment options/considerations/selection which will be led by MFLRNO. This will likely entail community focused sessions and/or field visits to discuss what habitat restoration objectives and considerations mean for the communities. Considerations including spiritual and cultural values need to be considered within the planning process.

In addition, an Aboriginal Inclusion Plan (AIP) is strongly recommended to be developed to facilitate opportunities to integrate the involvement of Aboriginal Peoples and Businesses as a core function in the execution of the multi-year habitat restoration implementation plan. Potential services and roles may include, but are not limited to, seed and seedling sourcing, environmental technologists, wildlife monitors, medics, general contractors, equipment operators, surveyors, safety supervisors, field technicians, data collectors, researcher assistants, archaeologist assistants, tree fallers, and danger tree assessors. The AIP would outline the necessary administrative, contractual, and logistical arrangements required to facilitate Aboriginal participation in the Plan as much as

practical. The AIP will outline our strategy to facilitate the participation of qualified local Aboriginal resources, where appropriate and available, and in accordance with health and safety policies and protocols. The AIP will seek to support three main streams of Aboriginal involvement, including providing on-the-job and other training support (e.g., wildlife survey) to Aboriginal individuals, where needed and feasible; identifying opportunities to augment consultant/contractor's existing workforce through direct hires; and retaining Aboriginal businesses as service suppliers under this contract (e.g., transportation, field technicians, wildlife (bear) monitors, and heavy equipment operators), where feasible.

6.3.6 Develop Annual Implementation and Monitoring Plans

The Quintette Caribou Habitat Restoration Plan is designed to be a multi-year program. Each year of the program will require the development of an Implementation Year planning document for the particular zone or area within a zone to be treated. The following elements will be captured within each annual implementation plan.

- Review elevations to focus treatments based on current FLNRO priorities.
- Review linear inventory mapping and treatment candidate sites to plan ground-truthing field program.
- Reviewing potential archeological requirements prior to ground-truthing, and incorporating any archeological field work with the ground-truthing.
- Reviewing imagery to document accessibility to the area:
  - Identify the locations of potential watercourse crossing locations, and determine if disturbance to the watercourse may be required to cross.
  - If disturbance is a possibility, incorporate a field watercourse crossing assessment into the ground-truthing plan.
- Ground-truthing of potential restoration segment sites to confirm treatment recommendation.
- Confirmed restoration segment sites will be given a treatment prescription guided by the Mountain Caribou Habitat Restoration Toolkit Treatment Matrix (Appendix D).
- The following will be noted for each treatment site to guide logistical planning for field implementation:
  - Treatment site location.
  - Treatment access route or other considerations (ground access vs. aerial support).
  - Site conditions which may impact treatment options (e.g., terrain, site wetness, pipeline crossing agreements, impact to existing vegetation between restoration segments).
  - Update vegetation mapping for the site where a variance occurs from original mapping interpretation (surrounding stand type, height of vegetation per strata, vegetation species composition, % vegetation cover, game trail/ human access presence, width, line orientation).
- Seed and seedling requirements will be finalized, and will be sourced, as required.
- The vegetation and treatment response and wildlife response monitoring programs will be revised as needed.

7.0 SUMMARY

The Quintette central mountain caribou population experienced a 50% decline between 2013 and 2016 (Seip and Jones 2016), and the Province of BC has developed a comprehensive set of actions to recover the herd (BC MFLNRO 2017). The Restoration Plan presented here is Phase 1 of a multi-phase habitat restoration project designed to be implemented over a multi-year period in low and mid elevation habitat to achieve the objectives of the Quintette Strategic Action Plan (BC MFLRNO 2017).

The preliminary linear disturbance inventory mapping from Phase 1 resulted in the classification of 7,941 km of linear disturbance. Of the 7,941 km of linear disturbance mapped within the Quintette Range, 6,454km (81%) were classified as requiring No-Treatment based on permanence (active disposition or protective notation, such as a pipeline, lease road, designated recreational trail, or ecological reserve), priority, and elevation (high elevation BEC series excluded). The remaining 1,487 km (19%) of linear disturbances within the Quintette Range are considered as restoration candidates.

Phase 2 of the Plan will require further desktop analysis of vegetation cover and heights using remote sensing and field validation to complete the linear disturbance mapping, to develop treatment priority classes and refine restoration candidacy. In addition, we recommend a one day workshop be held in Fort St. John, BC to meet with representatives from government agencies to refine and gather consensus on restoration objectives, priority zone considerations including the inclusion of elevation, timelines, feasibility, and meaningful inclusion for indigenous communities within the planning process prior to implementation of restoration treatments. Considerations will need to be made for strategic restoration given limited funds and ongoing changes to land use designations and protections.

8.0 CLOSURE

We trust this technical memorandum is sufficient for your current needs. If you have any questions or concerns, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

Michelle Bacon, MSc
Wildlife Biologist

Catherine Grima, BSc, RPBio
Biologist

Paula Bentham, MSc, PBiol
Principal, Senior Wildlife Biologist

MB/CG/PB/lih

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9.0 REFERENCES

Apps, C. D., and B. N. McLellan. 2006. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. Biological Conservation 130: 84 – 97.

Archaeology Branch. 1998. British Columbia Archaeological Impact Assessment Guidelines. Revised edition. Ministry of Forests, Lands and Natural Resource Operations, Archaeology Branch, Victoria, BC.

BC CDC (Conservation Data Centre). 2017. BC Species and Ecosystems Explorer. BC Ministry of Environment. Victoria, BC. Available: http://a100.gov.bc.ca/pub/eswp/. Accessed 13 February 2017.

BC MoE. 2013a. Guidance for the Development of Caribou Mitigation and Monitoring Plans for South Peace Northern caribou – 17 April 2013. Victoria, BC. 23 pp.

BC MoE. 2013b. Implementation plan for the ongoing management of South Peace Northern Caribou (Rangifer tarandus caribou pop. 15) in British Columbia. Victoria, BC.

BC MoE. 2013c. Natural Resource Board Direction: Planning and Approval of Development Activities in the South Peace Northern Caribou Area. 16 April 2013. Victoria, BC. 2 pp. Available at: http://www.env.gov.bc.ca/wld/speciesconservation/nc/documents/Natural%20Resource%20Board%20Direction.pdf. Accessed 23 March 2017.

BC MoE. 2014a. Science Update for the South Peace Northern Caribou (Rangifer tarandus caribou pop. 15) in British Columbia. 52 pp. Available at: http://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/science_update_final_from_web_jan_2014.pdf.

BC MoE. 2014b. Approved ungulate winter ranges. Ministry of Environment. Available at: http://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html. Accessed January 2014.

BC MoE. 2014c. British Columbia ungulate species regional population estimates and status – preseason 2014. Ministry of Environment, Victoria, BC. 1pp. Available at: http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/2014_Provincial%20Ungulate%20Numbers%20Oct%2030_Final.pdf. Accessed 9 March 2017.

BC MoE. 2014d. Experimental Wolf Reduction to Enhance the Recovery of Threatened Caribou Herds in the South Peace. s.15, s.19. Province of British Columbia, Victoria, BC. Available at: http://docs.openinfo.gov.bc.ca/Response_Package_FNR-2015-50572.pdf. Accessed: 9 March 2017.

BC MoE. 2017. Approved Wildlife Habitat Areas. Available at: http://www.env.gov.bc.ca/wld/frpa/iwms/wha.html. Accessed April 2017.

BC MFLNRO (Ministry of Forests, Lands and Natural Resource Operations). 2014a. Management plan for the Grey Wolf (Canis lupus) in British Columbia. BC Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC. 48 pp. Available at: http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grey_wolf_management_plan.pdf. Accessed 9 March 2017.

BC MFLNRO. 2014b. Mountain Pine Beetle Hazard Rating Documentation Version 1.2. Available at: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/barkbeetles/New%20Susceptibility%20Ratings/Documentation/. Accessed 5 April 2017.

BC MFLNRO. 2015. Silviculture Survey Procedures Manual. FLNRO Resource Practices Branch, Victoria BC. 309 pp. Available at: https://www.for.gov.bc.ca/hfp/silviculture/Silviculture%20Survey%20Procedures%20Manual%202015.pdf. Accessed 6 April 201.

BC MFLNRO. 2017. British Columbia's Quintette Strategic Action Plan. March 1, 2017. 25 pp.

Cichowski, D., T. Kinley, and B. Churchill. 2004. Caribou, Rangifer tarandus. Accounts and measures for managing identified wildlife. British Columbia Ministry of Water, Land and Air Protection, Victoria, BC.

CRRP (Caribou Range Restoration Project). 2006. Caribou Range Restoration Project: Guidelines for Planning and Implementation, Draft Unpublished Document.

CRRP. 2007a. Caribou Range Restoration Project: Guidelines for Planning and Implementation. Unpublished document created for the West Central Alberta Petroleum Producers Group, Canadian Association of Petroleum Producers and Environment Canada. 19 September 2007.

CRRP. 2007b. Permanent Sample Plot Manual for the Caribou Range Restoration Project in Alberta, 23 March 2007. Draft Unpublished Document.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2011. Designatable Units for Caribou (Rangifer tarnadus) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 88 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Caribou Rangifer tarandus, Northern Mountain population, Central Mountain population and Southern Mountain population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. Xxii + 113 pp. Available at: http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Caribou_Northern_Central_Southern_2014_e.pdf. Accessed 21 February 2017.

DataBC. 2017a. Caribou Herd Locations for BC. Published 2011, modified Jan 23 January, 2017. Available at: https://catalogue.data.gov.bc.ca/dataset/caribou-herd-locations-for-bc. Accessed 24 March 2017.

DataBC. 2017b. Bark Beetle Susceptibility Rating. Published 2017. Available at: https://catalogue.data.gov.bc.ca/dataset/bark-beetle-susceptibility-rating. Accessed 5 April 2017.

DeLong, C. 2004. A Field Guide to Site Identification and Interpretation for the North Central Portion of the Northern Interior Forest Region. Land Management Handbook 54. BC Ministry of Forests and Range, Victoria, BC. 243 pp.

DeLong, C., D. Tanner, and M.J. Jull. 1994. A Field Guide for Site Identification and Interpretation for the Northern Rockies Portion of the Prince George Forest Region. Land Management Handbook 29. BC Ministry of Forests and Range, Victoria, BC. 149 pp.

DeLong, C., A. Banner, W.H. MacKenzie, B. Rogers and B. Kaytor. 2011. A Field Guide to Ecosystem Identification for the Boreal White and Black Spruce Zone of British Columbia. Land Management Handbook 65. BC Ministry of Forests and Range, Victoria, BC. 250 pp.

Demarchi, D.A. 2011. The British Columbia Ecoregion Classification. Third Edition. Ecosystem Information Section, BC Ministry of Environment. Victoria, BC. Available at: http://www.env.gov.bc.ca/ecology/ecoregions/index.html. Accessed 23 March 2017.

Dickie, M. 2015. The Use of Anthropogenic Linear Features by Wolves in Northeastern Alberta. M.Sc. thesis. University of Alberta, Edmonton, Alberta. 80 pp.

Duthie-Holt, M., J. Burleigh, M. Cleaver, and T. Strome. 2007. Peace Forest District Mountain Pine Beetle Comprehensive Strategy. Prepared for: BC Forest Service, Peace Forest District. Available at: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/fh-strategies/peace_forest_district_mountain_pine_beetle_strategy.pdf. Accessed 5 April 2017.

EC (Environment Canada). 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. xi + 138 pp.

EC. 2014. Recovery Strategy for the Woodland Caribou, Southern Mountain population (*Rangifer tarandus caribou*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada. Ottawa, ON. viii + 103 pp.

ECCC and MoE (Environment and Climate Change Canada and BC Ministry of Environment). 2017. Canada-British Columbia Southern Mountain Caribou (Central Group) Protection Study. Final Report. 113 pp. Available at: http://registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=3106. Accessed 13 March 2017.

Enbridge (Enbridge Pipelines Inc.). 2010. Waupisoo Pipeline Project: 2010 Green Area Post-Construction Reclamation Assessment. Submitted to Alberta Sustainable Resource Development.

Finnegan, L., K. Pigeon, J. Cranston, and G. Stenhouse. 2014. Analysis and Restoration of Seismic Cutlines in Southern Mountain and Boreal Caribou Range in West-Central Alberta. Final Report. Foothills Research Institute Caribou and Grizzly Bear Programs.

FWCP (Fish and Wildlife Compensation Program). 2015. Enhancing caribou survival in the Klinse-Za herd. Available at: http://fwcp.ca/project/enhancing-caribou-survival-in-the-klinse-za-herd/. Accessed 20 March 2017.

