The Restoration of Linear Features in Caribou Habitat in BC – A Summary of Practices, Projects, and Costs

Introduction

The restoration of linear disturbance features has been highlighted as a key component of the British Columbia's Caribou Recovery Program. The Recovery Strategies for Woodland Caribou (boreal and southern mountain populations) set a recovery goal of achieving self sustaining populations of caribou in all ranges where they currently exist (Environment Canada 2012 and 2014). There are both population and habitat protection objectives within these recovery strategies. Objectives for habitat recovery, where habitat is insufficient or degraded and cannot meet the needs of the caribou population, can be achieved through the protection and restoration of critical habitat (Environment Canada 2012).

In Alberta, many companies have recognized the potential impact of legacy linear disturbance features for the survival of caribou populations. Recovery efforts in the province range from small on-lease (wellsites) restoration programs to extensive off-lease restoration programs aimed at recovering up to 300km of seismic lines (Appendix 3). The restoration of linear features is becoming an increasingly common investment in Alberta's caribou habitat.

Despite growing concern over declining caribou populations in British Columbia, and the identification of restoration as an important recovery tool, there has been few restoration projects implemented in BC. A variety of projects have focused on assessing the impact of disturbance on caribou habitat (both natural and anthropogenic) and more recently, government agencies, First Nations, and industrial proponents have begun to allocate resources toward restoration.

To date, four operational projects have specifically restored linear features; most notably within boreal caribou range in the Northeastern part of the Province. This includes two large-scale linear restoration programs in the Parker (boreal caribou) and Quintette (central group of Southern Mountain Caribou) herd ranges, one section of road that was deactivated within the range of the Moberly herd (central group), and the restoration of a section of road in the Columbia North herd range (southern group of Southern Mountain Caribou).

Report Scope

This report was commissioned to provide a summary of restoration projects. The specific intent was to focus on the costs, practices and treatments associated with the restoration of linear features in caribou habitat in BC. The report is not intended to be an in-depth scientific review of standards and procedures related to caribou-habitat restoration. Rather it provides a broad overview of current and past projects in northern BC and Alberta and may serve as a guide to initiating linear-feature restoration within caribou habitat.

Background

There has been a dramatic decrease in the spatial separation between wolves and caribou because of increased industrial activity and disturbance on the landscape (James et al. 2004; Latham et al. 2011b). Conventional seismic lines and other linear features are believed to be a main driver of this increased overlap between caribou and their predators. Linear features facilitate more efficient travel by wolves, and provide corridors that connect upland and lowland habitats (Latham et al. 2011a). This change in use of the landscape, and increased predator efficiency, is often described as a functional response to landscape disturbance.

Compounding this, the early-succession forests that result from anthropogenic and natural disturbances provide additional browse for moose, elk and deer (Athabasca Landscape Team 2009). Populations of these primary prey species increase in response to this elevated food-availability, which, in turn, leads to, increased wolf populations. An increased wolf population within close proximity to caribou habitat increases the likelihood that wolves will encounter, and kill, caribou (Latham et al., 2013). This shift in the number of primary prey and wolves is often referred to as a numerical response.

Comprehensive linear restoration strategies may be implemented to address both functional and numerical responses to habitat disturbance.

Restoration Objectives

Caribou research suggests that predators and primary prey are using linear corridors because of the ease of travel and accessible food sources, and not specifically to prey upon caribou (Latham et al. 2011a,b). The focus of restoration efforts have therefore been to establish treatments that will reduce or eliminate benefits that linear disturbances provide to predators and primary prey, thereby reducing the likelihood of caribou-encounters and increased rates of caribou mortality.

Linear Restoration

There is considerable discussion about an appropriate definition of restoration, particularly with reference to caribou conservation (Golder 2014a). In the context of this report, restoration is those actions taken that result (either in combination or in isolation) in a measurable influence on:

- Human access along, and use of, linear features;
- Rate of recovery of non-browse vegetation along linear features;
- Predator access and use of linear features.

Structural and Functional Restoration

Structural restoration focuses on restoring the structural components of an ecosystem through the promotion, of natural and induced, ecologically appropriate vegetation on linear features. To be effective, treatments must address the underlying causes for, and the limiting factors of, successful vegetative growth. These treatments generally consist of some form of site preparation, planting of seedlings and/or other vegetation and possibly the application of woody materials for microsite protection and enhancement.

