DWB Consulting Services Ltd.

Nadina-South Ootsa Woodland Caribou

Road Rehabilitation Standards and Effectiveness Monitoring

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Date: 26.03.2019 | DWB file: 19447-043 | Revisions: Draft

Engineering | Environmental | Forestry

Signature Page

DWB Consulting Services Ltd. is pleased to submit this report for your review. This report has been prepared using sound technical and professional judgement, based on our knowledge and experience, applicable regulatory framework, industry best management practices, and current understanding of project conditions, design, and project setting.

REPORT TITLE: Nadina-South Ootsa Woodland Caribou Road Rehabilitation Standards and Effectiveness Monitoring

PREPARED FOR: Society for Ecosystem Restoration in Northern BC (SERN BC)

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REVISION HISTORY			
DATE	**VERSION[1]**	**REVIEW TYPE[1]**	**REVIEWED BY** (NAME, COMPANY)
26.03.2019	DRAFT	PROFESSIONAL	ALLAN CARSON, DWB CONSULTING LTD.

[1] Editorial Review: Reviewed for formatting, grammar, spelling, etc.
Professional Review: Reviewed for content and professional signoff
Client Review: Reviewed by client
Regulatory Review: Reviewed by regulatory agency (i.e. DFO) if necessary
Peer Review: Reviewed for content and errors by peer

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- That by using the guidance in the report, the client will be approved by the contract holder for the applied works.

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1.0 INTRODUCTION

1.1 PROJECT SCOPE

DWB Consulting Services Ltd. (DWB) has been retained by the Society for Ecosystem Restoration in Northern BC (SERN BC) to prepare a rehabilitation standard planning document for the Tweedsmuir-Entiako Caribou (TEC) in order to support the Nadina-South Ootsa Woodland Caribou Road Rehabilitation Project (the "Project"). The Project is funded through the Habitat Stewardship Program for Species at Risk in partnership with staff from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD). The goal of the Project is to disrupt, block or slow predator movement on forest roads found within high value caribou forage and cover habitat. A GIS mapping exercise utilizing a Road Rehabilitation Algorithm developed by Forsite (2018) and SERN BC was completed during the first phase of the Project to determine a list of road candidates, and potentially existing fire guards, for restoration within the Nadina-South Ootsa Project area. The list of road candidates was further refined using the most recent telemetry data showing caribou locations on the landscape and expert local knowledge, including Traditional Ecological Knowledge (TEK). Field reconnaissance of the road candidates is to begin in the spring of 2019, with treatment prescriptions to follow. Prescription packages summarizing the proposed treatments for road restoration will be shared with local government agencies, Cheslatta Carrier Nation (CCN), licensees, and stakeholders to ensure all feedback and concerns regarding access for land-use are addressed. Once finalized, the proposed road rehabilitation work will be tendered to secure competitive bids for a subsequent implementation phase.

DWB will be responsible for organizing and overseeing the Project. The FLNRORD has already prepared a road dataset for the South Ootsa to model caribou habitat in relation to road density. Based on this, DWB has utilized SERN BC's road classification algorithm to classify applicable roads as 'temporary' or 'permanent' to identify roads that have the potential for rehabilitation (Forsite 2018).

In preparation for road rehabilitation, DWB has been tasked to develop rehabilitation and treatment standards that would reduce predator pressures on the TEC herd and provide long-term habitat. This report includes an extensive literature review that was utilized to come up with a general set of guidelines for proposed road rehabilitation. Following completion of a field reconnaissance survey, the standards provided in this document will be utilized to prescribe site-specific treatment prescriptions for rehabilitation of candidate roads.

1.2 REPORT OBJECTIVES

The objective of the Standards and Effectiveness Monitoring Plan is to provide a list of candidate roads (and potentially fire guards) for restoration of migration routes of the TEC herd and provide recommendations for the most effective approaches to rehabilitation based on experiential evidence to date. The objective of road rehabilitation would be to reduce predator pressures on the TEC herd and provide long-term forage and cover habitat. As more information becomes available, this document and any accompanying documents may be updated to reflect the necessary changes and additional information. The aim of this report is to help inform future management decisions regarding road rehabilitation in the Nadina-South Ootsa.

1.3 GUIDANCE DOCUMENTS

The following guidance documents have been identified and are referenced throughout this plan:

- *Tweedsmuir-Entiako Caribou Population Status and Background Information Summary* by Cichowski (2015).
- *Road Rehabilitation Algorithm* report by Forsite (2018).
- *BC Engineering Manual* (FLNRO 2019)
- *Best Management Practices Handbook: Hillslope Restoration in BC* (MOF 2001).
- *Boreal Caribou Habitat Restoration Operational Toolkit for BC* (Golder 2015).
- *A Field Guide for Site Identification and Interpretation for the Prince Rupert Forest Region* by Banner et al. (1993).
- *A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (MLFNRO 2014)
- *Best Practices for Managing Invasive Plants on Roadsides* by MOT (2010).
- *The Boreal Caribou Habitat Restoration Monitoring Framework* (Golder 2015)
- *Provincial Restoration and Establishment Framework for Legacy Seismic Lines in Alberta* (Alberta Government 2017)
- *Tweedsmuir Lichen Restoration Trial, Year 1 Report* by Ronalds and Grant (2018).

2.0 BACKGROUND

2.1 PROJECT LOCATION

The Project area is located in West-Central, British Columbia (BC) and encompasses approximately 141,000 hectares in the Nadina-South Ootsa immediately south of Ootsa Lake and Intata Reach. Burns Lake is the nearest major town centre and is approximately 70 km north (geodesic distance) from the Project area. Immediately west of the Project area, Tweedsmuir Provincial Park provides crucial summer range and calving grounds for the TEC herd, while Entiako Provincial Park provides critical winter range to the East. Therefore, the Nadina-South Ootsa is an important migration corridor between these two seasonal ranges. Forestry harvesting has been operating in the Nadina-South Ootsa since the early 1980's, although production has decreased in recent years. The area is also periodically used by CCN trappers, CCN guide outfitters, and researchers studying the TEC; however, due to its remote location and limited access by ferry and barge, recreational users are uncommon to this area. The Project area has been hit hard by the mountain pine beetle epidemic with the majority of mature lodgepole pine trees in the "grey attack" phase. The Chelaslie River fire in 2014 also passed through the area severely burning the most southern part of the Project area and burning a total of 140,000 hectares.

2.2 TWEEDSMUIR-ENTIAKO CARIBOU HERD

For further information and details, please refer to the *Tweedsmuir-Entiako Caribou Population Status and Background Information Summary* by Cichowski (2015).

2.2.1 Population Status

In Canada, woodland caribou are grouped according to evolutionary differences in genetics, behaviour, ecology, and distribution with discernable populations assigned a designatable unit (DU) for classification purposes (COSEWIC 2011). Woodland caribou populations in BC include the Boreal (DU6), Northern Mountain (DU7), Central Mountain (DU8), and Southern Mountain (DU9). The Tweedsmuir-Entiako caribou (TEC) is recognized as a subpopulation of the Northern Mountain caribou population (DU7). Federally, Northern Mountain caribou have been listed in Schedule 1 as a species of Special Concern under the *Species at Risk Act* (SARA) since 2005. In 2014, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that the Northern Mountain population remain designated as a species of Special Concern (COSEWIC 2014). The Northern Mountain population does consist of stable subpopulations in the most northern part of their range (COSEWIC 2014); however, subpopulations in the southern part of the range, including the TEC, are declining. As such, the TEC and a few other declining subpopulations of the Northern Mountain population are also designated as Threatened under SARA since they fall within the Southern Mountain National Ecological Area (SMNEA) recognized by COSEWIC as highly disturbed habitat for woodland caribou.