Glencore. 2016. Letter from Bryan Tiedt (Glencore) to David Grace and Fern Stockman (EAO) dated 7 April 2016. Information Request #95. http://a100.gov.bc.ca/appsdata/epic/documents/p394/1467651761661_pcYrX6LfWXSlngQLwgc8qCkwYwsr7S1rFVhjRFy2wCkvpyDyQPr0!-1711589748!1467648255023.pdf. 7 April 2016.

Goddard, A. D. 2005. South Peace Forest District caribou Ungulate Winter Range: biological requirements and management objectives. Report prepared for BC Ministry of Environment, Fort St John, BC. 28 pp.

Golder (Golder Associates Ltd.). 2005. Firebag Project 2004 Seismic Line Reclamation Study Annual Report. Submitted to: Suncor Firebag Inc.

Golder. 2009. Caribou Habitat Restoration Pilot Study. Prepared for Conoco Phillips Canada, Suncor Engery and Canadian Association of Petroleum Producers. 41pp.

Golder. 2010. Canadian Natural Resources Limited: Primrose and Wolf Lake: Wildlife Habitat Enhancement Program Development and Implementation. Submitted to: Canadian Natural Resources Ltd, Calgary, AB.

Golder. 2011. Waupisoo Pipeline 2011 Seedling Monitoring Plot Summary. Submitted to Enbridge Pipelines (Athabasca) Inc.

Golder. 2012. Interconnect Pipeline 2011 Seedling Monitoring Plot Summary. Memo submitted to CNRL, 23 February 2012.

Golder. 2015a. Parker Caribou Range: Boreal Caribou Restoration Pilot Program Plan. Submitted to the British Colombia Oil and Gas Research and Innovation Society's Research and Environmental Monitoring Board. 30 November 2015.

Golder. 2015b. Boreal Caribou Habitat Restoration Monitoring Framework. Prepared for BC Oil and Gas Research and Innovation Fund's Research and Effectiveness Monitoring Board. Project BCIP-2016-02. Report 1529986-001-R-Rev0. Available at: http://www.bcogris.ca/sites/default/files/bcip-2016-02-restoration-monitoring-framework-final-dec151.pdf. Accessed 23 February 2017.

Golder. 2015c. Boreal Caribou Habitat Restoration Toolkit: A Practitioner's Guide. Prepared for BC Oil and Gas Research and Innovation Fund's Research and Effectiveness Monitoring Board. Project BCIP-2015-05. Report 1313720037. Available at: http://www.bcogris.ca/sites/default/files/bcip-2015-05-restoration-toolkit-28final29-jan-2115.pdf. Accessed 8 March 2017.

Golder. 2017. Caribou Mitigation and Management Plan. Bonanza Ledge. Submitted to Barkerville Gold Mines Ltd.

Government of BC. 2015. First Nations Plant Nursery Gets Greener. British Columbia News. Available at: http://www.saulteau.com/wp-content/uploads/2015/09/greenhouse.pdf. Accessed 2 March 2017.

Government of Canada. 2017. Species At Risk Public Registry. Available: http://www.sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1. Accessed 13 February 2017.

Hamilton, D. 2011. Silviculture options for use in ranges designated for the conservation of mountain caribou in British Columbia. Extension Note. BC Journal of Ecosystems and Management 12:39-54.

Hatler, D.F., D.W. Nagorsen, and A.M. Beal. 2008. Carnivores of British Columba. Royal British Columbia Museum, Victoria, BC.

Jones, E.S. 2007. Use, selection and winter foraging patterns among woodland caribou herds in central British Columbia. M.Sc. Thesis. University of Northern British Columbia, Prince George, BC. x + 128pp.

Jones, E.S. 2008. Seasonal habitat use and selection by woodland caribou herds in the South Peace region, central British Columbia. Prepared for BC Ministry of Environment, Victoria, BC. vii + 56pp. Available at: ftp://ftp.geobc.gov.bc.ca/.virtual/slk6ftp/pub/outgoing/!_for_Cynthia/Peace%20Final%20Report_Jan08.pdf.

Jones, E.S., D. Seip, and M. Gillingham. 2004. Ecological relationships between threatened caribou herds and their habitat in the Central Rocky Mountains Ecoregion. Annual Report. 16 pp. Available at: http://www.env.gov.bc.ca/esd/distdata/Peace_Region_Wildlife_Values/Fish_and_Wildlife/SAR_Info/Caribou/SMNEA/.

Lee, P., and S. Boutin. 2006. Persistence and development transition of wide seismic lines in the western Boreal Plains of Canada. Journal of Environmental Management 78: 240-250.

MacFarlane, A. 1999. Revegetation of wellsites and seismic lines in the boreal forest. B.Sc. Honour's Thesis, Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada.

MacFarlane, A. K. 2003. Vegetation Response to Seismic Lines: Edge Effects and On-line Succession. Master of Science Thesis, Department of Biological Sciences, University of Alberta, Edmonton, AB.

McNay, R.S., Cichowski, D., & Muir, B.R. 2013. Action Plan for the Klinse-Za Herd of Woodland Caribou (Rangifer tarandus caribou) in Canada [draft]. Species at Risk Act Action Plan Series. West Moberly First Nations: Moberly Lake, British Columbia. 28 pp.

McNay, R. S., L. Giguere, B. Pate, and E. Dubman. 2016. Enhancing calf survival to help avert extirpation of the Klinse-Za caribou herd. Wildlife Infometrics Inc. Report No. 527. Prepared for BC Hydro Fish and Wildlife Compensation Program – Peace Region, Contribution Agreement Project No. PF16-W22. Wildlife Infometrics Inc., Mackenzie, British Columbia, Canada. 37 pp.

MCST (Mountain Caribou Science Team). 2005. Mountain caribou in British Columbia: A situation analysis. Available at: http://www.env.gov.bc.ca/wld/speciesconservation/mc/. Accessed 20 March 2017.

Meidinger, D. and J. Pojar (eds.). 1991. Ecosystems of British Columbia. Available at: https://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.pdf. Accessed 23 March 2017.

Nitschke, C.R. 2008. The cumulative effects of resource development on biodiversity and ecological integrity in the Peace-Moberly region of Northeast British Columbia, Canada. Biodiversity Conservation 17: 1715-1740.

OSLI (Oil Sands Leadership Initiative). 2012. Projects Land. http://www.osli.ca/projects/land Access on 13 March 2012.

Osko, T.J., and M. Glasgow. 2010. Removing the Well-Site Footprint: Recommended Practices for Construction and Reclamation of Well-sites on Upland Forests in Boreal Alberta. Department of Biological Sciences, University of Alberta.

Pojar, J., D. Meidinger, and K. Klinka. 1991. Concepts of Biogeoclimatic Ecosystem Classification. In: D. Meidinger and J. Pojar (eds.). 1991. Ecosystems of British Columbia. Available at: https://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.pdf. Accessed 23 March 2017.

PNCC (Peace Northern Caribou Committee). 2014. Maternal Penning to Enhance Survival of Cow Caribou and their Calves within the Klinse-Za Caribou Herd. Unpublished report.

Revel, R. D., T. D. Dougherty, and D. J. Downing. 1984. Forest Growth and Revegetation Along Seismic Lines. University of Calgary Press, Calgary, AB.

Royal Roads University. 2013. New training partnership for native plant growing. Available at: http://www.royalroads.ca/news-releases/new-training-partnership-native-plant-growing. Accessed 2 MarchAccessed 2 March 2017.

Schneider, R.R., Stelfox, J.B., Boutin, S., and S. Wasel. 2003. Managing the cumulative impacts of land uses in the Western Canadian Sedimentary Basin: a modeling approach. Conservation Ecology 7: 8 (online).

Seip, D. and E. Jones. 2011. Population status of threatened caribou herds in the Central Rockies Ecoregion of British Columbia, 2011. Ministry of Environment, Victoria, BC. iii + 23pp.

Seip, D. and E. Jones. 2012. Core high-elevation winter habitat for the Quintette herd. Ministry of Environment, Victoria, BC. 6 pp. Available at: http://www.env.gov.bc.ca/esd/distdata/Peace_Region_Wildlife_Values/Fish_and_Wildlife/SAR_Info/Caribou/SMNEA/PNCP_High_elev_winter_range/Quintette%20HEWR%20FINAL/Core%20High%20Elevation%20Habitat%20for%20the%20Quintette%20Caribou%20Herd.pdf. Accessed 11 February 2015.

Seip, D. and E. Jones. 2013a. Population status of caribou herds in the Central Mountain Designatable Unit within British Columbia. Ministry of Environment, Victoria, BC. iii + 30pp. Available at: http://www.env.gov.bc.ca/wld/speciesconservation/nc/documents/South%20Peace%20Northern%20Caribou%20Population%20Status_2013.pdf. Accessed 11 February 2015.

Seip, D., and E. Jones. 2013b. Kernel analysis of caribou radio-telemetry locations in the Peace Northern Caribou Management Area. Ministry of Environment, Victoria, BC. 14 pp.

Seip, D., and E. Jones. 2014. Low-elevation winter habitat for the Quintette caribou herd. Ministry of Environment, Victoria, BC. 4 pp. Available at: http://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/quintette_le_winter_2014.pdf. Accessed 13 March 2017.

Seip, D., and E. Jones. 2015. Core high-elevation summer range for the Quintette caribou herd. Ministry of Environment, Victoria, BC. 4 pp. Available at: http://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/quintette_caribou_hesr.pdf. Accessed 13 March 2017.

Seip, D. and E. Jones. 2016. Population status of Central Mountain Caribou Herds in British Columbia and Response to Recovery Management Actions, 2016. Ministry of Environment, Victoria, BC. 18pp.

Serrouya, R., B. N. McLellan, C. D. Apps, and H. U. Wittmer. 2008. A synthesis of scale-dependent ecology of the endangered mountain caribou in British Columbia, Canada. Rangifer 28: 33 – 46.

Sherrington, P.M. 2003. Measuring boreal forest fragmentation change in response to seismic line, wellsite, and road revegetation with scanned false-colour infrared aerial photography. M.Sc. Thesis, Department of Geography, University of Calgary, Calgary, AB.

Stantec (Stantec Consulting Ltd.). 2012. Caribou Mitigation and Monitoring Plan. Roman Mine. Final. Prepared for Peace River Coal Inc., Vancouver, BC.

Stantec . 2015. Preliminary Caribou Mitigation and Monitoring Plan. Sukunka Coal Mine Project. Final Rev. 01. Prepared for Glencore, Vancouver, BC.

Stevenson, S. K., H. M. Armleder, M. J. Jull, D. G. King, B. N. McLellan, and D. S. Coxon. 2001. Mountain caribou in managed forests: recommendations for managers. Second Edition. Wildlife report No. R-26. Report prepared for BC Ministry of Environment, Lands and Parks, Wildlife Program. Victoria, BC. 71 pp.

Szkorupa, T. 2002. Caribou Range Recovery in Alberta: 2001/02 Pilot Year. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species At Risk Report No. 48. Edmonton, AB. 8 pp.

Teck Coal Ltd. 2013. Quintette Project Caribou Mitigation and Monitoring Plan. A Component of the Joint Application for Authorizations under the Mines Act, Environmental Management Act, Water Act, Forest Act, Coal Act and Land Act. Submitted to The Quintette Mine Development Review Committee. Teck Coal Ltd., Calgary, Alberta.

Twin Sisters Native Plants Nursery. 2017. Available at: http://www.twinsistersnursery.com/. Accessed 2 March 2017.

van Rensen, C.K., S.E. Nielsen, B. White, T. Vinge, and V.J. Lieffers. 2015. Natural regeneration of forest vegetation on legacy seismic lines in boreal habitats in Alberta's oil sands region. Biological Conservation 184: 127 – 153.

WMFN and SFR (West Moberly First Nations and Saulteau First Nations). 2014. News release - klinse-za-maternal-penning-project-releases-19-caribou. Available at: http://www.marketwired.com/press-release/klinse-za-maternal-penning-project-releases-19-caribou-1928795.htm. Accessed 8 March 2017.

WMFN (West Moberly First Nations). Undated. Klinse-Za Caribou Maternal Release. Available at: http://www.westmo.org/news/klinse-za-caribou-maternal-release. Accessed 2 March 2017.

Williamson-Ehlers, L. 2012. Impacts of industrial development on the distribution and movement ecology of wolves (Canis lupus) and woodland caribou (Rangifer tarandus caribou) in the South Peace region of British Columbia. M.Sc. Thesis. University of Northern British Columbia, Prince George, BC.