Functional restoration, in contrast, has the primary objective of reducing the movement-efficiency of predators as a means of reducing interaction with, and predation on, caribou. Restricting human access can also be an objective of functional restoration as the conditions created by human travel (e.g. packed trails) have been shown to increase wolf travel efficiency, particularly in winter months (Keim et al. 2014). Functional restoration treatments generally create barriers to movement and obstruct sight-lines to reduce the hunting and movement efficiency for predators. There is a high degree of uncertainty regarding the efficacy of functional restoration (Neufeld 2006).

Distinguishing between structural and functional restoration objectives is important when designing restoration programs and selecting appropriate treatments. That said, this distinction does not mean that a restoration program can only achieve one objective or the other. Restoration programs often target both structural and functional objectives. For example, structural restoration treatments that focus on vegetative recovery often apply woody materials to create microsites for seedlings. If this woody material is applied at high enough volumes it can also function as a barrier to wolf movement and human access along linear features.

Limiting Factors

There are several factors that may limit the recovery of restored linear features. Identifying limiting factors at the planning and prescription stage helps practitioners to

understand and mitigate for variation in ecosystem recovery. Limiting factors may include:

Soil Moisture

- Wet cold northern soils are typically the most limiting factor for vegetation growth.
- Van Rensen (2014) found that sites showing the least potential to regenerate naturally are generally either too wet (bogs and fens) or too dry (upland pine forests).

Microsite conditions

- Microsites are essential for facilitating recovery along linear features.
- Sites with heavy vegetation cover (grass, moss, and shrubs) can limit sites for seed germination (contact with seedbed) and sites with little to no ground cover can experience temperature and moisture extremes which limit growth and recovery.

Compaction

- Traditional road construction methods may result in significant soil compaction, depending on the building season and conditions.
- Site preparation treatments can be applied to reduce soil bulk density and increase moisture availability and aeration in compacted soils.

Treatment Quality

- Vinge and Lieffers (2013) found that despite considerable effort, many treatments had limited success because of the way that they were carried out. For example, frost conditions can limit the efficacy of mounding unless care is taken to ensure that seedlings are planted in the right microsite and to an appropriate depth for site conditions.
- Hiring experienced contractors and ensuring staff have a strong understanding of the ecological limitations and the rationale behind treatments is key to successful implementation (COSIA 2014).

Human access

- Access by ATVs, snowmobiles, and other vehicles can cause direct damage to vegetation and reduce the successful recovery of vegetation on a linear feature.
- Motorized activities 'pack' snow along linear features creating conditions that can increase their use by predators (Keim *et al*., 2014).
- Applying treatments that reduce trafficability of lines can help protect natural regeneration and create microsites to assist with the recovery of vegetative features.
- Access management plans and engagement with local publics are critical to minimizing human access along restored features.

Restoration Planning

Restoration of linear features in caribou habitat can be complicated and requires planning at multiple levels to ensure that high-level corporate objectives are established and realized during the on-the-ground treatments of linear features. Overarching

objectives are often related to access management, vegetation recovery, and the creation of structural attributes that will reduce the efficacy of linear features. Identifying strategic, tactical, and operational objectives and tasks is critical.

Restoration success is often determined by the tactical considerations identified during the planning work phase. The planning framework consists of five general steps defined as follows:

1. Identify goals and objectives – Goals are clear, concise statements of high-level intent of the program. Why is the program being undertaken?
2. Select approach – selecting a functional restoration approach or a habitat restoration approach (i.e., combined functional/structural restoration) for the program.
3. Plan – the steps required to plan and coordinate an efficient, effective program that will achieve the program objectives. Includes linkages to specific site conditions and desirable treatments. Planning activities include:
    a. Inventory of candidate features (e.g. seismic lines)
        - remote sensing can be used to spatially map the current state of legacy features.
        - field verification of candidate sites to document the type(s) of disturbance, level of human and wildlife use, vegetative state (natural regeneration), width and orientation, soil compaction, microsite availability, adjacent forest attributes, and availability of woody materials.
    b. Prioritization candidate sites through a combination of strategic and tactical considerations. In caribou habitat, priority areas for restoration involve those linear features that will reduce access and travel into and within areas considered to be critical caribou habitat. For large-scale programs, future development plans, land-use priorities, and tenuring and/or ownership of the land needs to be incorporated into process. Practitioners may also consider whether a site can be left to re-vegetate naturally.
    c. Complete treatment prescriptions. Prescriptions for linear corridors differ significantly from silviculture practices used to restore cutblocks and larger forest openings. Considerations include the:
        - surrounding forest stand attributes;
        - ecosystem type - upland, lowland or transitional and BEC subzone and site series;
        - original disturbance type and method (seismic, cutline, road, pipeline);
        - potential level of reuse or disturbance (ATV use);
        - availability of woody material;
        - width of disturbance, light levels, and orientation;
        - level of human and/or predator use; and
        - moisture and nutrient regimes.

4. Treat – applying the treatments on the ground.
5. Monitor – follow-up monitoring and assessments to resolve key uncertainties and adjust future programs for improved performance. Clearly linked to objectives/goals of program.
6. Report – communication of the results is important to learn and guide future restoration programming. The Provincial Ecosystem Restoration Program has developed a reporting system, using two programs, Estate Model and ER Pro, to track restoration activities. The system is necessary, as ecosystem restoration activities are not currently captured in Provincial databases such as RESULTS. The data is archived in the Provincial government's database and is intended to be the main tool for tracking ecosystem restoration activities over time.

Restoration Treatments

The Province of British Columbia compiled information on the restoration of linear features in the Boreal Caribou Habitat Restoration Operational Toolkit for British Columbia (Golder 2015a). The Golder Toolkit combines practical experience from existing habitat restoration programs (primarily in) with feedback from BC regulators to ensure consistency with BC's resource management practices.

The Golder Toolkit was prepared as an operational handbook and is intended to guide restoration activities within caribou ranges in BC by providing common measures and standards intended to promote recovery while addressing human- and predator-access issues. It addresses:

- regulatory considerations through the restoration process;
- reclamation of new disturbance and historical linear features;
- restoration in and outside of tenure or other permit holders area of responsibility;
- approval of access control treatments and specifications; and
- monitoring of treatment applications to determine success.
- treatment options for structural and functional restoration (summarized in Table 1)

To help guide restoration practitioners in their determination of the appropriate silviculture treatment, the Alberta Environment and Sustainable Resource Development (ESRD) Land Management Branch has developed a treatment matrix for linear restoration. This has been modified for use in British Columbia by incorporating the Biogeoclimactic Ecosystem Classification (BEC) subzones within boreal caribou habitat range. This treatment matrix includes a range of potential vegetation treatments and stocking-standards that are based on site characteristics. Practitioners are encouraged to use a qualified restoration or silviculture professional familiar with the strategic and tactical restoration objectives and ecological conditions of the program area.

Caribou Restoration Programs and Projects in BC

To date, four restoration programs/projects, designed specifically to restore linear features in caribou habitat, have been implemented in BC. These four programs/projects are the:

- Boreal Caribou Restoration Program – Parker Herd
- Quintette Caribou Restoration Program – Quintette Herd
- Bickford Road Deactivation Project – Moberly (Klin-se-Za) Herd
- Bigmouth Creek Road Deactivation Project – Columbia North Herd

A summary of each completed and ongoing program/project along with treatment types and estimated costs are offered below. Its important to note that there are substantial differences between these four projects in terms of location, size, scope, geography, and topography, which in turn influence the specific practices, treatment types, and associated costs.

Boreal Caribou Restoration Program – Parker Herd

The Boreal Caribou Habitat Restoration Pilot Program Plan was initiated in April 2015. The program was the first plan to propose applying restoration techniques over an entire boreal caribou range in Canada. It was developed to guide a multi-year, range-scale, restoration program with field implementation planned for January 2017 (Golder 2015b). The program was designed to guide the implementation of habitat restoration treatments along treatment areas identified during the desktop linear classification exercise and confirmed through ground-truthing throughout the entire Parker Range.