Previously, the Province of BC classified woodland caribou according to three ecotypes (Boreal, Northern, and Mountain); however, the province has recently adopted COSWIC's classification system of designatable units. Northern Mountain Caribou are presently blue-listed by the BC Conservation Data Centre (CDC), which designates the population as a species of Special Concern in the province (CDC 2019).

Survey results and population growth estimates suggest that the TEC herd has been declining since the early 1960s (Cichowski 2015). The most recent surveys have estimated the TEC herd at approximately 150-200 individuals (Cichowski and McNay 2014, Apps et al. 2018), which is down from 300 in 2003 (Cichowski 2015). It is predicted the TEC herd will continue to decrease over the long-term if external pressures affecting habitat and predator-prey dynamics continue (Environment Canada 2014, Cichowski 2015, Cichowski and Ramsay 2017).

2.2.2 Habitat and Ecology

Subpopulations that belong to the Northern Mountain DU7 share similar genetic, ecological and behavioral characteristics (COSEWIC 2011). Caribou within this designation typically forage for terrestrial lichen by cratering (i.e., digging) in the snow along windswept, alpine slopes and in low elevation forests in the winter (Cichowski 2015). Terrestrial lichen is the primary forage choice for this group, but arboreal lichens are an important secondary choice in subalpine forests where they are abundantly found (Cichowski 1993) or when terrestrial lichens become difficult to access in unfavourable winter conditions (e.g., reduced snow penetrability; Cichowski 2016). Similar to other caribou populations, the TEC herd migrates between summer and winter grounds and have a range of approximately 1,700,000 hectares (Cichowski 2015). Migration between the Entiako and Tweedsmuir areas occurs in the Nadina-South Ootsa in the spring through the Chelaslie River drainage and in the fall through the Quanchus Mountains (Cichowski 2015). Although some geographical variation exists between individuals, the majority of the herd spends the winter in Entiako Provincial Park and the East Ootsa area (Cichowski 2015). Summer is spent west of the Nadina-South Ootsa in the northern half of Tweedsmuir Park and further west of Whitesail Lake (Cichowski 2015). Females tend to prefer high elevation and subalpine habitat for calving to avoid predators (Bergerud and Page 1987), although the TEC have used islands in Whitesail Reach to successfully raise young at lower elevations (Cichowski and Maclean 2005). Calf mortality is high for this herd, although the reasons for the mortality have not been clearly documented; however, wolf and bear predation has been shown to be an important cause of adult mortality (Cichowski 2015). For all subpopulations of caribou found within the SMNEA, predation risk is considered a serious threat due to habitat alterations within their ranges (Environment Canada 2014).

The TEC range has been exposed to a variety of external pressures over the past 60 years. Disturbances within the TEC range have included the flooding of the Nechako Reservoir which submerged lower elevation portions of the Entiako winter range, forest harvesting in the southeast portion of the winter range (Cichowski and Maclean 2005), severe levels of mountain pine beetle attack throughout most of the winter range (Cichowski 2007), and the recent Chelaslie Arm fire which burned most of the winter range in Entiako park and along the north side of Tetachuck Lake (Cichowski 2016). Telemetry data from radio-collared caribou in 2016 revealed that the herd was moving further north of their historical Chelaslie migration corridor in the Nadina-South Ootsa (Cichowski and McNay 2014), which may be in response to these larger landscape-level disturbances. The regions north of the Chelaslie migration corridor are more densely harvested and, therefore, contain early seral habitat preferred by species that will attract and sustain wolf populations (e.g., deer and moose). Roads and linear corridors associated with industrial activities also increase wolf travel time and hunting efficiency (Dickie et al. 2016, DeMars and Boutin 2014). As wolf density in the TEC range was recently found to be higher when compared to other areas of the western Canadian interior (Apps et al. 2018), the TEC herd are at risk of increased predation pressures within these disturbed regions of their migration corridor. Therefore, long-term restoration of critical habitat within the Nadina-South Ootsa may be an important recovery strategy for the TEC.

2.3 Road Rehabilitation for Predator-Prey Management

Road rehabilitation may be effective at decreasing predation on caribou by limiting predator access and hunting efficiency (Whittington et al. 2011, Dickie et al. 2016) while also ensuring that critical habitat is restored to a functional or ecologically stable state earlier than if left to regenerate naturally.

The development of roads results in increased predation of caribou in two principle ways. One is by increasing the numbers of other ungulates which prefer early seral conditions following disturbance, which in turn increases the number of predators. Another is by increasing the efficiency of how predators move through the landscape, especially into caribou ranges. This is largely attributed to improving sightline by way of roads, which allows predators to spot caribou over large distances, as well as aiding the ease and speed of travel due to the removal of obstructing vegetation. These hypotheses have long been supported (e.g., Seip 1992, Latham 2009, Apps et al. 2013, Serrouya et al. 2016, Silvacom 2015, Boutin et al. 2016, Serrouya et al. 2017, BC MFLNRORD 2018). Continued use of roads has been further associated with enabling predator access into caribou habitat since motorized vehicles reduce natural regeneration of linear features (Pigeon et al. 2016) and provides a compact snowpack for predators to travel on during winter.

In recent years, research has specifically tried to determine how to reduce the rate of predation associated with linear development. Some studies have assessed the rate of natural regeneration on linear features to determine where restoration may be most beneficial (Finnegan et al. 2017), while others have tried to determine feasible ways to deter predators from roads.

For example, Bohm et al. (2015) assessed the feasibility of snow fencing to block access, Dickie et al. (2017) assessed wolf travel rates in relation to vegetation height, Pigeon et al. (2017) assessed animal signs and tracks on linear features to determine the highest spatial overlap between caribou and their predators. DeMars et al. (2018) is currently testing whether tree-hinging and/or tree-bending can reduce linear features used by predators. Some of these methods have only been applied to linear features, such as seismic lines, and not roads; however, the same principles should apply. While some of these methods have not been tested for effectiveness over a long period of time, blocking predator access is considered an important step to significantly reduce caribou predation. Road rehabilitation standards outlined in this report were developed based on preliminary results and successes noted thus far. As future monitoring of rehabilitated linear features yields results, it is anticipated that restoration methods will improve as new information allows for better determination of the most viable techniques.

3.0 ROAD SELECTION

3.1 METHODS AND CRITERIA

3.1.1 Road Rehabilitation Algorithm

The road rehabilitation algorithm is outlined in further detail in the *Road Rehabilitation Algorithm* report by Forsite (2018). A GIS mapping exercise was conducted using an algorithm developed by Forsite and further adapted by SERNbc to identify forestry roads in low relief terrain that would be suitable for rehabilitation based on a set of criterium. The FLNRORD has prepared a road dataset for the Nadina-South Ootsa to model caribou habitat in relation to road density. The road rehabilitation algorithm was used classify roads within those key areas utilized by the TEC as temporary or permanent in order to narrow down a list of candidate roads for habitat restoration.

The algorithm utilizes The Integrated Roads Database (IRDB), which provides raw data for road classification and identifies reforestation opportunities. Path analysis is then used to accurately identify access to harvest opportunities, while avoiding multiple redundant roads accessing a single harvest block.

The key selection criteria used for road classification were:

1. **Harvest opportunities**, defined as a function of merchantable conifer volume, patch size, and distance between vegetation resource inventory (VRI) polygons.
2. **Free growing status** of a harvested block, with a primary focus on maintaining access to harvested blocks that were **not** classified as free growing to accommodate potential silviculture activities; in the case of large blocks, maintaining safe walking distances from a driveable road (defined as 800m) were also maintained.
3. **Constraints** that may limit road construction and harvesting, such as streams, wetlands, and old growth management areas. The model set streams of order 3 and greater as ‘hard’ constraints, order 2 streams as ‘soft’ constraints, while order 1 streams were not considered a constraint. Wetlands were considered to be a ‘hard’ constraint with no buffer.