Williamson-Ehlers, L., C.J. Johnson, and D.R. Seip. 2013. Quantifying behavioural responses, landscape change and habitat loss for woodland caribou (Rangifer tarandus caribou) across the South Peace region of British Columbia. Prepared for the Habitat Conservation Trust Fund, Victoria, BC.

Wilson, S.F. 2009. Recommendations for predator-prey management to benefit the recovery of mountain caribou in British Columbia. Prepared for the British Columbia Ministry of Environment, Victoria, BC.

Wittmer, H.U., Sinclair, A.R.E., and B. N. McLellan. 2005. The role of predation in the decline and extirpation of woodland caribou. Oecologia 144:257-267.

Personal Communications

Campbell, J. 2017. Ecosystem Section Head, BC Ministry of Forests, Lands, and Natural Resource Operations. Legislation pertaining to caribou habitat. Personal communication between Megan Watters (BC MFLNRO) with Michelle Bacon and Paula Bentham (Golder) on April 3, 2017.

Cooper, D. 2017. Archaeological Site Inventory Information and Data Administrator. Archaeology Branch, BC Ministry of Forests, Lands and Natural Resource Operations. Personal communication with Michelle Bacon (Golder) on March 14, 2017.

Davis, S. 2017. Manager at Twin Sisters Native Plants Nursery. Email communication to Catherine Grima (Golder) on 9 March 2017.

Watters, M. 2017. Wildlife Ecologist, Ecosystems Branch, BC Ministry of Forests, Lands and Natural Resource Operations. Personal communication with Michelle Bacon and Paula Bentham (Golder) on 1 March 2017.

APPENDIX A

Habitat Restoration Prescription Types/Techniques for Linear Disturbances

Table 1 Habitat Restoration Prescription Types (Restoration Techniques) for Seismic Lines

Type of Mitigation Prescription	Objective(s)	Specifications	Positive Experiences with this Technique	Considerations to take into account	Ideal Timing for Treatment	References
Mechanical site preparation: Mounding and/or ripping using an excavator	▪ Create microsites in areas where it is deemed to be effective for enhanced survival and growth of planted seed and seedlings, and natural regrowth of woody species ▪ Access control	▪ For access control purposes, mounds should be created using an excavator. The holes left behind by the mounds should generally be approximately 0.75 m deep, if feasible. The excavated material is positioned right beside the hole, creating the mounds. ▪ Ripping should focus on upland sites where excessive moisture is not a concern. ▪ Troughs created by ripping should be positioned to reduce erosion potential. ▪ Target density of mounding for this plan is 1200 mounds/hectare (Appendix A) ▪ When completing in synergy with seedling planting, seedlings are generally planted near the hinge of the mound: – Slightly higher up from the hinge for lowland and transitional sites – At or slightly lower than the hinge for upland sites	▪ For the purposes of enhancing microsites for planted seedlings, mounding is a well-researched site preparation technique in the silviculture industry. It is commonly used in wetter, low-lying areas to create higher, better-drained microsites for seedlings ▪ Mounding treed fen and bog areas can enhance a site to promote natural revegetation over time, as higher, drier spots are created that seed can eventually settle into and germinate ▪ Mounding has been used as an access control measure on decommissioned roads, seismic lines, and pipelines to discourage off-road vehicle activity. It is effective immediately following implementation ▪ Ripping is a standard site preparation method that has been modified in this case for tighter workspaces	▪ Sufficient frost is required to access sites in the winter when crossing lowland areas: This varies from winter to winter ▪ Research regarding machines that can operate in lowlands during non-frozen conditions is underway in NE Alberta	▪ Winter (frozen ground conditions)	▪ Macadam and Bedford 1998 ▪ Roy *et al.* 1999 ▪ MacIsaac *et al.* 2004 ▪ Golder 2010, 2015a, 2015b ▪ OSLI 2012a, 2012b ▪ Nexen 2013 ▪ CRRP 2007 ▪ Archuleta and Baxter 2008 ▪ USDA 2009 ▪ BC MFR 2014a ▪ BC Forest Service 1998 ▪ BC MOF 2000 ▪ BC MFR 1998
Tree/shrub seedling planting and/or seeding	▪ access control ▪ erosion control ▪ reduce line-of-sight ▪ restore habitat	▪ Tree/shrub species are determined based on the treatment table located in the Operational Toolkit (Appendix A) ▪ Coniferous tree species (Spruce sp., Pine sp.) are recommended to meet caribou habitat needs. Considerations for the use of shrubs: – Alder is generally planted because it forms an effective access control and line of sight break in a relatively quick period of time – Alder has a similar palatability rating for ungulates as conifer species (CRRP 2007) – Willow is avoided due to the high palatability rating for ungulates (CRRP 2007) ▪ Shrub and tree seedlings are often planted together, depending on site conditions and anticipated natural revegetation of both species	▪ Seedling planting is considered a long-term restoration treatment due to the length of time it takes to establish effective hiding cover and access deterrents ▪ Seedlings should ideally be sourced at least six months prior to planned planting dates ▪ Seedlings and/or seed for growing seedlings may not be available for every species prescribed and therefore seed may need to be collected and grown in the nursery ▪ Seedling planting during winter is generally restricted to lowland and transitional sites with organic soil that have been treated with mechanical site preparation immediately prior to planting, although trials are underway to plant upland sites using a drill. ▪ Seedling planting density is based on the treatment table from the Operational Toolkit (Appendix A). ▪ For this plan all sites scheduled for seedling planting will be planted to 1200 stems/hectare and some upland sites will be seeded to lodgepole pine, as required.	▪ Use of frozen seedlings needs to consider preparation of nursery stock, storage, planting temperature, and use of snow packing following planting to avoid winter freeze/thaw seedling mortality	▪ Seedlings can be planted on frozen sites in the winter (OSLI 2012; MEG 2014; Cenovus 2013) ▪ Non-frozen stock are generally planted as summer stock in consideration of the Least Risk Timing Windows for caribou	▪ AENV 2010, 2011 ▪ BC MFR 1998 ▪ Cenovus 2013 ▪ CRRP 2007 ▪ DES 2004 ▪ Golder 2005, 2010, 2011, 2012a, 2012b, 2015a, 2015b ▪ MEG 2014 ▪ OSLI 2012a, 2012b ▪ Nexen 2013 ▪ NEIPC 2010
Spreading of woody material	▪ control of human access during snow free periods ▪ erosion control ▪ protect planted seedlings from extreme weather, wildlife trampling, and damage from ATVs ▪ provide site nutrients when the wood decomposes ▪ provide microsites for natural seed ingress	▪ Spread woody material evenly across the entire corridor ▪ Ensure woody material is consistently dense enough on the ground to discourage ATV and wildlife use ▪ The Guide to Fuel Hazard Assessment and Abatement in British Columbia (2012) recommends woody loads do not exceed 99 tonnes/ha (~175 m^3/ha). An exemption may be allowed for larger volumes from the local fire centre under Section 25 or 26 of the Wildfire Regulation. ▪ Vinge and Pyper recommend applying between 60 to 100 m^3/ha of woody material to reclaimed sites to mimic the natural range of variability for woody material in the forest ▪ Implement at sites left for natural recovery when woody material is available as well as sites that are planted with seedlings	▪ The length of a treated segment is dependent on sufficient quantities of woody material available. Longer segments are a more effective treatment at controlling human access since ATV riders will be less inclined to attempt to travel through the woody material or traverse around it in adjacent forest stands if the woody material continues for an extended distance. There are no guidelines or research to suggest the optimal distance for woody debris placement for wildlife and human access control purposes. ▪ Woody material can also conserve soil moisture, moderate soil temperatures, provide nutrients after it decomposes, prevent soil erosion, provide a source of seed for natural revegetation, provide microsites for seed germination and protection for introduced tree seedlings, and protect seedlings from wildlife trampling and browsing ▪ Spreading of woody material is effective as an access control immediately following implementation ▪ Woody material can be brought to a site from another location that has identical tree species	▪ Potential for fuel loading is a concern. The BC MFLNRO specifies acceptable levels of woody material while considering fire management objectives. Consultation with the local fire centre is recommended prior to treatment (stay under 99 tonnes/ha) ▪ Storage and use of woody materials may be compromised if bark beetle is a concern in the area and would be discussed with the local forest officer ▪ Storage of woody material for extended periods without increasing fire hazard can be challenging and should be discussed with district fire managers as part of the planning process when using woody materials	▪ Winter (frozen-ground conditions)	▪ CRRP 2007 ▪ Enbridge 2010 ▪ Osko and Glasgow 2010 ▪ Golder 2010, 2011 ▪ Government of Alberta 2013 ▪ OSLI 2012a,2012b ▪ BC MFLNRO 2012 ▪ Pyper and Vinge 2012 ▪ Vinge and Pyper 2012

Table 1 Habitat Restoration Prescription Types (Restoration Techniques) for Seismic Lines

Type of Mitigation Prescription	Objective(s)	Specifications	Positive Experiences with this Technique	Considerations to take into account	Ideal Timing for Treatment	References
Tree-felling/ Tree Bending	▪ access control ▪ reduce line-of-sight ▪ reduce shade effect	▪ Bend (hinge) mature trees partially across the line with an excavator while treating the features for mounding purposes or spreading woody material ▪ Fell mature trees across the line on upland and transitional sites (e.g., white spruce, pine, aspen, and black spruce) – An excavator is preferred for felling trees by pushing them over, if site conditions are suitable for excavator access – Trees can be felled with a chain saw if site access is suitable to address safety concerns ▪ Trees are to be felled perpendicular to the line. Trees are not to be felled parallel to the line to reduce a fire hazard ▪ Treatment locations to occur approximately every 20 m on lowland and upland sites ▪ At each treatment location, 2 or more trees to be felled, from opposite sides of the line, to create an access control and line of sight break – Treatment locations should occur where sufficient sized timber is present. Before using merchantable timber, consultation between the province of BC's MFLNRO and the local forestry company would need to occur to decide approval process and tracking method for species and number cut – Treatment locations should be as frequent as possible to discourage wildlife use, understanding that locations will be variable depending on forest stand adjacent to line – More trees to be felled near access points and intersections to restrict access and predator movement. Additional trees can be felled along identified lines where the adjacent trees are of suitable height (depends on width of line, need to cover across entire corridor)	▪ Tree-felling and tree bending across the line is mimicking natural processes that occur in the forest. ▪ Tree-felling from the adjacent eco-site can reduce the shade effect on the corridor, leading to more sunlight and warmer soils, creating an enhanced environment for plant growth	▪ Tree-felling will result in tree mortality. Tree bending may keep trees alive with longer term needle cover ▪ Potential for fuel loading is a concern. The BC MFLNRO specifies acceptable levels of woody material while considering fire management objectives. Consultation with the local fire centre is recommended prior to treatment. ▪ Felling and bending is difficult to implement using hand fallers due to difficulties with access, and safety considerations. Mechanical equipment and site safety supervision should be considered ▪ A permit from FLNROwill be required to fall trees	▪ Winter (frozen-ground conditions)	▪ Cody 2013 ▪ Cenovus 2013 ▪ CRRP 2007 ▪ Neufeld 2006 ▪ MEG 2014 ▪ Keim et al. 2014

Literature Cited

AENV (Alberta Environment). 2010. Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition. Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, Alberta. December 2009.

AENV. 2011. 2010 Reclamation Criteria for Wellsites and Associated Facilities for Forested Lands. Updated June 2011. Alberta Environment, Edmonton, Alberta. 99 pp.

Archuleta, J.G. and E.S. Baxter. 2008. Subsoiling Promotes Native Plant Establishment on Compacted Forest Sites. Native Plants. 9: 117-122.

BC MFLNRO (BC Ministry of Forests, Lands, and Natural Resource Operations). 2012. A guide to fuel hazard assessment and abatement in British Columbia. Wildfire Management Branch. Available at: http://bcwildfire.ca/Industry_Stakeholders/Industry/Hazard%20Assess%20%20Abate%20Guidance%20Doc%20FINAL%20with%20all%20Links%20April%202012.pdf. Accessed: 15 September 2014.

BCFS (British Columbia Forest Service). 1998. Silviculture Note 16 - Forest Floor Planting: a Discussion of Issues As They Relate to Various Site-Limiting Factors. Forest Site Management Section, Forest Practices Branch. 25 March 1998. Victoria, BC. 11 pp.

BC MFR (BC Ministry of Forests and Range). 1998. Provincial Seedling Stock Type Selection and Ordering Guidelines. BC Ministry of Forests, Forest Practices Branch. Available at: http://www.for.gov.bc.ca/hfp/publications/00078/. Accessed: 27 February 2014.