A high-level tactical plan was developed within the program area based on treatment of four priority zones within the Parker Range. The zones, numbered one to four, were created and prioritized based on ecological and logistical considerations associated with each zone. The Zone 1, which is approximately 9,215 hectares in size, contained approximately 143km of traditional seismic lines. Approximately 52 km were designated for restorations treatments, ~90 km was left for natural regeneration, and ~38 km of seismic or road features were considered as 'no treatment' due to their active use as a recreational trail, resource road, or forestry service road.

Table 1: Summary of common treatments used in linear restoration programs in BC
(adapted from COSIA 2014 and Golder 2015a)

Site Preparation Treatments

Treatment	*What*	*Why*	*Where*	*Considerations*
Mounding	An excavator digs holes and inverts the soil beside the hole creating an elevated 'mound'.	Mounds create elevated microsites that increase soil temperature and improve growing conditions for natural regeneration and planted seedlings. Mounds help create an access barrier for human use and may influence wildlife movement.	Lowlands with high water tables (moisture concerns) Dry stands to improve moisture availability (pooling of water in mound holes) Uplands to address competition concerns (grasses etc.)	Operator training is essential. Proper construction is critical to ensure moisture wicking for seedlings and to ensure integrity through seasonal conditions.
Bar mounding	A variation on mounding where piles of soil are placed in rows perpendicular to lines.	Goal is to create a microsites similar to mounds, but to reduce costs and improve efficiency.	Uncertain whether microsite effect will match that of mounds and whether soil compaction below mounds is an issue.	May also be used to enhance/create access barriers.
Ripping	A dozer with ripping tines is used to de-compact the soil.	Reduces site compaction, improves moisture availability, soil aeration and root development	Generally used on upland sites and where soil compaction will restrict root development.	May use ripping tines on dozers but specialized ripping plows are available.
Scarification (Screefing)	An excavator roughs the ground surface in a systematic manner	Creates seedbed and plantable spots, improves moisture availability and soil aeration.	On upland sites with heavy debris and/or vegetation and LFH layers.	Works well but can be expensive.
Recontouring	Full pull back of road prism and return to natural contour of	Returning slope contour restores natural drainage patterns and reduces of	Desired on steep slopes where instability is a possibility.	May require geotechnical assessment. Cost can be a barrier.

	surrounding slope.	soil movement risk.		
Spreading of woody debris	Woody materials from beside the line or from nearby operations are spread.	Creates microsites for vegetation establishment and protection of seedlings Can restrict access when applied at high volumes.	Anywhere microsites would help regeneration or where access management is required.	Materials may be limited dependent on area and site history. Debris may be transported from nearby areas.

Revegetation Treatments

Treatment	***What***	***Why***	***Where***	***Considerations***
Summer planting	Seedlings are planted to encourage vegetation recovery.	Establishes coniferous or deciduous cover. Can help ensure desirable species mixes.	Any sites where improving regeneration is desired. Wetlands can be difficult to plant in summer due to access considerations.	Ecologically suitable species should be selected based on site conditions. Provides opportunity to plant diversity of species.
Winter planting	Seedlings are planted to encourage vegetation recovery.	Establishes conifer cover and puts vegetation on a long-term recovery trajectory to a restored condition.	Generally used in wet forested where site preparation (mounding) has occurred. Enables planting of wet ground when access is possible due to winter conditions.	Planting occurs alongside site preparation. Winter planting is limited to black spruce. Proper storage and handling of seedlings is critical.
Tree transplants	Established trees and other vegetation adjacent to the treatment lines are excavated and moved into treatment areas.	Various attempts have been made on Alberta projects.	Possible where vegetation is abundant.	Transplanted trees generally fail to establish on site and quickly die due to lack of root establishment.

Lichen transplants/seeding	*Cladina* and *Cladonia* species are collected and moved to desired site for re-establishment.	Speeds post disturbance re-establishment of critical forage species for caribou.	Thought to be suitable in fire-disturbed landscapes where forage to support caribou is critical.	Two experimental projects have attempted hand and aerial distribution of lichen mats and pieces (Appendix 2).