Based on these assumptions, roads were classified according to whether a Reforestation Opportunity (ROP) existed or No Opportunity was Expected (NOE).

3.1.2 Incorporating Traditional Ecological Knowledge

Traditional Ecological Knowledge (TEK) is a valuable resource in conservation and wildlife management. TEK may provide information regarding preferred habitat-use by species, as well as capture important species behaviour and locations that can be masked by simplified model parameters or model biases (Polfus et al. 2013). Therefore, utilizing both TEK and western science approaches creates a more comprehensive, robust recovery strategy that is especially important during the early planning stages.

Three questions were posed to the CCN community to better understand how predators might be using the landscape specifically within the Nadina-South Ootsa and how caribou habitat may be effectively restored:

1) What information can you share about caribou or their predators (e.g., wolves) in these areas?
2) How do wolves move through the forest? What kind of roads are they using to move?
3) What would you do to restore caribou habitat?

The CCN and regional community provided information during an open house event in the spring of 2019. Answers to the posed questions are provided in Appendix ##.

3.2 SELECTION RESULTS

Based on the selection criteria outlined in Section 3.1, ## roads were selected as potential candidates for rehabilitation. Licensees provided guidance on future harvest development within the Project area to help supplement and/or confirm the results of the algorithm. The feedback acquired from local experts and TEK were able to further refine the selection down to ## road candidates. The final list of road candidates is included in Appendix ##.

4.0 ROAD DEACTIVATION GUIDELINES

Prior to rehabilitation, deactivation of the selected forestry roads will be required. In accordance with the *Forest Range and Practices Act* (FRPA), deactivation of a road involves an engineered application of techniques to stabilize the road prism, restore or maintain natural drainage patterns, and minimize sediment transport to natural surroundings. Rehabilitation is considered the next phase and typically employs silvicultural techniques to convert roads into a productive site for growing crop trees. The objective of this Project is to rehabilitate roads to a state that will disrupt, block or slow predator movement; therefore, additional techniques that favour this objective may be used in conjunction with silviculture practices.

The following outlines general road deactivation measures to be implemented as required prior to road rehabilitation. This section provides an overview of those measures that are most likely to be applicable to this Project; for detailed instructions on how to apply these techniques, refer to the *BC Engineering Manual* (FLNRO 2019) and *Best Management Practices Handbook: Hillslope Restoration in BC* (MOF 2001).

4.1 DRAINAGE STRUCTURE REMOVAL

Prior to rehabilitation, any bridges or stream culverts that still exist along selected roads should be removed. Removal of structures will prevent the need for continued maintenance and access to the area, thus allowing for better protection of rehabilitated areas. In place of pipe crossings, cross ditches are typically constructed to allow for conveyance of surface drainage. Stream crossings are restored by re-establishing the natural width and gradient of the stream, as well as armouring the banks as needed. The exact size, depth and shape of any new stream crossings will be established during the field reconnaissance survey.

Care will have to be taken during culvert structure removal where flows are present at the time of removal. This may include temporary diversion of stream flow and supervision by an environmental monitor, particularly when flows are connected to fish-bearing waters. Refer to Section 6.0 for further details.

4.2 Surface Water Management and Soil Erosion Control

Restoration of surface drainage patterns and control of subsurface flows is an essential part of road deactivation. To maintain natural drainage patterns, several techniques are available. In an effort to reduce the need for ongoing routine maintenance on forests roads and associated ground disturbance, it is recommended that the methods chosen will not require maintenance over the long-term.

4.2.1 Cross ditches

Cross ditches are used to intercept road surface and ditchline runoff and direct flows across the road. To prevent erosion and ensure water is released onto stable, non-erodible surfaces on the downhill side of the road, armouring the slope with rock may be required. Alternatively, the outlet area may be revegetated. Soil bioengineering techniques, erosion control mats, or woody debris may also be utilized. A physical block is required down-grade from the cross ditch to convey flow into the cross ditch. For compacted roads that will be ripped and recontoured (Section 5.0), cross ditches are most likely to be used along sections experiencing excessive seepage and where small streams and non-classifiable drainages are present; this is especially the case when a culvert has been removed and connectivity needs to be restored. Refer to Section 6.0 for environmental considerations when working in, and in close proximity to, streams.

4.2.2 Water Bars

Water bars are used to capture surface water from the road and direct flow into the ditch line or across the road onto a non-erodible bank. Unlike cross ditches, water bars do not intercept ditch line flow and, therefore, no ditch block is required. For compacted roads that will be ripped and recontoured (Section 5.0), water bars may be most applicable on slopes to prevent or minimize rilling. In the absence of a road ditchline, surface water may be routed to adjacent vegetation.

4.2.3 Berm Pullback

Soil windrows (i.e., continuous berms of soil) may be present, especially along fire guards where the primary purpose was to remove soil down to the mineral layer as quickly as possible. For unvegetated windrows along fire guards, the soil will need to be pulled back and spread over top of the exposed mineral layer to improve growing conditions for seedlings and reduce the potential for sediment mobilization near waterways. For older windrows along maintained forestry roads that are vegetated and no longer pose a soil erosion concern, full pullback is not required. However, a partial pullback of soil, or a small breach in the berm, may be required if the window is obstructing natural surface water drainage paths.

4.2.4 Mulching

Mulching may be used as a soil erosion control method along sections of road that are in close proximity to environmental sensitive receptors, such as streams, drainages, wetlands, and bogs. Mulching involves spreading straw over surfaces vulnerable to erosion and work by dissipating the energy from falling precipitation before it reaches the ground. Mulching may be an additional measure of protection after mechanical site prep until planted tree and shrub crops have had time to establish, especially on slopes.

Only a certified weed-free straw should be used. Care should also be taken to avoid layering the mulch too thick, which could then smother or slow the growth of seedlings.

5.0 ROAD REHABILITATION GUIDELINES

The following outlines a list of techniques which may be utilized as part of road rehabilitation efforts in order to reduce road densities, shorten predator sightlines and/or impede the ease of predator travel. The majority of these methods also allow for an advancement in the timing of forest structure regeneration. Additional details of these techniques are outlined in the *Boreal Caribou Habitat Restoration Operational Toolkit for BC* (Golder 2015).

5.1 MECHANICAL SITE PREPARATION

Mechanical site preparation may be applied along a linear feature to promote natural vegetation re-growth and to increase survival of seeds and seedlings. The intent of mechanical site practices is to provide suitable growing conditions by creating microsites and to control site access. Mechanical site preparation is typically applied during winter when frozen ground conditions protect against excessive disturbance. A wide range of mechanical site preparation methods exist; however, excavator mounding and excavator ripping will be the most effective for restoring forestry roads built using compacted fill material.

5.1.1 Mounding

Mounding involves the development of mounds by flipping the soil to provide a suitable planting site. Skidders or excavators with a mound attachment may be used to create an elevated mound by digging a hole and placing the soil beside the hole. The mound provides an elevated microsite with warmer soil temperatures that allow for improved seedling growth; in addition, mounding can provide dry microsites along sections where excessive seepage or pooling is present. Mounds should be created in an irregular pattern along the road, especially on slopes. Mounding may also be used for access control, in which case a minimum depth of 0.75 m is recommended. Appropriate mound sizing and densities will depend on site parameters noted during the field reconnaissance. If this technique is to be used, site-specific prescriptions are recommended.