BC MFR. 2014. Microsite Planting Presentations. Available at: http://www.for.gov.bc.ca/hfp/training/00009/microsite.htm. Accessed: 27 February 2014.

BC MOF (BC Ministry of Forests). 2000. Extension Note: Opportunities for Improvements to Reforestation Success. Prepared by Marek J. Krasowski, Research Branch, British Columbia Ministry of Forests, and Ronald J.F. Elder, R.J.F. Elder Forestry Consulting. January 2000. 15 pp.

Cenovus (Cenovus Energy). 2013. Woodland Caribou Mitigation and Monitoring Plan: Cenovus FCCL Ltd. Christina Lake Thermal Project (Approval 48522-01-00). 22 February 2014.

Cody, M. 2013. Restoration Efforts in Northern Alberta: Knowledge Sharing. Cenovus Linear Deactivation (LiDEA) Projects Update. Golder Restoration Update Workshop, Edmonton AB, 6 June 2013.

CRRP. 2007. Caribou Range Restoration Project: Guidelines for Planning and Implementation. Unpublished document created for the West Central Alberta Petroleum Producers Group, Canadian Association of Petroleum Producers and Environment Canada. 19 September 2007.

DES (Diversified Environmental Services). 2004. Canadian Natural Resources Ltd. Ladyfern Pipeline d-87-H/94-H-1, British Columbia to NE Section 20- Township 94-Range 12 W6M, Alberta: Revegetation Monitoring Report Year 2 (2003). Prepared for Canadian Natural Resources Ltd. 18 pp. + Appendices.

Enbridge (Enbridge Pipelines (Athabasca) Inc.). 2010. Waupisoo Pipeline Project: 2010 Green Area Post-Construction Reclamation Assessment. Submitted to Alberta Sustainable Resource Development.

Golder (Golder Associates Ltd.). 2005. Firebag Project 2004 Seismic Line Reclamation Study Annual Report. Submitted to: Suncor Firebag Inc.

Golder. 2010. Canadian Natural Resources Limited: Primrose and Wolf Lake: Wildlife Habitat Enhancement Program Development and Implementation. Submitted to Canadian Natural Resources Ltd, Calgary, AB.

Golder. 2011. Waupisoo Pipeline 2011 Seedling Monitoring Plot Summary. Submitted to Enbridge Pipelines (Athabasca) Inc.

Golder. 2012a. Interconnect Pipeline 2011 Seedling Monitoring Plot Summary. Memo submitted to Canadian Natural 23 February 2012.

Golder. 2012b. Waupisoo Pipeline Project: Seedling Planting and Monitoring Final Report. Submitted to Enbridge Pipelines (Athabasca) Inc.

Golder. 2015a. Boreal Caribou Habitat Restoration Operational Toolkit for British Columbia. Prepared for BC Science and Community Environmental Knowledge Fund's Research and Effectiveness Monitoring Board. Report number 1313720037. Available at: http://scek.ca/sites/default/files/bcip-2015-05-restoration-toolkit-28final29-jan-2115.pdf. Accessed 6 July 2015.

Golder. 2015b. 9 to 13 Year Follow-up Monitoring in the Little Smoky Caribou Range 15-ERPC-07: Caribou Range Restoration Treatment Sites. Submitted to Petroleum Technology Alliance of Canada,Foothills Land Management Forum, and the Government of Alberta. November 2015.

Government of Alberta. 2013. Integrated Standards and Guidelines – Enhanced Approval Process. Version 2. 85 pp. Available at: http://esrd.alberta.ca/forms-maps-services/enhanced-approval-process/eap-manuals-guides/documents/EAP-IntegratedStandardsGuide-Dec01-2013.pdf.

Keim, J.L., P.D. DeWitt, T. Shopik, J. Fitzpatrick and S.R. Lele. 2014. Understanding and mitigating the effects of linear features and snow condition on caribou predator-prey overlap in the Alberta Oil Sands. 15th North American Caribou Workshop, Whitehorse, Yukon, 14 May 2014. Oral presentation.

Macadam, A. and L. Bedford. 1998. Mounding in the Sub-boreal Spruce Zone of West-Central British Columbia: 8-year Results. The Forestry Chronicle 74: 421-427.

MacIsaac, D.A., G.R. Hillman and P.A. Hurdle. 2004. Alternative Silvicultural Systems for Harvesting and Regenerating Spruce-Dominated Boreal Mineral Wetlands. Canadian Forest Service, Northern Forestry Centre, Information Report Nor-X-399.

MEG (MEG Energy). 2014. MEG Energy Christina Lake Regional Project: Linear Deactivation Trial. March 2014.

Neufeld, L. 2006. Spatial Dynamics of Wolves and Woodland Caribou in an Industrial Forest Landscape in West-Central Alberta. Department of Renewable Resources, University of Alberta.

Nexen (Nexen Energy). 2013. Algar caribou habitat restoration program, 2012/13 Phase 2 & 3 areas. Draft report prepared for Canada's Oil Sands Innovation Alliance (COSIA). Calgary, AB. 109 pp.

NEIPC (Northeast Invasive Plant Committee). 2010. Peace – Liard Re-Vegetation Manual. Approved by the NEIPC Membership on 28 April 2010. Available at: http://prrd.bc.ca/services/environmental/weed_control/documents/NEIPC_Reveg_manual_PeaceLiard_April2010.pdf. Accessed November 2014.

Osko, T. and M. Glasgow. 2010. Removing the wellsite footprint: recommended practices for construction and reclamation of wellsites on upland forests in Boreal Alberta. University of Alberta, Edmonton, Alberta. 72 pp. Available at: http://www.biology.ualberta.ca/faculty/stan_boutin/ilm/uploads/footprint/Upland%20Recommendations%20-%20Final%20Revised%20-%20Small%20File.pdf. Accessed July 2014.

OSLI (Oil Sands Leadership Initiative). 2012a. Algar caribou habitat restoration program, field operations: phase 1 area. Report. Calgary, AB. 76 pp.

OSLI. 2012b. Algar caribou habitat restoration program: area 1 – re-measurement 1. Report. Calgary, AB. 91 pp.

Pyper, M. and T. Vinge. 2012. A visual guide to handling woody materials for forested land reclamation. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta Report No. TR-31. 10 pp.

Roy, V., P.Y. Bernier, A.P. Plamondon and J.C. Ruel. 1999. Effect of Drainage and Microtopography in Forested Wetlands on the Microenvironments and Growth of Planted Black Spruce Seedlings. Canadian Journal of Forest Research, 29: 563 -- 574.

USDA (United States Department of Agriculture). 2009. Multipurpose Subsoiling Excavator Attachments. Prepared by Bob Monk, Forester. U.S. Department of Agriculture, Forest Service National Technology and Development Program. Revised June 2009. 21 pp.

Vinge, T. and M. Pyper. 2012. Managing woody materials on industrial sites: Meeting economic, ecological, and forest health goals through a collaborative approach. Department of Renewable Resources, University of Alberta, Edmonton, Alberta. 32 pp.

APPENDIX B

Historic and Current Caribou Habitat Restoration Initiatives in Canada

Table 1 Historic and Current Habitat Restoration Initiatives in Canada (modified from Golder 2012a and NGTL 2012)

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports

Consortium composed of oil/gas companies, Environment Canada, Alberta Conservation Association, the Alberta Caribou Committee, and Alberta Environment and Sustainable Resource Development [AESRD]) (previously referred to as Alberta Sustainable Resource Development[ASRD])	Caribou Range Restoration Program (CRRP)	Program active from 2001 to the end of 2007.
		• Mandate was to use an adaptive management approach to restoring caribou habitat while testing methods to speed recovery of anthropogenically created linear disturbance.
		• Involved trials to increase the recovery path of seismic and other linear corridors to treed cover, studying the effect of access management techniques on wildlife and humans, performing a cost/benefit analysis, and drafting recommended operating practices and planning strategies from the construction through to the reclamation phases of oil and gas developments.
		• Field treatments included: transplanting trees and shrubs, seeding, tree seedling planting, using planting enhancements, soil decompaction, mounding, slash rollback, and installation of wooden fences for line-of-site breaks.
		• Planning strategies included the use of aerial imagery for collecting vegetation inventories, and developing logistical best practices for seedling planting in wetland areas during the summer.
			• Tested site preparation techniques as they pertain to promoting revegetation and limiting human use of linear corridors, including excavator mounding, decompaction and slash rollback.
			• Planted different species of tree and alder seedlings on a number of ecosites on seismic lines and pipelines. Follow-up surveys have shown good survival of most species when planted on native site conditions.
			• Researched and tested the use of aerial imagery and LiDAR for collecting vegetation inventories on linear disturbances, of which aerial imagery was proven to be successful and adopted for other habitat restoration programs.
			• Managed the macro-scale Suncor/ConocoPhillips Caribou Habitat Restoration Pilot implemented within the Little Smoky caribou range in 2006:
			  ○ over 100 km of linear corridors treated, encompassing several townships;
			  ○ included site preparation techniques (excavator mounding and slash rollback);
			  ○ included planting of tree seedlings on a variety of different ecosites, treatment types and disturbances. Effectively used helicopters and slings to plant seedlings in predominately wetlands sites and along seismic lines;
			  ○ included the installation of wooden fences at the beginning of linear corridors to serve as line-of-sight breaks;
			  ○ focused on access management by using excavator mounding at the beginning of linear corridors; and
			  ○ installation of signs at treatment sites.
			• Produced an unpublished draft document on recommended practices for implementing a habitat restoration program, from the planning through to the treatment and monitoring phases.
			• Produced an unpublished monitoring manual for collecting revegetation data on linear corridors.
				CRRP 2007a,b,c
				Neufeld 2006

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
			• Successfully transplanted trees and shrubs during planting trials during winter and summer conditions, on a number of ecosites including treed wetlands. • Sponsored trials of frozen tree seedling planting. Note, since this showed promise, OSLI has sponsored further research and this technique is being implemented as part of the Algar Reclamation Program. • Sponsored trials for the use of encapsulated seed products for reclamation purposes. • Sponsored a line-blocking study, as part of L. Neufeld's Master's Thesis on wolf/caribou dynamics in the Little Smoky caribou range.	
Suncor Energy	Accelerated Seismic Line Restoration	Program initiated in 2000. • Objective was to promote revegetation of seismic lines through the use of tree seedling planting, bioengineering (willow staking) and transplanting existing vegetation. • Techniques tried on upland, transitional wetlands and wetland ecosites. • No follow-up monitoring beyond this program.	Four years post-treatment: • upland black spruce transplants survived but showed signs of stress; • black spruce and willow plugs worked better than transplants; • poor results for lines with mulch on them; • transitional wetland black spruce transplanting showed high survival but low growth or vigour rate; and • wetland black spruce and willow transplants and plugs had poor survival, but slightly better survival when planted in elevated microsites.	Golder 2005
Canadian Natural Resources Limited (CNRL), Diversified Environmental Services	Ladyfern Pipeline Re-vegetation Program (natural gas pipeline running from northeast BC into northwest Alberta)	Pipeline construction occurred in 2002. • Promoted revegetation on a pipeline development by: minimizing root disturbance during construction; mechanical seeding of the right-of-way (RoW) on areas of erosion concern only; promoting the growth of native species from seed; planting of tree seedlings; and transplanting of existing trees. • Goal was to create line-of-sight breaks as introduced trees grow over time. • Upland habitat: tree seedlings were planted primarily with white spruce and lodgepole pine. • Lowland habitat: planted larger, locally collected and transplanted black spruce.	• Annual monitoring of species composition and percent vegetation ground cover was conducted for two growing seasons. • Survival rates were higher in upland sites than lowland sites (focus on lowland sites was black spruce transplants). • Poor survival of locally collected transplanted black spruce. • Coniferous tree seedling (nursery stock white spruce and lodgepole pine) survival and growth appeared to be more successful than using locally collected transplants. • Natural regeneration in both upland and lowland sites was noted in areas that had minimized root disturbance during construction of the pipeline and where there was no mechanical seeding of grass seed. • Re-colonization of coniferous species provided the best visual barrier; deciduous species effective more quickly. • Recommended that transplants should be conducted in the fall when trees are dormant, but still have sufficient time to establish roots.	Diversified Environmental Services 2004

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
			• Recommended that the most effective method for establishing a line-of-sight break is to concentrate efforts on productive uplands. • Recommended that smaller trees (20 to 30 cm) be selected for further transplants.	
AXYS Environmental	Recommended Peatland Restoration Techniques for Oil and Gas in Boreal Forest	AXYS conducted a literature review of successfully used peatland reclamation techniques within wildlife habitats in the boreal forest.	• A mean water table level higher than 40 cm and preferably within 20 cm promotes peatland growth[1]. • Removing drainage ditches following decommissioning will help restore peatlands[2]. • Water table management is essential to ensure successful re-vegetation of peatlands and to guide the direction of re-vegetation. Soil chemistry adjustment may be required for problem soils[3]. • To achieve improved black spruce seedling growth and environmental quality, use selected mycorrhizal fungi when reclaiming dense black spruce bogs[4]. • Re-establish site hydrology, site topography, and appropriate bog vegetation to reclaim raised bogs. • Patches of discontinuous permafrost (e.g., in northeastern Alberta) are not yet possible to reclaim[5].	AXYS 2003 [1]Tedder and Turchenek 1996 [2]Girard *et al*. 2002 [3]Naeth *et al*. 1991 [4]Khasa *et al*. 2001 [5]Robinson and Moore 2000 [5]Turetksy *et al*. 2000 [5]Camill 1999

Enbridge Pipelines (Athabasca)	Waupisoo Pipeline Habitat Restoration	Pipeline construction occurred in the winter of 2007/08.
		• Promoted revegetation on a pipeline development within critical moose and caribou habitat by: mechanical seeding of the RoW on areas of erosion concern only; promoting the growth of native species from seed; planting tree and shrub seedlings; transplanting existing shrubs; and using slash rollback for access control and micro-site creation for seedling and seed establishment.
		• Goal was to use growth of planted trees to create line-of-sight breaks, directly restore habitat and control access.
			• Approximately 250,000 seedlings were planted at strategic locations over 3 summers. Locations included:
			  ○ intersections with other linear corridors;
			  ○ upland sites to create line-of-sight breaks; and
			  ○ riparian areas.
			• Slash rollback was applied on some steeper slopes and at some intersections with all-season and winter roads.
			• Shrub species (alder and willow) transplanted successfully on the banks of the Christina River during the winter.
			• Planting sites were subject to monitoring over a five year period.
			• Good survival of seedlings was observed on all classes of eco-sites.
			• Vegetation ingress of clover and native grasses has had a negative impact on seedling survival in some areas.
			• Where no access control measures were applied, human use of the RoW by ATV damaged many seedlings.
			• Seedlings planted in conjunction with slash rollback were not damaged.
				Enbridge 2010
				Golder 2012b

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports

Canadian Natural Resources Limited, Wolf Lake	Interconnect Pipeline	Pipeline construction occurred during the winter of 2007/08.
		• Promoted revegetation on a pipeline development adjacent to the Cold Lake Air Weapons Range (CLAWR) by planting of tree and shrub seedlings.
		• Goal was to use growth of planted tree species to create line-of-sight breaks, limit the overall width of the developed corridor that the pipeline parallels, directly restore habitat and control access.
			• Approximately 60,250 seedlings planted at strategic locations over 2 summers. Locations included:
			  ○ intersections with other linear corridors;
			  ○ upland sites to create line-of-sight breaks; and
			  ○ riparian areas.
			• Planting sites are currently subject to monitoring over a five year period.
			• Good survival of seedlings where mechanical seeding of grasses was avoided.
			• Areas mechanically seeded to native grass mixtures had lower survival and vigour of planted seedlings, possibly due to increased competition for sunlight, water and nutrients, and graminoid vegetation laying over and choking out the seedlings when snowfall occurs.
			• Damage to seedlings from ATV use in many monitoring plots.
			• Other environmental factors such as frost and wetland encroachment possibly contributing to seedling mortality.
				Golder 2012c

University of Alberta led project, supported by a number of oil/gas companies, Canadian Association of Petroleum Producers (CAPP), Forest Resource Improvement Association (FRIA), and Alberta-Pacific Forest Industries Inc. (ALPAC)	Integrated Land Management	• Ongoing study began in 2004 and focused on contributing to best practices for wellsite construction and reclamation on forested lands in the Green Area of northeastern Alberta. Techniques to enable appropriate revegetation and accelerate recovery of ecological processes after disturbance were studied.
		• Old wellsites component involved monitoring soils and vegetation.
		• New wellsites component researched methods to use during well-site construction that will promote the prompt revegetation of the site during the reclamation phase.
			• Report produced in 2010, “Recommended Practices for Construction and Reclamation of Wellsites on Upland Forests in Boreal Alberta”, that evaluated soil and vegetation responses to different winter construction and reclamation techniques.
			• Recommendations included:
			  ○ maximizing low disturbance construction practices;
			  ○ use of snow/water to level sites as opposed to stripping;
			  ○ retain root zone when stripping and store soil layers in separate piles;
			  ○ plant seedlings promptly after reclamation to lessen impact of native vegetation competition;
			  ○ slash rollback is preferable to mulching;
			  ○ mulch layers need to be less than 10 cm thick when present;
			  ○ avoid planting tree and shrub species that may impact predator/prey dynamics and do not occur naturally in the area. For example, planting of species palatable to moose in caribou areas should be avoided; and
			  ○ pre-disturbance assessments and prescription planning can pay dividends at the reclamation stage.
				Osko and Glasgow 2010

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
Oilsands Leadership Initiative (currently referred to as COSIA)	Faster Forests	Ongoing since 2007, planting trees to increase the pace of reclamation.	• Planting shrubs along with trees allows for trees to grow healthier, faster and with less competition for nutrients and water from fast-growing grasses. • Planted 143,850 seedlings on 113 sites in 2009. • Planted 238,632 seedlings on 120 sites in 2010. • Planted >600,000 seedlings in 2011 on 200 sites (included 4 tree species, 7 shrub species).	OSLI 2012
Grande Prairie Regional College / University of Alberta, COSIA	Winter Wetland Frozen Seedling Planting Trial	• Wetlands re-vegetation trials consisting of winter planting of frozen black spruce seedlings to address challenges involved with planting wetland sites during the summer months. • Goal is to improve reclamation performance.	• Planted 900 trees in winter 2011. ○ >90% survival rate in spring 2011. • Findings were used to help develop an on-going large scale frozen seedling program located in the Algar area.	OSLI 2012

OSLI (or COSIA)	Algar Reclamation Program	• Program targeting the restoration of seismic lines through re-vegetation and access control to improve wildlife habitat in a caribou area with historic seismic disturbance.
		• The Algar area of northeastern Alberta covers approximately six townships (each township is 6 miles by 6 miles).
			• Inventory of linear disturbance completed using remote sensing methods.
			• Detailed restoration plan developed.
			• Stakeholder consultation led by AESRD on the closure of selected seismic lines to the general public (i.e., to provide some level of protection to areas with restoration treatments).
			• Macro-scale restoration activities concluded in winter include:
			  ○ excavator mounding;
			  ○ slash rollback; and
			  ○ frozen tree seedling planting.
				OSLI 2012
				Update from Golder 2013

Alberta School of Forest Science and Management / OSLI	Coarse woody debris management - best practices	• Goal is to come up with consistent standards that industry users can implement when spreading woody debris on reclaimed sites.	• Developed a guide for improved management of coarse woody debris materials as a reclamation resource. • Best practices manual was prepared through consultation with resource managers and operators, consideration of economic and ecologic requirements, and synthesis of the most relevant and current scientific knowledge. • Wood mulch depths exceeding 3-4 cm form an insulating layer over the soil surface limiting plant growth. • Use of whole logs enhances forest recovery by creating microsites, which creates improved conditions for vegetation to establish and grow. • Total rollback of material along the entire length of exploration and access features is the most effective way to discourage recreational use of linear features. • Well designed scientific monitoring of wildlife use is needed to provide managers with an understanding of treatment effectiveness.	OSLI 2012 Vinge and Pyper 2012 Pyper and Vinge 2012

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports

Canadian Natural Resources Ltd. (CNRL)	Habitat Enhancement Program	• Program is part of the Terms and Conditions of the *Environmental Protection and Enhancement Act* (*EPEA*) approval for the construction, operation and reclamation of the Canadian Natural Primrose and Wolf Lake (PAW) Project.
		• Program targeted the restoration of seismic lines, old lease roads, and abandoned well and core hole sites through re-vegetation and access control to improve wildlife habitat on a caribou range within the CLAWR.
		• Focused on restoration of historic (pre-oil sands development) features on the landscape that are recovering poorly, either due to environmental conditions (cold, wet soils), historical clearing and reclamation practices, or recent clearing for winter access.
		• Focused on areas outside of 10 year development plan to avoid re-entry into areas where restoration treatments are placed.
			• Used aerial imagery to conduct linear corridor vegetation inventories on all of CNRL's CLAWR operations, encompassing approximately nine townships.
			• Detailed restoration plan developed.
			• Ground-truthed sites that appeared on aerial imagery as having little to no woody plant regeneration.
			• Focused on access control and micro-site creation for introduced tree seedlings, using the following three treatments:
			  ○ mounding;
			  ○ tree seedling planting; and
			  ○ slash rollback.
			• Planting sites are subject to monitoring over a five year period.
			• To date, monitoring has only occurred for black spruce seedlings planted in the summer on sites treated in the winter with excavator mounding in treed bog and fen sites.
			• Excellent survival and vigour of seedlings at all monitored sites.
			• On-going program that began with restoration treatments in 2010.
			• Additional site preparation and seedling planting scheduled for winter 2014/15.
				Golder 2010

ConocoPhillips, Suncor Energy, and the Canadian Association of Petroleum Producers	Caribou Habitat Restoration Pilot Study	• Remote camera study (summer 2008) initiated within the Little Smoky caribou range in Alberta. Objectives included comparing wildlife (caribou, deer, moose, bear, wolf, coyote, cougar and lynx) presence and use between naturally restored seismic lines and open cutlines.	• Pooled prey species (caribou, deer, moose) preferentially select restored seismic lines (>1.5 m vegetation heights, average age of trees 23 years) over non-vegetated sites. • Deer had the strongest preference for restored sites, with the preference attributed to the increased forage within the restored sites, as well as reduced line-of-site and potentially predator avoidance. • Caribou were shown to have a slight preference for re-vegetated seismic line sites over non-vegetated sites, but with limited data there was no statistical difference. However, caribou on control sites were observed to be running much more frequently than on re-vegetated sites and engaged in standing related behaviours only while on re-vegetated sites. Data indicate that caribou are more likely to travel quickly through open seismic lines, which may be a response to the minimal vegetation cover.	Golder 2009

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
Cenovus LiDEA I and II	Linear Deactivation Programs LiDEA I and II	• Habitat restoration program, focusing on synergistic objectives of access control and creating plant community trajectories to native species as soon as possible. • Implementation of a monitoring program to look at wildlife use (caribou, predator)	• The problem? Numerical as well as functional dimension • possible reasons conifer growth is delayed (lack of viable seed bed, mulching, displacement of topsoil, competition, shade, traffic, historical seeding, compression of surfaces relative to water table) • comparative tests needed • sampling areas for LiDEA include treatment linear deactivation, Control A Business as usual, Control B Ecological baseline • overlay with AESRD Restoration Priority Areas • response metrics are multi-species, multi-level (site, individual, population) • Treatment objectives: conifer abundance/growth, species distribution, reduce trafficability, reduce site lines, develop operationally viable method • Treatments: use silviculture to alter soil-plant system including mounding, planting, stand modification • Use geomatic work and prescription key • Strong results from mounding • Equipment issues to resolve • Some early collar data	Cenovus 2013 Cody 2013

TransCanada Piplines	Leismer to Kettle River Crossover Pipeline Project: Caribou Habitat Restoration Plan
	
	Northwest Mainline Pipeline Project: Caribou Habitat Restoration Plan
		• Habitat restoration program, focusing on synergistic objectives of access control and creating plant community trajectories to native species as soon as possible.
		• Restoration program included on and off ROW restoration treatments
			• Detailed restoration plan developed for both on and off ROW:
			  ○ On ROW to mitigate project development
			  ○ Off ROW to compensate for loss of habitat during development that wasn't able to be mitigated during construction and/or reclamation
			• Creation of measurable targets table, to monitor effectiveness of treatments
			• Focused on access control and micro-site creation for introduced tree seedlings, using the following three treatments:
			  ○ mounding;
			  ○ tree seedling planting ;and
			  ○ spreading woody debris.
				NGTL 2014a
				NGTL 2014b

Foothills Landscape Management Forum (FLMF)	West Central Alberta Habitat Restoration Program: meeting	Immediate Need: • It is expected that the West Central Alberta caribou range plan will have a requirement to restore significant amounts of linear and other disturbances. Assessing the past treatments will help inform the design and	• In 2013, principal investigator Laura Finnegan with the FRI began the program entitled 'Analysis and Restoration of Seismic cutlines in southern mountain and boreal caribou range in west-central Alberta'. Field work commenced in the summer of 2013 collecting vegetation attributes, evidence of human use, and evidence of wildlife use. Field work will	FRI 2014.