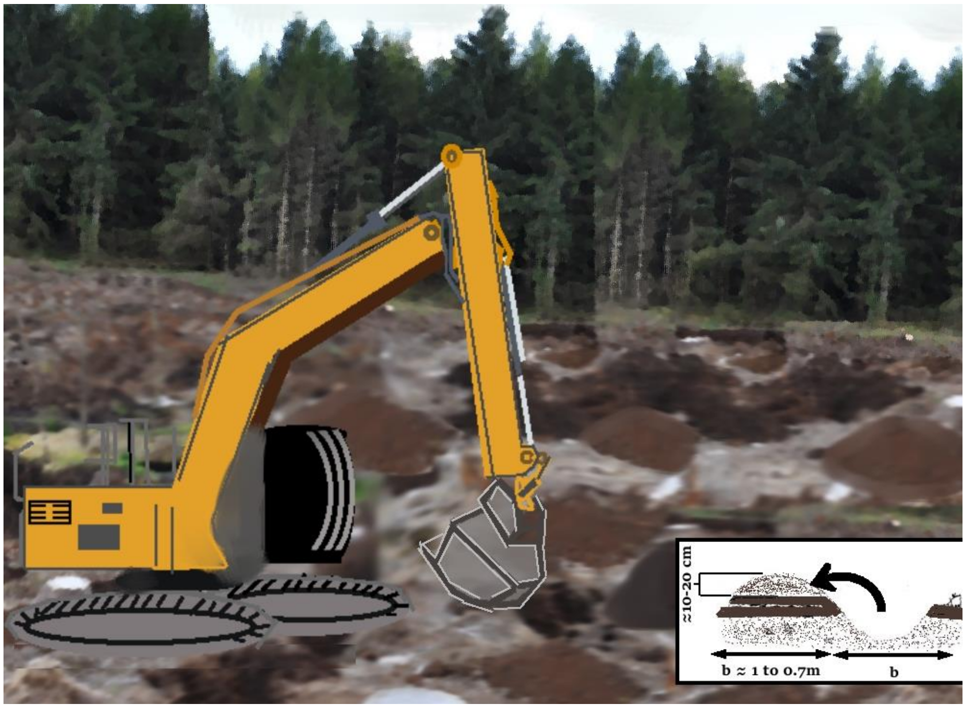

Figure 1. Mounding technique.

5.1.2 Ripping

Ripping is a standard site preparation method used to rip up soil at sites where soil compaction may be a concern and the risk of rill erosion is low (e.g., upland areas). Using an excavator or skidder with an attachment equipped with ripping teeth/plows, the soil is de-compacted to allow for improved root development. Ripping may not be necessary for roads where compaction has not occurred (e.g., spur roads) or for fire guards.

Figure 2. Ripping technique.

5.2 Revegetation

Planting tree and shrub seedlings, as well as grass seeding, will be an important component to road rehabilitation to regenerate habitat as quickly and efficiently as possible. Replanting roads with tree and shrub seedlings will also serve to break-up sightlines along longer linear corridors in a shorter period of time and reduce ease of movement for predators (Section 2.0). Planting densities and seedling survival targets will be established based on applicable site conditions (e.g., moisture regime, slope, elevation) and adjacent forest stand cover, all of which will be determined during field reconnaissance. Planting and seeding may not be necessary for roads that will naturally regenerate more quickly (e.g., short spur roads); however, rationale should be provided for why revegetation treatment is unnecessary during field reconnaissance, as well as a recommendation to include these roads in the effectiveness monitoring plan (Section 8.0) to ensure natural regeneration is occurring as predicted. Best management practices for managing invasive plant species should be incorporated throughout the works (Section 7.0). For further details regarding species suitability and planting densities, refer to *A Field Guide for Site Identification and Interpretation for the Prince Rupert Forest Region* by Banner et al. (1993).

5.2.1 Planting Recommendations

For the purposes of caribou habitat restoration, the focus is generally on planting coniferous species since conifers are an important component of caribou habitat and provide a better line of sight break year-round compared to deciduous trees. Plant species chosen should be somewhat robust in disturbed conditions; however, fertilizer inputs may be required where nutrient-poor fill material is the primary growing medium. Other factors that should be considered during plant selection include:

- **Biogeoclimatic (BEC) zone**; whether species are naturally found, or will thrive, within a designated BEC zone. Three BEC zones are found within the Project area: ESSFmc, SBSmc2, and SBSdk
- **Low-Palatability** to other ungulates, such as moose and deer, to avoid drawing predators into the area where caribou are expected to be.
- **Competition**; planting particular species and seedling densities that will not compete with native tree and shrub cover and with lichen colonization. Revegetation should still allow for natural establishment of native species over time.

Based on the above factors, the following plant species are recommended for the Nadina-South Ootsa Project (Table 1); however, final plant/seed selection may be amended to account for site-specific requirements observed during the field reconnaissance.

Table 1. Tree, shrub, and grass species recommended for planting within the Project area.

PLANT SPECIES	SITE SUITABILITY	RATIONALE
Lodgepole pine (*Pinus contorta*)	• Most sites, • Dry, nutrient poor • SBSmc2, SBSdk, ESSFmc	• Resistant to drought and frost • Unpalatable to deer • Will reduce line-of-sight over time
Spruce Engelmann x white (*Picea engelmannii x glauca*)	• Moist, lowland sites • SBSmc2, SBSdk, ESSFmc	• Unpalatable to deer • Will reduce line-of-sight over time

PLANT SPECIES		SITE SUITABILITY	RATIONALE
Sitka alder (*Alnus viridis spp. Sinuate*)		• Dry, nutrient poor • Slopes • SBSmc2 and ESSFmc	• Does well in nutrient-poor growing mediums • Less preferred by ungulates compared to other common shrub species, such as *willow spp*. • Will reduce ease of predator movement and line-of-sight
Native grass seed mix Rocky Mountain fescue Canada wildrye Canada bluegrass Timothy Slender wheatgrass	 (*Festuca saximontana*) (*Elymus canadensis*) (*Poa compressa*) (*Phleum pretense*) (*Elymus trachycaulus*)	• Dry to moist sites? • SBS Zone	• Known to naturally occur within the Nadina Forest District • Occurs at elevations similar to project area (range 800 to 1200m) • Adapted to shallow or poorly developed soils • Adapted to either dry to moist or moist to wet soil conditions • Low to moderate competitiveness and forage yield rating • Commercially available

Although Subalpine fir (*Abies lasiocarpa*) was predicted to grow well in the region, it was not included as a primary choice since it is considered a preferred forage by other ungulates.

5.2.2 Lichen Transplants

Woodland caribou are diet specialists that rely heavily on terrestrial lichen species (in particular, *Cladonia* sub-genus *Cladina*) during the winter when forage options limited. Researchers have been assessing whether a key component to restoration of caribou habitat includes lichen transplants to increase winter forage opportunities and accelerate lichen propagation, especially after a large disturbance. The Chelaslie River fire in 2014 burned a significant portion of the TEC's winter and migration range and although food may not necessarily be a direct limitation, it may encourage the herd to expand its range thereby increasing interactions with predators (Ronalds and Grant 2018). When left to recolonize naturally after a wildfire, lichen mats may take 40-70 years to recover depending on climate and severity of the disturbance (Bruelisaur et al. 1996, Coxson and Marsh 2001). In 2017, a lichen restoration trial was initiated by FLNRORD in collaboration with the CCN in the southern half of the Nadina-South Ootsa along Tetachuck Lake. The purpose of the trial is to test whether distributing lichen fragments by ground or air can effectively accelerate lichen recovery and, if so, be done at an operational scale. The results for the trial are still in the early stages (Ronalds and Grant 2018); however, preliminary results look promising for trials west of the Williston Reservoir in the traditional territory of the Tsay Keh Dene Nation (Rapai 2017), and for trials conducted in northern Sweden after year 7 (Roturier et al. 2017). Rapai et al. (2018) has had preliminary success transplanting *Cladonia* sub-genus *Cladina* on forest roadways capped with coarse gravel, although uncertainty still exists on whether fragment or mat transplants are the most effective.

Therefore, lichen transplants may be a suitable component of road restoration efforts. For further guidance on how to transplant lichen fragments at an operational scale, refer to the *Tweedsmuir Lichen Restoration Trial, Year 1 Report* by Ronalds and Grant (2018) and *Examining the role of terrestrial lichen transplants in restoring woodland caribou in winter habitat* by Rapai et al. (2017). The following general guidelines should be considered:

- Lichen collection areas should be selected outside of critical caribou range and should be confirmed with FLNRORD.
- No more than 20% of lichen should be collected from one area.
- Minimize the period of time between collection and transplantation as much as possible to avoid potential issues with storage (e.g., rot); ideally store lichen in cool, dry conditions until it is time to transplant.
- Avoid transplanting lichen fragments/matts in areas where water may accumulate (e.g., toes of slopes, depressions, wetland/riparian habitat, etc.)

A standardized monitoring plan should be implemented to ensure transplant efforts are effective (Section 7.0).

5.3 Spreading of Large Woody Debris

The spreading of large or small woody material may serve as access control to prevent human and predator movements onto restored road surfaces, and it may serve as a site preparation technique by creating microsites. Woody debris may encourage seedling establishment and supplement sites left to revegetate naturally. Appropriate sizing and densities of woody debris will depend on site parameters found during the field reconnaissance. If this technique is to be utilized as part of the Project, site-specific prescriptions will be made. Suggested sizing is identified in the *Boreal Caribou Habitat Restoration Operational Toolkit for BC* (Golder, 2015) which may be considered and adjusted according to site conditions.

Spreading of large woody debris (LWD) along deactivated roads may be done in conjunction with mechanical site prep (Section 5.1) and revegetation (Section 5.2) wherever LWD is available on the landscape. Longer stretches of scattered LWD are considered more effective for access control. LWD may also be beneficial on slopes to prevent soil erosion, especially on slopes near sensitive environmental receptors (e.g., streams).

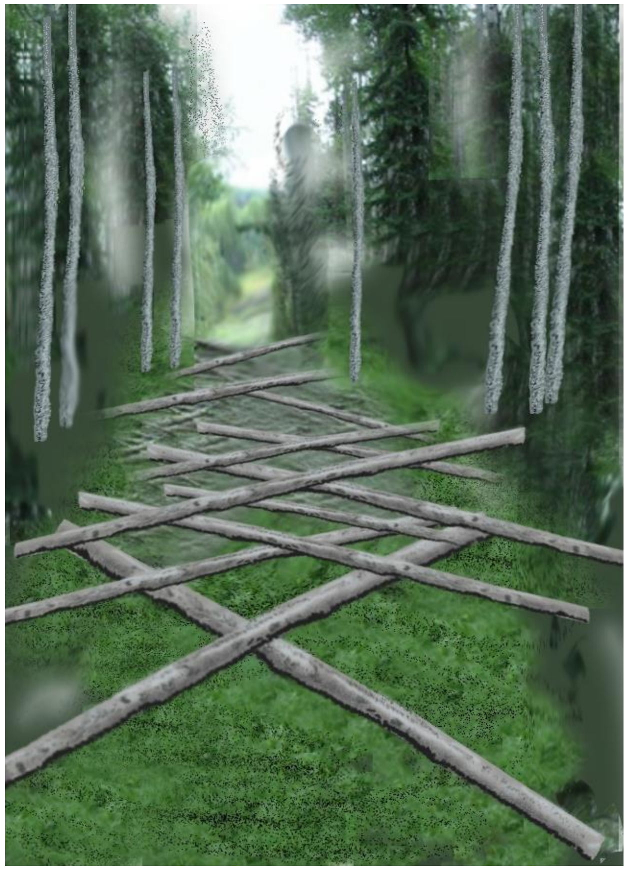

Figure 3. Large woody debris spread along a linear feature.

5.4 Tree Felling and Bending

Tree stem bending/hinging or tree felling may be suitable for reducing sightlines and impeding predator travel along roads, especially where LWD is not available on the landscape to accomplish the same task.

An excavator is used to bend or fell trees across the line by either pushing over trees or lifting them from the roots. These techniques are often combined with mounding and tree planting to control access. However, one potential problem associated with tree bending and felling of deciduous trees is that deer and moose may be attracted to sprouting shoots on easily accessible trees. Careful consideration of site conditions is required in order to determine if this treatment is appropriate.

Figure 4. Tree hinging.

Figure 5. Tree tipping.

5.5 Installation of Fences

Fences may be utilized to block access and sightlines on linear features where tree felling/bending isn't feasible. Fences may consist of wooden structures or orange snow fencing; however, fences consisting of decomposable material is recommended so that they can be left safely on the landscape with minimal maintenance requirements. An advantage of wooden fencing is that gates can be included to allow for continued human access where needed for maintenance or safety purposes. Alternatively, brush fences made out of LWD may also be used to block access and disrupt sightlines. Fencing should not consist of a material that increases the risk of animals getting tangled up in it, or can become damaged or buried by snow (Bohm et al. 2015). It is recommended that fence installation is only considered for the following scenarios:

- Linear sections with long sightlines that are difficult or impossible to reduce by any other method. An example of this may be transitional areas on the landscape (lowland to upland),
- Where a gate is necessary because continued human access may still be required,
- Where natural materials that do not require further maintenance (e.g., brush fences) can be used.

6.0 ENVIRONMENTAL CONSIDERATIONS

6.1 Permitting

The following licences and/or permits may be required for select phases of the restoration works. Each licence or permit will be obtained from the appropriate government agency including the Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) and the Ministry of Environment and Climate Change Strategy (MOE). Field reconnaissance and site-specific prescriptions will determine which licences or permits will be required.

- MLFNRORD - Forest Licence to Cut (BC *Forest Act*),
- MLFNRORD - Special Use Permit (BC *Forest Act*),
- MKFNRORD - Road Permit and/or Road Use Agreement (BC *Forest Act*),
- MLFNRORD - Change Approval for Instream Works (BC *Water Sustainability Act*),
- MOE – Any Permit Related to tracking or Monitoring Wildlife (BC *Wildlife Act*),
- MOE - Wildlife Salvage Permit (BC *Wildlife Act*).

6.1.1 Timing Windows

Reduced Risk Timing Windows for fish and wildlife are intended to provide specific timing windows to reduce the risk of impacts to fish and wildlife during Project works; they do not authorize anyone to conduct or participate in activities that are contrary to any statute.

Northern Mountain Caribou Timing Window

The recommended timing windows for Northern Mountain Caribou are outlined in *A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (MLFNRO 2014) and are summarized in Table 2.

Table 2. Timing windows for Northern Mountain Caribou

WINDOW	PERIOD	RATIONALE
Low-Risk	July 16 – September 14	Lowest risk period to conduct Project works in Northern Mountain Caribou ranges.
Caution	September 15 – January 14	Winter/rut period.
Critical	January 15 – July 15	Late winter gestation and calving period.
Critical	April 1 – May 20 December 1 – January 1	Migration period for caribou in North-Central BC.

In support of the timing windows, Cichowski (2015) recommends avoiding industrial activities within 500m of known calving/post calving habitats between May 15th and June 30th.

Fisheries Timing Window

Many of the streams within the Project area are tributaries to the Nechako Reservoir. Due to the presence of Burbot, Kokanee, Mountain Whitefish and Rainbow Trout within the reservoir (Table 3), no specific period throughout the year has been identified as a reduced risk period for completing works within the Nechako Reservoir (MFLNRORD 2018). Wherever possible, working instream should be avoided by planning to work in dry or frozen conditions. In the event instream works become required to complete a certain phase of the restoration works, further investigation of the tributary will need to be conducted to confirm which fish species have been reported in that system and whether a least-risk period can be identified.