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
• Foothills Research Institute (FRI) • Greenlinks Forestry Inc. • Golder Associates	short and long term objectives	cost of restoring historic linear disturbances. The assessment will look, on an eco-site / treatment type basis, at successes, failures, growth rates, unintended consequences, human use, animal use, line of sight, density, crown closure, primary prey browse species presence. Long term: • In the long term a trajectory model for functional habitat restoration of linear disturbances by eco-site / treatment type (including natural regeneration) will be developed so that appropriate modeling and sensitivity analysis can be completed to inform how and when intervention should be (or should not) be done. This will include long term monitoring of predator use, primary prey use, caribou use, human use, as well as vegetation growth / response to inform/update the trajectory model (adaptive management). • Greenlinks provides mapping and remote sensing products to support the restoration program. • Golder to survey CRRP treatment sites. Objectives: as of fall 2014 the CRRP treatment sites will have had 8 to 12 growing seasons since they were treated, and the lack of long-term monitoring results for habitat restoration treatments implemented throughout Alberta, Golder will return to many of the previously monitored sites in the Little Smoky caribou range to measure the site parameters laid out above in the immediate need objectives. The ultimate goal is to determine the growth trajectories of the seedlings across a variety of ecophases and treatment methods	continue until the fall of 2014. Remote camara data was also collected on wildlife use of lines during the winter of 2013/2014. A geographic information system (GIS) was used to select seismic lines within the ranges of A La Peche, Little Smoky, Redrock Prairie Creek and Narraway caribou that intersected with the Berland Smoky Regional Access Plan active road layer produced by the FLMF and road layers available for the RPC and NAR caribou ranges. A subset of sites has been selected to visit in the field and conduct human use surveys (June to October 2013, May to October 2014). At each site, vegetation, topographic, and human use data are collected at the 0m, 100m and 500m point of each seismic line. Presence - absence of tracks and scat for canid (Canis spp.), ursid (Arctos spp.), caribou, elk, moose, and deer is also collected. • Greenlinks preparation of a semi-automated lineal inventory project is to determine whether it is possible to correlate ecophases with predicting revegetation success on linear features, thereby automatically taking certain areas out the equation for having to ground truth them. Initial results support previous learnings from linear inventory classification programs that most sites do not need vegetation enhancement, only access blocking from human (predator) use of the features • Golder field work still in proposal stage with FLMF.	

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
Cold Lake Regional Initiative • MEG Energy • Cenovus Energy • Canadian Natural Resources Ltd. • Devon Energy • Alberta Biodiversity Monitoring Institute (ABMI) • University of Alberta	Caribou Habitat Restoration / Linear Deactivation Program	• Linear deactivation program, focusing on synergistic objectives of predator access control and creating plant community trajectories to native species as soon as possible.	• Pre and Post treatment predator location data and study design through the UofA/ABMI • Regional study area • Used aerial imagery and/or LiDAR to conduct linear corridor vegetation inventories. • Detailed restoration plans developed for each company, in collaboration with the University of Alberta, in order to help guide restoration sites towards actively monitored wolf populations. • Field truthed sites that appeared on aerial imagery as having little to no woody plant regeneration. • Focused on access control and micro-site creation for introduced tree seedlings, using the following treatments: o mounding; o tree felling, bending, and transplanting; o tree seedling planting (winter and summer); and o spreading woody debris. • Additional site preparation and seedling planting scheduled for winter 2014/15.	MEG Energy 2014 Cenovus 2013 Cody 2013
Department of Renewable Resources, University of Alberta • Cassidy van Rensen M.Sc. Candidate	Seismic Line Regeneration Research Northeast Alberta	Masters research focused on: 1. variation in vegetation regeneration along seismic lines and our ability to predict the regeneration probability over the landscape (understanding the factors affecting regen for 2 recovery criteria; 3 m height using the min green-up rule and meeting 50% of adjacent stand height); and 2. development of a restoration optimization tool • CEMA study area, south of Fort McMurray, 180,000 hectares within the East Side Athabasca Caribou Range (ESAR)	• For the 3 m recovery target (height), there was a negative relationship with Ecosite i and j (bogs and fens very negative response to regen as microsites pushed below the water table). Overall, fens most difficult for regen establishment (limited regen and delayed regen). Positive relationship with distance to road (i.e., as you move further from roads, natural recovery rate is improved). • For reaching 50% of adjacent stand height Model: o positive relationship with distance to road and depth to watertable o negative relationship with line width o negative relationship with ecosites j,k, and l • When depth to water table is 2-3m; this is the best regen probability. Very wet sites or very dry sites show very limited regen, or difficult regen. Terrain wetness and ecosite were the major influences on regeneration rate. When low depth to water table, limited regen. Fens show very limited regen even after 50 years. • Created mapped probabilities for 3 m recovery target/criteria (i.e., potential for regen if disturbed; a vulnerability map which indicates regen expected after 50 years. Quantified regen for use in mapping and restoration planning. Moisture and	van Rensen et al. 2015 C. van Rensen MSc. Thesis Defense (pers. comm.) 19 September 2014

Company or Group	Initiative Name or Goal	Description	Accomplishments and/or Learnings	Key Reports
			nutrient regimes of surrounding ecosites, Depth to Water Table (DTW) and distance to nearest road (probability of human re-use) play an important role in regeneration rates. Identified that composition or density of regen should be considered in recovery criteria; as well as terrain wetness and implementation of ecosite based treatments. • Used Marxan with zones to create a restoration planning tool which considers active zones, passive zones (natural recovery with human access control) and available zones. Zonation focuses restoration dollars on areas of high degree of success at low cost.	

LITERATURE CITED

AXYS Environmental Consulting Ltd. 2003. Literature review of reclamation techniques for wildlife habitats in the boreal forest. Prepared for: Biodiversity and Wildlife Subgroup of the Reclamation Working Group, Cumulative Effects Management Association. Prepared by Axys Environmental Consulting, Calgary, Alberta.

Camill, P. 1999. Patterns of boreal permafrost peatland vegetation across environmental gradients sensitive to climate warming. Canadian Journal of Botany 77: 721–33.

Cenovus (Cenovus Energy). 2013. Woodland Caribou Mitigation and Monitoring Plan: Cenovus FCCL Ltd. Christina Lake Thermal Project (Approval 48522-01-00). 22 February 2013.

Cody, M. 2013. Restoration Efforts in Northern Alberta: Knowledge Sharing. Cenovus Linear Deactivation (LiDEA) Projects Update. Golder Associates Restoration Update Workshop, Edmonton AB, 6 June 2013.

CRRP (Caribou Range Restoration Project). 2007a. Permanent Sample Plot Manual for the Caribou Range Restoration Project in Alberta, 23 March 2007. Draft Unpublished Document.

CRRP. 2007b. Caribou Range Restoration Project: Guidelines for Planning and Implementation. Unpublished document created for the West Central Alberta Petroleum Producers Group, Canadian Association of Petroleum Producers and Environment Canada. 19 September 2007.

CRRP. 2007c. Little Smoky Caribou Habitat Restoration Pilot Project Summary. Unpublished document prepared for Suncor Energy, ConocoPhillips, Canadian Forest Products and Alberta Newsprint Co.

Diversified Environmental Services. 2004. Canadian Natural Resources Ltd. Ladyfern Pipeline d-87-H/94-H-1, British Columbia to NE Section 20- Township 94-Range 12 W6M, Alberta: Revegetation Monitoring Report Year 2 (2003). Prepared for: Canadian Natural Resources Ltd. 18 pp. + Appendices.

Enbridge (Enbridge Pipelines (Athabasca) Inc.). 2010. Waupisoo Pipeline Project: 2010 Green Area Post-Construction Reclamation Assessment. Submitted to Alberta Sustainable Resource Development.

FRI (Foothills Research Institute). 2014. 'Analysis and Restoration of Seismic Cutlines in Southern Mountain and Boreal Caribou Range in West-Central Alberta: June 2014 Report'. Online at https://foothillsri.ca

Girard, M., C. Lavoie and M. Thériault. 2002. The regeneration of a highly disturbed ecosystem: A mined peatland in southern Québec. Ecosystems 5: 274–288.

Golder (Golder Associates Ltd.). 2005. Firebag Project 2004 Seismic Line Reclamation Study Annual Report. Submitted to: Suncor Firebag Inc.

Golder. 2009. Caribou Habitat Restoration Pilot Study. Prepared for Conoco Phillips Canada, Suncor Energy and Canadian Association of Petroleum Producers. 41pp.

Golder. 2010. Canadian Natural Resources Limited: Primrose and Wolf Lake: Wildlife Habitat Enhancement Program Development and Implementation. Submitted to Canadian Natural Resources Ltd, Calgary, AB.

Golder. 2012a. Boreal Caribou Habitat Restoration. Prepared for: Ministry of Forests, Lands and Natural Resource Operations. Fish Wildlife and Habitat Management Branch, Government of British Columbia. Prince George, BC. 24 pp.

Golder. 2012b. Waupisoo Pipeline Project 2012. Seedling Planting and Monitoring Final Report. Prepared for Enbridge Pipelines (Athabasca) Inc. 27 December 2012.

Golder. 2012c. Interconnect Pipeline 2011 Seedling Monitoring Plot Summary. Memo submitted to CNRL 23 February 2012.

Golder. 2013. Caribou Habitat Restoration Workshop. Edmonton, Alberta. 6 June 2013.

Khasa, P.D., L. Sigler, P. Chakravarty, B.P. Dancik, L. Erikson and D. Mc Curdy. 2001. Effect of fertilization on growth and ectomycorrhizal development of container-grown and bare-root nursery conifer seedlings. New Forests 22: 179–197.

MEG Energy. 2014. MEG Energy Christina Lake Regional Project: Linear Deactivation Trial. March 2014.

Naeth, M.A., D.J. White, D.S. Chanasyk, T.M. Macyk, C.B. Power and D.J. Thacker. 1991. Soil physical properties in reclamation. Alberta Land Conservation and Reclamation Council Report No, RRTAC 91-4. ISBN 0-7732-0880-I, Edmonton, AB. 216 pp.

Neufeld, L.M. 2006. Spatial dynamics of wolves and woodland caribou in an industrial forest landscape in west-central Alberta. M.Sc. Thesis. University of Alberta, Edmonton, AB. 155 pp.

NGTL (NOVA Gas Transmission Ltd.) 2014a. Final Caribou Habitat Restoration Plan for the NOVA Gas Transmission Ltd. Northwest Mainline Expansion. Prepared for: TransCanada Ltd. Prepared by: TERA Environmental Consultants.

NGTL. 2014b. Final Caribou Habitat Restoration Plan for the Leismer to Kettle River Crossover Project. Prepared for: TransCanada Ltd. Prepared by: Golder Associates Ltd.

Osko, T., and M. Glasgow. 2010. Removing the Well-Site Footprint: Recommended Practices for Construction and Reclamation of Well-sites on Upland Forests in Boreal Alberta. Department of Biological Sciences, University of Alberta. Available at: http://www.biology.ualberta.ca/faculty/stan_boutin/ilm/uploads/footprint/Upland%20Recommendations%20-%20Final%20Revised%20-%20Small%20File.pdf. Accessed September 2014.

Oil Sands Leadership Initiative (OSLI). 2012. Projects: Land. Available at: http://www.osli.ca/projects/land. Accessed: July 2012.

Pyper, M. and T. Vinge. 2012. A visual guide to handling woody materials for forested land reclamation. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta Report No. TR-31. 10 pp.

Robinson, S.D. and Moore, T.R. 2000. The influence of permafrost and fire upon carbon accumulation in high boreal peatlands, Northwest Territories, Canada. Arctic, Antarctic, and Alpine Research 32: 155-166.

Tedder, W.S. and L.W. Turchenek. 1996. Natural Revegetation of an Alberta Peatland After Horticultural Peat Extraction. 4th Annual Canadian Peatland Restoration Workshop, 13-14 July, Quebec City, Canada; Universite Laval, Faculte des Sciences de Sciences de L'agriculture et de l'alimentation, Quebec City, Canada; 62 PP. (Abstract, P. 51)

Turetsky, M.R., R.K. Wieder, C.J. Williams and D.H. Vitt. 2000. Organic matter accumulation, peat chemistry, and permafrost melting in peatlands of boreal Alberta. Écoscience 7: 379–392.