Table 3. Timing windows for fish species in the Nechako Reservoir.

COMMON NAME	SCIENTIFIC NAME	LEAST RISK WINDOW
Burbot	*Lota lota*	September 1 to December 31
Kokanee	*Oncorhynchus nerka*	June 15 to July 15
Mountain Whitefish	*Prosopium williamsoni*	June 1 to August 31
Rainbow Trout	*Oncorhynchus mykiss*	October 1 to November 30

Vegetation Clearing Window

It is an offense to kill, capture or take birds and/or damage, disturb, remove or destroy nests as per the BC *Wildlife Act* and the federal *Migratory Bird Convention Act*. Clearing, grubbing, tree felling and hinging operations should be avoided during the most active nesting period in the region, which occurs between April 15th and August 15th, to minimize the risk to breeding birds (ECCC 2018).

If clearing, grubbing, tree felling and hinging operations must occur during the peak nesting period, a Qualified Environmental Professional (QEP) must conduct a bird nest survey of the area(s) where vegetation is to be removed in accordance with best management practices for Breeding Bird Nest Survey Protocols. In the event active nests are identified, appropriate mitigation measures will be implemented under the supervision of a QEP for the duration of the nest occupancy.

6.2 Invasive Plant Management

Ground disturbance and earth works will be an important component of road restoration. Therefore, best management practices will need to be followed to prevent and minimize the spread of noxious and invasive plant species in accordance with the *BC Weed Control Act*. For further information, refer to *Best Practices for Managing Invasive Plants on Roadsides* by MOT (2010).

6.2.1 Pre-Work

The most effective way to manage for invasive plant species is to prevent the initial spread. Although there are no invasive vegetation sites reported within the Project area, right-of-way areas along mainline roads have a higher probability of being populated by the more common invasive species in the area, such as Oxeye Daisy (*Leucanthemum vulgare*), Orange Hawkweed (*Hieracium aurantiuacum*), Yellow Hawkweed (*Hieracium caespitosum/glomeratum*), and Common Tansy (*Tanecetum vulgare*). During field reconnaissance, crews should identify any invasive species present in the project area, record notes regarding its location and density, take photographs, and collect GPS coordinates so that the sites can be reported through BC's Report-A-Weed program. The presence of allelopathic mechanisms within some species (*Hieracium sp.,* for example) could negatively influence the growth of native vegetation within the prescription area. To prevent this spread, the contractor should power-wash and inspect all vehicles and equipment off-site to assure equipment is clear of soil, seeds and plant components prior to entering the Project Site for the first time. Similar procedures are required for equipment leaving the Site or being transferred between work sites within the Project area.

6.2.2 Mid-Work

If planting seedlings is the preferred method of rehabilitation for the project, then the inclusion of a small packet of fertilizer with each root plug is a possible way of mitigating some of the negative effects that invasive vegetation could have on the growth of the seedling. Since many invasive species are opportunistic and prefer disturbed or low-quality sites, the inclusion of fertilizer may supress proliferation by increasing the quality of the site for native species (Stone 2010).

An effort should be made to minimize contact between equipment and the locations where invasive vegetation is present. For example, pullouts with native plant species should be preferred over those with invasive plant species when parking or turning around.

6.2.3 Post-Work

Field crews should record the presence of invasive vegetation at the site (photo, UTM at site center, and notes detailing extent/coverage) during effectiveness monitoring, especially the first year after rehabilitation is complete. Each infestation should be reported via BC's Report-A-Weed program.

Infestations that are further than 100m apart (with no invasive vegetation in-between) should be reported as separate sites. In cases where infestation numbers are fewer than approximately 100 individuals, field crews should treat the site immediately using mechanical methods. Approved mechanical methods for treating invasive vegetation involve digging up each individual (to avoid leaving root pieces behind which may grow back), gently dislodging excess soil, and depositing them into a plastic garbage bag for disposal.

In cases where invasive plants have flowered, the inflorescences must be carefully removed prior to digging to avoid dislodging any seeds and disposed of in a plastic garbage bag. Where the infestation numbers are greater than 100 individuals, mechanical methods may have to be abandoned; instead, the Northwest Invasive Plant Council (NWIPC) should be notified so that a new strategy can be employed. The NWIPC can be contacted at 1-866-44WEEDS.

6.3 Water Quality and Erosion Control

Water quality will need to be considered when equipment is working near streams and wetlands. Sediment mobilization should be prevented in order to maintain water quality. Temporary erosion control measures, such as silt fencing and mulching, may be used to prevent erosion from occurring during the occurrence of road deactivation and mechanical site preparation adjacent to streams, drainages, and wetlands. Earth works may need to be temporarily suspended during heavy rain events to prevent compaction and mobilization of disturbed sediment.

Equipment shall not enter streams or wetlands at any time. Works instream should only occur during dry conditions. However, if instream works become required when water is present as part of road deactivation measures (e.g., culvert removal), the appropriate permits and environmental best management practices will be necessary. Instream works may require an environmental monitor present throughout the works to install and maintain site isolation, as well as ensure water quality is maintained.

7.0 EFFECTIVENESS MONITORING

Effectiveness monitoring is separated into two sampling windows: 1) Survival Surveys and 2) Establishment Surveys. Survival surveys should be completed during years 1 and 2 following road rehabilitation, unless otherwise specified in contract or permit conditions. A survival survey allows for an initial assessment of seedling survival and early response of vegetation growth. Establishment surveys are intended to be completed within 8-15 years of treatment delivery, ideally one at 10 years and one at 15 years. Establishment surveys are conducted to assess whether the restored sites are on the trajectory of recovering to the desired vegetation density, as well as to confirm that predator and human access concerns have been addressed. Refer to *The Boreal Caribou Habitat Restoration Monitoring Framework* (Golder 2015) and the *Provincial Restoration and Establishment Framework for Legacy Seismic Lines in Alberta* (Alberta Government 2017) for further details and guidelines.

7.1 Vegetation Survival Surveys

It is recommended that an initial survival survey is conducted after one full growing season to identify any immediate issues with seedling mortality, seed germination and/or access control. Within the following four years, surveys will be able to identify issues with vegetation growth. After five growing seasons, monitoring results should be able to indicate whether recommended targets will be met. Specific restoration targets are outlined in Section 7.4.

Monitoring will be completed following the growing season between August and September while vegetation is leafing. The monitoring crew will only access treatment areas by foot in order to protect the restored area from disturbance and to prevent altering monitoring results.

7.1.1 Sampling Design

Survival surveys are established by applying a stratified sampling design which ensures that a representative percentage of the treatment area is assessed. This approach includes an assessment of treatment plots located at specified sites within treatment areas. Typically, treatment plots should be compared with disturbed, but untreated areas to assess whether planting efforts have accelerated habitat restoration when compared to natural propagation of native vegetation in untreated plots. A paired treatment/reference plot design is suitable for linear disturbances where natural propagation can occur (e.g., seismic lines). However, for this Project, reference plots may be less meaningful since untreated plots would occur along roads where compacted fill would prevent natural seedling growth.

Paired treatment/reference plots would be recommended in the scenario where field reconnaissance crews recommend mechanical site preparation (e.g., ripping) without revegetation under the assumption that natural propagation may be possible. Should those prescriptions occur, then ripped, vegetated roads (i.e., treated) should be compared to ripped, unvegetated roads (i.e., reference). Treated plots should only be compared to reference plots that share similar site characteristics (e.g., upland, treed lowland and transitional habitat) to reduce the amount of variability in expected vegetation growth patterns.

7.1.2 Plot Design

Monitoring plots and reference plots (if necessary) will be established in accordance with the sampling design described above. The number of treatment and reference monitoring plots required for the survival survey will depend largely on the size of the area that was restored and is to be established by DWB. The number of plots will also depend on how many different treatments were applied, and the variety of site characteristics. Generally, a minimum of one paired plot (i.e., treatment and reference plot) per treatment or 1 plot/km of linear feature is recommended.

A systematic plot design will be utilized to determine appropriate locations of treatment and reference monitoring plots. Monitoring plots will be spaced evenly across the restoration area to encompass a variety of site conditions. Spacing between plots may vary greatly depending on the size of the area and the number of treatments applied (i.e., anywhere between 5m and 500m). Plots will be a standard $50m^2$ consisting of either a 3.99m radius circle or a 5m x 10 m rectangle. Alternatively, where narrow road features prevent this size of plot, three circular subplots of 1.78 m fixed radii ($10m^2$ each) may be used within a distance of 25m to replace one $50m^2$ plot. An equivalent number of reference plots will be established for all treatment plots.

7.1.3 Data Collection

At the pre-established treatment and reference monitoring plots, the following minimum data will be collected for a vegetation survival survey:

- Road and plot identification and location
- Date and time
- Treatment Plot Results

    - Total tally of tree and shrubs
    - Percentages of tree, shrub, and grass cover
    - Height of each planted seedling
    - Number of dead planted seedlings (if present)
    - Vigour of each planted seedling (i.e., low, medium or high; Figure 6)
- Slope and aspect
- Line of sight distance class
- Percent sightability

Should time permit, collection of additional site information is also recommended and may include:

- General site vegetation characteristics
    - BEC zone, subzone and site series
    - Vegetation community presence
    - Tree canopy adjacent to disturbed area
- Ground characteristics
    - Soil moisture regime
    - Nutrient regime
    - Presence of non-living matter (e.g. woody debris and rocks)

Refer to Appendix E in Golder (2015) for details regarding standardized protocols for collecting the above parameters. In addition, general notes on weather conditions and wildlife signs noted during the assessment will be reported. Photographs will be taken approximately 5 m from the plot center at a standard cardinal direction (e.g., south) during every monitoring event. Flagging will be placed at the edge of the plots in each of the four cardinal directions. Any naturally colonized native (or non-native) plant species should also be identified within the plot and recorded (e.g., trees, shrubs, forbs, herbs, bryophytes or lichen). Emphasis will be placed on collecting as much information as possible (e.g., height, % cover, vigour) for all naturally established plants within the plot.

Seedling vigour will be determined based on the visual observation of seedling foliage and development. Examples of various seedling vigour conditions (low, medium, high or dead) are provided in Figure 6.

Figure 6. Photographs illustrating vigour conditions for a conifer seedling, including high (left), moderate to poor (middle) and dead (right).

7.1.4 Data Analysis and Remedial Actions

Results of each survival survey will be evaluated based on the recommended restoration targets described in Section 7.4. The data collected during each survival survey will be summarized into a report and submitted to SERN BC. Where expected targets have not been met, remedial actions will be determined in consultation with the MFLRNORD and implemented at the earliest practicable time. Remedial actions may include, but not be limited to, several of the following:

- Replacement of seedlings that have died. Seedling mortality factors must be assessed and addressed as much as possible (e.g., disease, poor seedling stock, issues with storage or planting),
- Modification of surface drainage patterns where seedling growth was impeded by wet site conditions,
- Manual vegetation control where desired vegetation growth is impeded by competing plants,
- Manual control where noxious or invasive species have been noted,
- Modification of access control measures where predator signs or damage due to human access are noted.

7.2 Lichen Transplant Surveys

Similar to revegetation efforts, any lichen transplants incorporated into the restoration Project will require confirmation of survival in years 1 and 2, followed by confirmation of colonization in years 10 and 15 during establishment surveys. An initial survey will also be completed immediately following completion of lichen transplanting to provide a baseline assessment; information collected in the following years will then be compared to the baseline results to determine whether lichen cover has decreased, been maintained, or increased over time. Additional years of survey may also be incorporated into the monitoring plan upon recommendation by MFNRORD to aid management decisions and support lichen transplant research that is currently ongoing in the Project area. Percent lichen cover will be evaluated for vegetation survival surveys; however, to conduct a thorough assessment of lichen survival and growth, independent surveys of transplanted lichen will be completed. The approach and methodology of the independent lichen transplant surveys will be based on Ronald and Grant's (2018) transect and ecosystem plot designs.

For each treated road, both transect and ecosystem plots will be established. Transplant survey plots will consist of 100m long transects that include a randomly placed 1 x 1m plot for at every 10m intervals. Ecosystem survey plots will include $100m^2$ plots, each of which will contain four randomly placed 1 x 1m plots.

Within each of the 1 x 1m plots for both transect and ecosystem plots, measures of substrate and vegetation will be recorded. Variables of the substrate that will be assessed will include organic matter and fine woody debris (<10cm thick), decaying wood and coarse woody debris (≥10cm thick), bedrock, rock (cobbles and stones >7.5cm diameter), litter and exposed mineral soil. Vegetation (i.e., lichen) cover (%) will also be assessed visually.

In addition to a field evaluation of % cover, vegetation cover will be assessed utilizing plot photographs. For each 1x1m plot, a photograph of the surface will be taken at a standard height (1.3m) and angle. The photographs will include a 50 x 50cm area of the center of the plot. Photographs will be taken using a tripod to maximize photo quality. The photographs will provide a digital image record that can be used to analyze changes in lichen cover over time using software such as ImageJ version 1.46r plant image analysis (Ferreira and Rasband 2012).

7.3 Establishment Surveys

Establishment surveys are applied at the program-level to combine data from a large cross-set of restoration and rehabilitation projects. This allows for an increased sample size and more robust analysis of high-level effectiveness. Establishment surveys are designed to compare treatment plots to paired reference plots collected from individual projects as well as to adjacent undisturbed habitat to assess the overall ecological and economic value of treatment amongst various restoration projects. As such, program-level effectiveness monitoring is typically the responsibility of the FLNRORD. Program-level effectiveness monitoring enables regulators to determine the usefulness of relevant best management practices, policies and legislation.

The following standards were developed to complete individual establishment surveys at the Project planning area only. A comparison to other rehabilitation projects is outside of the scope of the Project and will be the responsibility of the FLNRORD. Two establishment surveys, one at 10 years and one at 15 years will be conducted as a final check to assess whether the road rehabilitation sites are on the trajectory of recovering to desired vegetation and/or if predator and human access concerns have been addressed.

7.3.1 Sampling Design and Data Collection

Establishment monitoring is anticipated to be conducted using both aerial or remote sensing protocols and ground-based protocols. Reconnaissance aerial assessments and remote sensing are efficient in evaluating regeneration over large areas in a timely and economic fashion. Aerial assessments involve flying over treated roads and visually assessing stocking densities, vegetation height, ground cover and evidence of human or wildlife access. Treated and adjacent undisturbed areas are photographed or filmed to record observations. Alternatively, Light Detection and Ranging (LiDAR) or other remote sensing information may be collected and analysed for treatment areas. Digital elevation models (DEM) may be created using LiDAR to determine vegetation height. DWB's professionals who will perform aerial reconnaissance or remote sensing surveys are qualified surveyors trained in the use of required equipment and in assessing restoration establishment targets.

Following an aerial/remote sensing survey, a limited number of ground-based plots will be utilized to verify the accuracy of these assessments and to provide quality control. Since establishment surveys are based on treatment and reference plots developed during rehabilitation, ground plot locations will be pre-determined by previously conducted survival surveys. In the event that plots can no longer be located, the same plot design methodology as described in Section 7.1.2 will be utilized to develop new ground plots for establishment surveys.