Vinge T. and M. Pyper. 2012. Managing Woody Materials on Industrial Sites. University of Alberta, Alberta School of Forest Science & Management. 56 pp.

van Rensen, C. K., S. E. Nielsen, B. White, T. Vinge, and V. J. Lieffers. 2015. Natural regeneration of forest vegetation on legacy seismic lines in boreal habitats in Alberta's oil sands region. Biological Conservation 184: 127 – 135.

APPENDIX C

Linear Disturbance Remote Sensing Mapping: Options Comparison

31 March 2017
Report No. 1775025-001-R-Rev0-4000

Table B-1: Comparison of Remote Sensing Mapping Options

Data Provider	Option Description	Benefits/Potential Cons	Data Specifics	Data Acquisition Costs	Processing Effort	Projected Processing Costs*	Total Costs*
Geodesy Group	LiDAR	Large detailed dataset Does not include classification of vegetation into height categories At 1ppm may not hit bare earth	LiDAR collected at 1 ppm Medium format image 30 cm GSD	Flying component ~ $66,000 LiDAR ~ $93,000 AT & Image component ~$27,900 ZI/Purview ~ $3,400 Total: $190300	Golder vegetation mappers to map linear features and attribute type, with expected ~ 1000 hours for: map interpretation senior mapping review vegetation QA/QC,	$125,000 (predicted)	$315,300
	Photo @ 20cm GSD	Stereo images can be used to map vegetation Does not include classification of vegetation into height categories		Flying component ~ $66,000 AT/Purview ~ $24,500 Optional SGM ~ $31,500 Total: $126,000			$251,000
Vieworx	LiDAR and Ortho-imagery	Combination of LiDAR and Ortho-imagery will reduce effort needed for ground truthing, and increase accuracy of treatment candidacy/method	LiDAR collected at 30 cm accuracy	~ $400/km		$125,000 (predicted)	$804,927 (predicted)
		includes vegetation heights	estimated 110 hours of flying time to collect data	total of $679,927			
			includes post collection process				
McElhanny	LiDAR and Ortho-imagery	Combination of LiDAR and Ortho-imagery will reduce effort needed for ground truthing, and increase accuracy of treatment candidacy/method	Orthophoto Imagery with 20 cm resolution	~ $67/km^2		$125,000 (predicted)	$560,500 (predicted)
		Does not include classification of vegetation into height categories			IM support (LiDAR processing for DEM, PURVIEW MXD set up, IM processing)		
		May not include post data collection processing	LiDAR accuracy: 15 cm in open and 50 cm in heavily vegetated areas	total of $435,500			

APPENDIX C
Remote Sensing Mapping: Options Comparison

Data Provider	Option Description	Benefits/Potential Cons	Data Specifics	Data Acquisition Costs	Processing Effort	Projected Processing Costs*	Total Costs*
Eagle Mapping	LiDAR and Ortho-imagery	Combination of LiDAR and Ortho-imagery will reduce effort needed for ground truthing, and increase accuracy of treatment candidacy/method	no specifics provided at this time	LiDAR - $271,993	Post field refinement by vegetation mappers	$125,000 (predicted)	
		May not include post data collection processing		Orthoimagery - $118,874			$515,900 (predicted)
		Does not include classification of vegetation into height categories		total of $390,900			

* all processing/effort costs are esitmates and can be revised pending data provider and scale

https://golderassociates.sharepoint.com/sites/11023g/shared documents/deliverables/1775025-001-r-reva-4000/attachments/appendix_c remotesensingoptions_new.docx

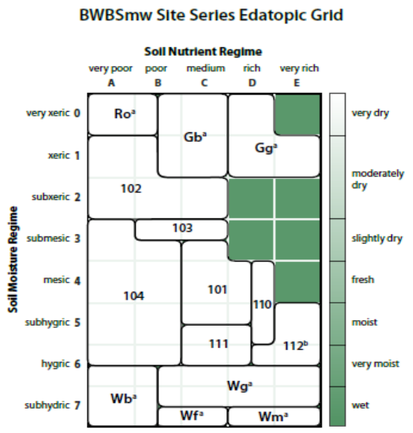
APPENDIX D

Preliminary Mountain Caribou Habitat Treatment Matrix Tables

DRAFT- Treatment Matrix for Linear Restoration - BOREAL WHITE AND BLACK SPRUCE - MOIST WARM VARIANT

Site Type	BWBSmw Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75-100	None	None	Pl	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Screefing	None	Pl	Natural Seed/ Applied Seed	None	2,000	None
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic	poor to medium	Drought may limit productivity during dry growing seasons	High - No LFH	75-100	None	None	Pl; Sw	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Screefing	None	Pl; Sw	Natural Seed/ Applied Seed	None	2,000	None
Slightly Dry to Very Moist	104	Sb – Lingonberry – Step moss	submesic to hygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	High - No LFH	150	Mound	500	Sb; Pl	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Mound	1,200	Sb; Pl	Plant/ Natural seed	Sb 800 ; Pl 400	1,000	Small
Slightly Dry to Fresh	101	Sw – Trailing raspberry – Step moss	submesic to subhygric	medium to rich	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150	Mound	500	Sw	Natural Seed/ Applied Seed	None	1,000	None
						Low - LFH present	75	Mound	1,200	Sw	Plant/ Natural seed	Sw 1,200	1,000	Large
Fresh to Moist	110	Sw – Oak fern – Sarsaparilla	mesic to subhygric	rich	Few limiting factors; cold air drainage causing frost damage to young trees can occur on lower to toe slopes	High - No LFH	150	Mound	500	Sw	Natural Seed/ Applied Seed	None	1,000	None
						Low - LFH present	75	Mound	1,200	Sw	Plant/ Natural seed	Sw 1,200	1,000	Large
Moist to Very Moist	111	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150	Mound	500	Sw	Natural Seed/ Applied Seed	None	1,000	None
					Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75	Mound	1,200	Sw	Plant/ Natural seed	Sw 1,200	1,000	Large
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	rich to very rich	Periodic flooding and very high vegetation competition may limit Sw establishment.	High - No LFH	150	Mound	500	Acb; Sw	Natural Seed/ Applied Seed	None	1,000	None
						Low - LFH present	75	Mound	1,200	Acb; Sw	Plant/ Natural seed	Acb 1,200 or Sw 1,200	1,000	Large
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10-50	Mound	1,200	Sb	Plant/ Natural seed	Sb 1,200	1,000	Medium
Wetland	Wf	Wetland fen	subhydric	poor to medium		Same Low/High	10-50	Mound	1,200	Sb; Lt	Plant/ Natural seed	Sb 1,200 or Lt 1,200	1,000	Medium

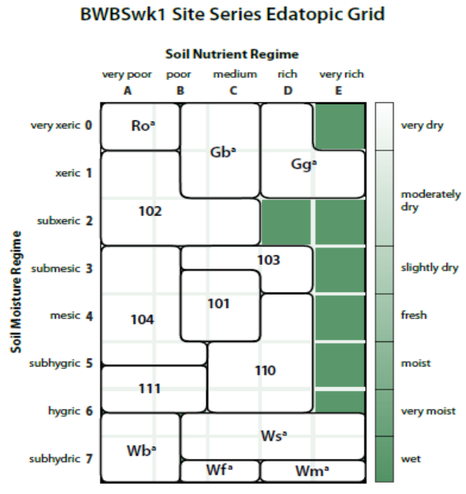
a. Source: DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm



DRAFT- Treatment Matrix for Linear Restoration - BOREAL WHITE AND BLACK SPRUCE - MURRAY WET COOL VARIANT

Site Type	BWBSwk1 Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Moderately Dry	102	Pl – Lingonberry – Reindeer lichen	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75-100	None	None	Pl	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Screefing	None	Pl	Natural Seed/ Applied Seed	None	2,000	None
Slightly Dry	103	SwPl – Soopolallie – Showy aster	submesic	poor to rich	Drought may limit productivity during dry growing seasons	High - No LFH	75-100	None	None	Pl; Sw	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Screefing	None	Pl; Sw	Natural Seed/ Applied Seed	None	2,000	None
Slightly Dry to Moist	104	Sb – Huckleberry – Lingonberry	submesic to subhygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	High - No LFH	150	Mound	500	Sb; Pl	Natural Seed/ Applied Seed	None	2,000	None
						Low - LFH present	75-100	Mound	1,200	Sb; Pl	Plant/ Natural seed	Sb 800; Pl 400	1,000	small
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	poor to medium	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150	Mound	500	Sw	Natural Seed/ Applied Seed	None	1,000	None
						Low - LFH present	75	Mound	1,200	Sw	Plant/ Natural seed	Sw 1,200	1,000	large
Fresh to Very Moist	110	Sw – Oak fern – Sarsaparilla	mesic to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150	Mound	500	Sw	Natural Seed/ Applied Seed	None	1,000	None
					Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75	Mound	1,200	Sw	Plant/ Natural seed	Sw 1,200	1,000	large
Moist to Very Moist	111	Sb – Lingonberry – Horsetail	submesic to subhygric	very poor to poor	Lack of soil nutrients; high water tables limit soil aeration and thus root development	High - No LFH	150	Mound	500	Sb	Natural Seed/ Applied Seed	None	1,000	None
					Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist; high water tables limit soil aeration and thus root development	Low - LFH present	75	Mound	1,200	Sb	Plant/ Natural seed	Sb 1,200	1,000	large
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10-50	Mound	1,200	Sb	Plant/ Natural seed	Sb 1,200	1,000	medium
Wetland	Wf	Wetland fen	subhydric	poor to medium	Soil temperature and drainage	Same Low/High	10-50	Mound	1,200	Sb; Lt	Plant/ Natural seed	Sb 1,200 or Lt 1,200	1,000	medium

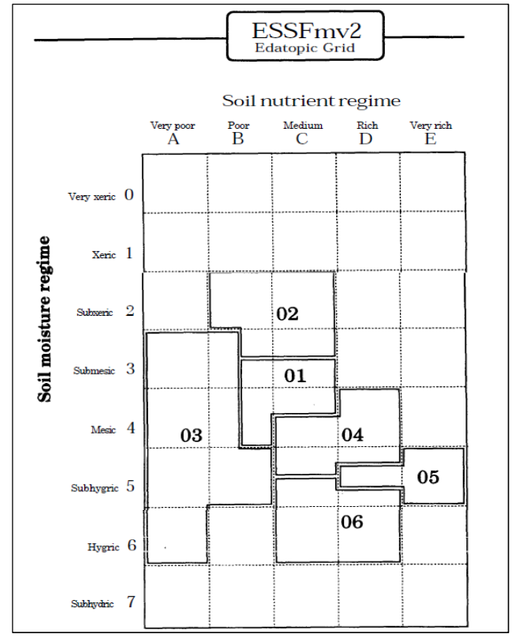
a. Source: DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm



DRAFT- Treatment Matrix for Linear Restoration - ENGELMANN SPRUCE SUBALPINE FIR - BULLMOOSE MOIST VERY COLD VARIANT

Site Type	ESSFmv2 Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Moderately Dry	02	Bl - Lingonberry	subxeric to submesic	poor to medium	Very poor soil productivity; thin soils	High - No LFH	75-100	None	None	Pl; Bl	Natural Seed/ Applied Seed	None	2,500	None
						Low - LFH present	75-100	None	None	Pl; Bl	Natural Seed/ Applied Seed	None	2,500	None
Slightly Dry to Fresh	01	Bl - Rhododendron - Feathermoss	submesic to mesic	poor to medium	Reduced spring soil temperatures; thick organic horizons	High - No LFH	75-100	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Slightly Dry to Very Moist	03	BlSb - Labrador tea	submesic to hygric	very poor to poor	Reduced spring soil temperatures; thick organic horizons. Soils are saturated in spring, but may experience summer drought, both resulting in poor root development	High - No LFH	75-100	Mound	500	Bl; Sb	Plant/ Natural seed	Bl 2,000; Sb 1,500	3,000	Large
						Low - LFH present	75-100	Mound	1,000	Bl; Sb	Plant/ Natural seed	Bl 2,000; Sb 1,500	3,000	Large
Fresh to Moist	04	Bl - Oak fern - Knight's plume	mesic to sybhygric	medium to rich	Reduced spring soil temperatures; thick organic horizons	High - No LFH	150	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Moist	05	Bl - Devil's club - Rhododendron	subhygric	rich to very rich	Reduced spring soil temperatures; thick organic horizons	High - No LFH	150	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Moist to Very Moist	06	Bl - Alder - Horsetail	subhygric to hygric	medium to rich	Reduced spring soil temperatures; thick organic horizons; high water tables limit soil aeration and thus root development	High - No LFH	150	Mound	150	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Mound	300	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Wetland	Wf	Wetland fen	subhydric	Medium	High water tables limit soil aeration and thus root development	Same Low/High	10-50	Mound	1,000	Bl; Se	Plant/ Natural seed	Bl 1,200 or Se 1,200	1,000	Large

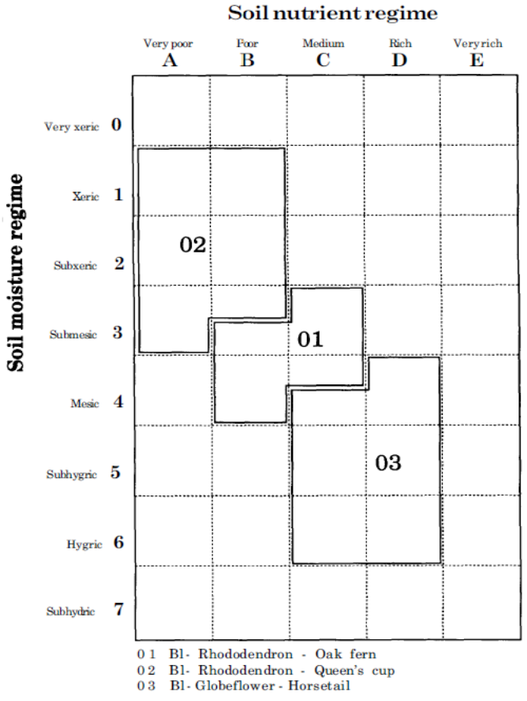
a. Source: DeLong, C., D. Tanner and M.J. Jull. 1994. *A Field Guide for Site Identification and Interpretation for the Northern Rockies Portion of the Prince George Forest Region.* Land Management Handbook 29. Ministry of Forests Research Branch. Victoria, BC. 149 pp.



DRAFT- Treatment Matrix for Linear Restoration - ENGELMANN SPRUCE SUBALPINE FIR - CARIBOO WET COLD VARIANT

Site Type	ESSFwc3 Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors to Tree Establishment and Early Growth (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Moderately Dry	02	Bl – Rhododendron – Queen's cup	xeric to subxeric	poor to rich	Moisture deficits; cold soils; snowpress/ snow creep	High - No LFH	75-100	None	None	Bl; Se	Natural Seed/ Applied Seed	None	2,500	Large
					Moisture deficits; cold soils; light deficits (vegetation overtopping); snowpress/ snow creep	Low - LFH present	75-100	Screefing	None	Bl; Se	Natural Seed/ Applied Seed	None	2,500	Large
Fresh	01	Bl – Rhododendron – Oak fern	submesic to mesic	poor to rich	Summer frosts; snowpress/snow creep	High - No LFH	75-100	None	None	Bl; Se	Planting/ Natural Seed	Bl 3,000; Se 1,500	4,000	Large
					Summer frosts; light deficits (vegetation overtopping); cold soils; snowpress/snow creep	Low - LFH present	75-100	Screefing	None	Bl; Se	Planting/ Natural Seed	Bl 3,000; Se 1,500	4,000	Large
Moist to Very Moist	03 (Ws08)	Bl – Globeflower – Horsetail	subhygric to hygric	poor to rich	Summer frosts; cold/wet soils; snowpress/snow creep	High - No LFH	150	Mound (winter)	150	Bl; Se	Planting/ Natural Seed	Bl 2,500; Se 1,000	3,000	Large
					Summer frosts; light deficits (vegetation overtopping); cold/wet soils; snowpress/snow creep	Low - LFH present	150	Mound (winter)	300	Bl; Se	Planting/ Natural Seed	Bl 2,500; Se 1,000	3,000	Large
Wetland	Wf	Wetland fen	subhydric	Medium	High water tables limit soil aeration and thus root development	Same Low/High	10-50	Mound (winter)	1,000	Bl; Se	Plant/ Natural seed	Bl 1,200 or Se 1,200	1,000	Large

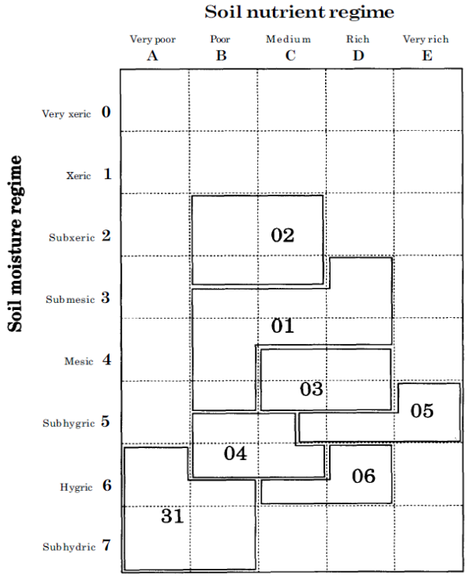
a. Source: DeLong, C., D. Tanner, and M.J. Jull. 1994. A Field Guide for Site Identification and Interpretation for the Northern Rockies Portion of the Prince George Forest Region. Land Management Handbook 29. BC Ministry of Forests and Range, Victoria, BC. 149 pp.



DRAFT- Treatment Matrix for Linear Restoration - ENGELMANN SPRUCE SUBALPINE FIR - MISINCHINKA WET COOL VARIANT

Site Type	ESSFmv2 Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Moderately Dry	02	Bl - Oak fern - Sarsaparilla	subxeric to submesic	poor to medium	Very high coarse fragment context; soil moisture holding capacity greatly reduced	High - No LFH	75-100	None	None	Bl; Se	Natural Seed/ Applied Seed	None	2,500	None
						Low - LFH present	75-100	None	None	Bl; Se	Natural Seed/ Applied Seed	None	2,500	None
Slightly Dry to Fresh	01	Bl - Oak fern - Knight's plume	submesic to subhygric	poor to rich	Reduced spring soil temperatures; thick organic horizons; heavy snowpack/snow creep could cause stem deformity	High - No LFH	75-100	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Fresh to Moist	03	Bl - Oak fern - Bluebells	mesic to sybhygric	medium to rich	Reduced spring soil temperatures; thick organic horizons; fine textured soils susecptible to compaction; heavy snowpack/snow creep could cause stem deformity	High - No LFH	75-100	None	None	Bl; Se	Plant/ Natural seed	Se 2,500; Bl 2,000	4,000	Large
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Se 2,500; Bl 2,000	4,000	Large
Moist to Very Moist	04	Bl - Devil's club - Rhododendron	subhygric to hygric	poor to medium	Reduced spring soil temperatures; thick organic horizons; fine textured soils with poor soil structure leads to poor root development	High - No LFH	150	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
Moist	05	Bl - Rhododendron - Lady fern	subhygric	medium to very rich	Reduced spring soil temperatures; thick organic horizons; fine textured soils with poor soil structure leads to poor root development; heavy snowpack could cause stem deformity	High - No LFH	150	None	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
						Low - LFH present	75-100	Screefing	None	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
Very Moist	06	Bl - Horsetail - Sphagnum	hygric	medium to rich	Reduced spring soil temperatures; thick organic horizons; high water tables limit soil aeration and thus root development	High - No LFH	150	Mound	150	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
						Low - LFH present	75-100	Mound	300	Bl; Se	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	High water tables limit soil aeration and thus root development	Same Low/High	10-50	Mound	1,000	Sb	Plant/ Natural seed	Sb 1,200	1,000	Medium

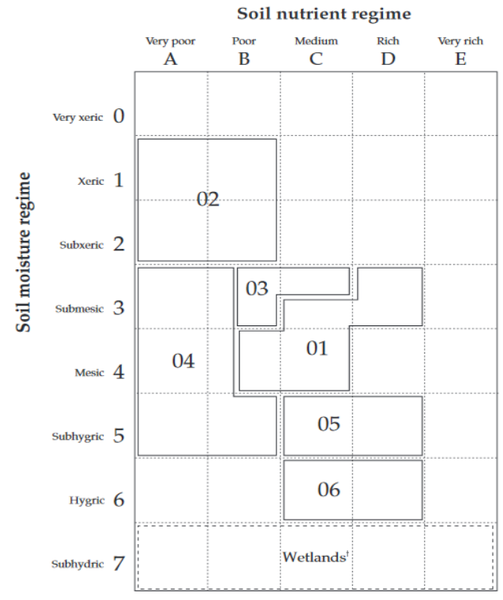
a. Source: DeLong, C., D. Tanner and M.J. Jull. 1994. *A Field Guide for Site Identification and Interpretation for the Northern Rockies Portion of the Prince George Forest Region.* Land Management Handbook 29. Ministry of Forests Research Branch. Victoria, BC. 149 pp.



DRAFT- Treatment Matrix for Linear Restoration - SUB-BOREAL SPRUCE - FINLAY-PEACE WET COOL VARIANT

Site Type	ESSFmv2 Site Series (a)	Site Series name (a)	Moisture Regime (a)	Nutrient Regime (a)	Limiting Factors (a)	Disturbance Level	CWD Level (m3/ha)	Site Prep.	Mound density/ha	Target Tree Species	Vegetation Treatment	Planting Density (stems/ha)	Final Minimum Density (stems/ha)	Stock Size
Dry	02	Pl - Huckleberry - Cladina	xeric to subxeric	very poor to poor	Very high coarse fragment context; soil moisture holding capacity greatly reduced	High - No LFH	75-100	None	None	Pl	Natural Seed/ Applied Seed	None	2,500	None
						Low - LFH present	75-100	None	None	Pl	Natural Seed/ Applied Seed	None	2,500	None
Slightly Dry	03	Sxw - Huckleberry - Highbush-cranberry	mesic to sybhygric	medium to rich	Very high coarse fragment context; soil moisture holding capacity greatly reduced	High - No LFH	75-100	None	None	Pl; Sx	Natural Seed/ Applied Seed	None	2,500	None
						Low - LFH present	75-100	None	None	Pl; Sx	Natural Seed/ Applied Seed	None	2,500	None
Slightly Dry to Fresh	01	Sxw - Oak fern	submesic to mesic	poor to rich	Reduced spring soil temperatures; thick organic horizons; fine textured soils with poor soil structure leads to poor root development	High - No LFH	75-100	None	None	Sx	Plant/ Natural seed	Sx 4,500	4,000	Large; Cu-treated; low root to shoot ratio
						Low - LFH present	75-100	Screefing	None	Sx	Plant/ Natural seed	Sx 4,500	4,000	Large; Cu-treated; low root to shoot ratio
Slightly Dry to Moist	04	SbPl - Feathermoss	submesic to subhygric	very poor to poor	Reduced spring soil temperatures; thick organic horizons; fine textured soils with poor soil structure leads to poor root development; soils are saturated in spring, but may experience summer drought, both resulting in poor root development	High - No LFH	150	Mound	500	Pl; Sb	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
						Low - LFH present	75-100	Mound	1,000	Pl; Sb	Plant/ Natural seed	Bl 2,500; Se 2,000	4,000	Large; Cu-treated; low root to shoot ratio
Moist	05	Sxw - Devil's club	subhygric	medium to rich	Colluvial soils difficult to plant; some sites have fine textured soils susecptible to compaction	High - No LFH	150	None	None	Sx	Natural Seed/ Applied Seed	None	4,000	None
						Low - LFH present	75-100	None	None	Sx	Natural Seed/ Applied Seed	None	4,000	None
Very Moist	06	Sxw - Horsetail	hygric	medium to rich	Reduced spring soil temperatures; thick organic horizons; high water tables limit soil aeration and thus root development	High - No LFH	150	Mound	150	Sx	Plant/ Natural seed	Sx 4,500	4,000	Large
						Low - LFH present	75-100	Mound	300	Sx	Plant/ Natural seed	Sx 4,500	4,000	Large
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	High water tables limit soil aeration and thus root development	Same Low/High	10-50	Mound	1,000	Sb	Plant/ Natural seed	Sb 1,200	1,000	Medium
Wetland	Wf	Wetland fen	subhydric	poor to medium	High water tables limit soil aeration and thus root development	Same Low/High	10-50	Mound	1,000	Sx	Plant/ Natural seed	Bl 1,200 or Se 1,200	1,000	Large

a. Source: DeLong, C. 2004. *A Field Guide for Site Identification and Interpretation for the North Central Portion of the Northern Interior Forest Region.*Land Management Handbook 54. Ministry of Forests Research Branch. Victoria, BC. 243 pp.



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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
590 McKay Avenue, Suite 300
Kelowna, British Columbia, V1Y 5A8
Canada
T: +1 (250) 860 8424

Golder Associates