7.3.2 Data Analysis

Monitoring data collected from the Project will be combined and analysed. A variety of statistical analyses may be employed if the sample size is sufficient. Within 3 months of each establishment survey, DWB will submit a summary report outlining which parts of restoration areas pass and which ones fail stocking criteria based on the restoration targets as outlined in Section 4.0. SERN BC will store the data and the FLNRORD may have additional analyses performed to compare the Project to other restoration/rehabilitation projects. The MFLNRORD may release this data to other government agencies or proponents who wish to conduct analyses in the region.

7.4 Restoration Targets

As outlined in the previous two sections, survival surveys will focus on the survival of seedlings and early response of vegetation growth, while establishment surveys will focus on assessing the density, height and survival rate of trees, as well as presence of human/predator trails.

To set a standard for quantifying restoration success, general principles adopted by the forestry industry in BC have been utilized. Stocking standards are best applied in order to determine if and how stand objectives are met over time. Tables 1 and 2 below outline some of the evaluation criteria, indicators of success, and standards for targets generally recommended to be utilized to establish restoration goals for survival surveys and establishment surveys, respectively.

Table 3. Generalized Restoration Targets for a Survival Survey*.

RESTORATION GOAL	EVALUATION CRITERIA/INDICATORS	TARGETS
Vegetation Establishment	• Density (stems/ha), Height, Percent Cover (%) and Vigour (i.e. presence of chlorosis or other health issues) of live tree and shrub seedlings including planted and natural regeneration. • Number of dead planted seedlings (survival rate). • Number of browsed seedlings. • Percent cover of seeded grass. • Percent cover of transplanted terrestrial lichens. • Percent cover of naturally established vegetation. • List of plant species naturally established.	• Target survival rate is 70% in the 1st growing season and 50% in the fifth growing season. • Target density is 1200 stems/ha in the 1st growing season and 1600 - 2000 stems/ha in the 5th growing season. • >80% of surviving seedlings are well-spaced (defined in Golder 2015). • No signs of browsing on planted seedlings. • Little to no evidence of tree health issues (microsites of poor growing conditions may be present). • Evidence of natural colonization of native plant species. • Transplanted (i.e., mats) terrestrial lichen cover is maintained or has increased (due to natural or transplant recruitment).
Access Control	• Evidence of access (Y/N) • Type of access (Predators/other ungulates or Motorized vehicles, including ATV, truck, snowmobile • Level of use (May be low to infrequent with few signs or considered high with tracks and ground disturbance very visible)	• No evidence of predator or motorized vehicle use following installation of access control.

*Adapted from Golder, 2015; based on upland and transitional sites.

Table 4. Generalized Restoration Targets for an Establishment Survey*.

RESTORATION GOAL	EVALUATION CRITERIA/INDICATORS	TARGETS
Vegetation Establishment	• Density (%) of targeted vegetation (stems/ha) • Percent cover of targeted vegetation • Height and leader growth of targeted vegetation	• Density, percent cover and height should mimic adjacent undisturbed habitat. • Stocking targets for the 5th growing season are maintained (1600 - 2000 stems/ha). • Transplanted terrestrial lichen cover (i.e., mats) is maintained or has increased (due to natural or transplant recruitment).
Access Control	• Evidence of access • Line of Sight	• Less than 35% of overall treatment areas show signs of human and predator access, as compared to reference areas. • Line of sight is limited to <500m on linear disturbances.

*Adapted from Golder, 2015; based on upland and transitional sites.

7.5 WILDLIFE/VALIDATION MONITORING

Effectiveness monitoring as described in the previous sections focuses on compliance and native vegetation responses to road rehabilitation treatments. The aim of wildlife/validation monitoring is to assess the response of caribou populations, predators and other ungulates to the restored features. Information collected from monitoring will be essential to determine the large-scale success of habitat restoration efforts across BC. The objective of wildlife/validation monitoring is to determine if restoration treatments have succeeded in providing quality habitat for caribou while reducing predation pressures to achieve caribou recovery goals.

Wildlife tracking methods may include one or more of the following methods:

- Monitoring flights combined with GPS collaring
- Ground-based monitoring using Remote Cameras
- Satellite data: NDVI, thermal sensors, resolution, and LiDAR
- Tracks/scat/carcass observations
- TEK, hunters, trappers, biologists (expert input)

Data collected from these sources should provide valuable information regarding use of the restored roads by wildlife, especially by caribou, predators of caribou, and wildlife that may attract predators into the area. Information from GPS collars and remote field cameras may also inform how efficiently predators are moving along the restored roads compared to existing, untreated linear features (e.g., Dickie et al. 2016). Comparing wildlife data between restored and untreated roads within the Project area will help confirm whether treatment efforts are successful. While all tracking methods have the potential to be informative, there are multiple approaches and questions that can be used to assess wildlife/validation monitoring; therefore, it will be important to select a specific question to be addressed so that an appropriate model and data collection method can be chosen to maximize effectiveness.

7.5.1 Radio Collars & Telemetry

An ongoing monitoring effort is already being conducted by the MFLNRORD through the use of telemetry collars on individuals of the TEC herd, as well as predatory wolves, within the Project Area. The data from this research has already been made available to the DWB team[1] and will be used in future phases of the project. The telemetry information may provide insight into the current activity level along the selected roads prior to restoration, as well as afterwards, and might relay whether or not restoration has reduced predator occupancy along the roads.

7.5.2 Wildlife Cameras

Wildlife cameras can be a reliable, cost effective, and less-labour-intensive method to capture data on population demographics and behaviour (Caravaggi et al 2017, Gillespie et al. 2015). For example, camera studies conducted in Banff National Park have helped managers understand the efficacy of road impact mitigation strategies (Clevenger and Waltho 2005, Ford et al. 2009) and have been used to test corridor model predictions (LaPoint et al. 2013). Similarly, the use of cameras at carefully selected locations for the Project could offer insight into the effectiveness of road restoration methods. Suitable locations for camera installations may include:

- On roads previously known to have high occupancy rates by caribou and predators,
- Along road sections with long sightlines (i.e., > 500 m),
- At key prescription locations (e.g., LWD spread, tree felling and hinging, fencing, etc.),
- On untreated (i.e., unrestored) roads that share similar site characteristics (i.e., slope, elevation, adjacent habitat, etc.) to roads that have been restored,
- Roads historically considered high-traffic by industrial or recreational users.

Access should also be considered during installation so that camera footage can be collected, or at least maintained, as needed. The use of wildlife cameras may help to gain a better understanding of whether restoration methods are reducing the speed, efficiency, or occupancy of predators within the TEK range. Camera footage of some of the locations that used key prescription methods (e.g., revegetation, brush fences, etc.) could clarify which methods are the most effective for reducing predator efficiency and maintaining access control. Observing the behaviour of caribou and predators using the restored roads compared to individuals using untreated roads will also be informative regarding how wildlife used the roads prior to restoration efforts and how effective the restoration efforts were at transforming the roads into useable habitat for caribou. This information may help guide management decisions regarding restoration plans for additional roads in the Project area in the future.

7.5.3 Track and Pellet Counts

The use of tracks and pellet counts is a valuable tool for conservation managers to better understand a species' diversity, population size and habitat use within an area (Bagherirad et al. 2013, Patterson et al. 2014, Skarin 2009). Counting of pellet groups may be a useful tool for gaining a better understanding of the caribou's use of the roads before and after restoration activities are conducted, and to understand

[1] Under signed non-disclosure agreements.

the access routes more dominantly used by the herd and their predators. While telemetry data and cameras may be able to sufficiently capture occupancy data, pellet counts may be used as a supplemental source of information to further improve understanding of road use, especially by uncollared individuals.

Some of the challenges associated with monitoring pellet counts includes the difficulty in distinguishing one species from another. In addition, pellet counts do not provide behavioural data in regards to movement efficiency along roads compared to information collected from cameras.

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