Functional Treatments

Treatment	***What***	***Why***	***Where***	***Considerations***
Tree felling	Trees adjacent to treatment area are felled across the feature.	Creates human and animal line-of-sight and access and movement barrier.	Suitable on critical pathways that lead to high value caribou habitat or where access management is required.	Approvals are needed to fell trees. Depends on adjacent stand density. Prioritizing felling on south sides of lines may improve light availability for vegetation.
Tree hinging/bending	A process by which trees are fully or partially felled/ and or pulled over by equipment.	Reduce line-of-sight and restricts access and movement. Felling trees results in rapid loss of needles. Stem bending is being tested to extend the life of the tree.	Various programs have tested the technique, but costs are high. Winter applications have resulted in stem breakage and summer use is being tested.	Treatments are often applied in the winter and can be logistically challenging to implement safely.
Line blocking	Heavy applications of woody material over short segments of lines.	Goal is to reduce movement efficiency of wolves and to deter human access.	Trials have placed heavy applications of debris at intersection of lines and shown reduced wolf use.	May include excavated features as additional access deterrents.
Fencing	Wooden fences are constructed at predetermined locations along lines.	Goal is to quickly and temporarily reduce wolf sight lines along linear features.	Can be used where access to features is good to ease logistical challenges.	Wooden panels, poles and textiles, and other solutions are possible.

The restoration of 56km of linear features was implemented between January and March 2017 using a variety of functional and structural treatment techniques in six different treatment combinations including:

- Tree Felling;
- Mounding, tree felling, and seedling planting;
- Mounding and seedling planting;
- Tree felling and debris application;
- Tree felling and scarification; and
- Mounding and tree felling.

Twenty-one long-term vegetation monitoring treatment plots were installed to collect vegetation data of which 20 were visited in the fall of 2017 to assess seedling survival other restoration features.

Quintette Caribou Restoration Program – Quintette Herd

The overall objective of the Quintette Caribou Restoration Plan is to transition highly disturbed, low-quality woodland caribou habitat into higher quality habitat, with a particular focus on linear disturbances. In this case, habitat restoration is predicted to reduce the benefits that predators and their primary prey have gained through linear corridor use in the immediate term (functional restoration) and to establish a vegetation recovery trajectory that will, in the long-term, increase habitat intactness (Golder 2017).

Restoration over the entire Quintette range (approximately 607,519 ha) is expected to require 5 to 10 years. Therefore a priority area was identified for more immediate restoration activities (approximately 45,205 ha). Within the Priority Area, a total of 745 km of linear disturbances have been mapped. Through desktop and field reconnaissance 496.5 km of linear disturbances are classified as 'no treatment' based on existing dispositions (tenures, leases, licenses or other agreement for land use), protective notices, or ongoing human use. Two hundred and eighteen kilometers have been recommended as 'no treatment' based on existing vegetation cover and lack of human or predator access, and ~27.9 km are recommended as 'treatment candidates' in the first year of restoration. More recently, this figure was reduced due to an additional area being designated as 'no treatment – stakeholder conflict' due to overlapping use and/or concerns by stakeholders.

A restoration plan has identified restoration treatment locations and associated treatment types for linear segments classified as treatment candidates. Cost estimates have been developed based on similar projects involving boreal caribou restoration projects in northern BC and Alberta. Activities included in the cost estimate represented

in Table 2 include:

- Project management;
- Stakeholder engagement;
- Road deactivation;
- Sowing requests,
- Tree felling; and
- Seedling planting.

An implementation plan has been prepared under the Quintette Caribou Habitat Restoration Plan to support the planning and logistical considerations to complete habitat restoration activities over the Priority Area within the Quintette Range (approximately $156,245) not represented in Table 2). Restoration planning and implementation of funded tasks in the restoration plan are scheduled to begin in 2017 and continue to 2019.

Bickford Road Deactivation Project – Moberly Herd

The deactivation of 2.3km of the Fisher Creek Forest Service Road in the Mount Bickford area near Chetwynd began in late September 2017 and was completed in October 2017 at an approximate cost of $223,385. Deactivation of this road consisted of the excavation of deep 'waterbars' or pit-like barriers, the installation of soil mounds, and the strategic placement of woody debris to close the road to vehicle traffic.

Specifically, this road was taken out of service to assist with the recovery of the Klin-se-Za caribou herd (previously the Moberly and Scott-East herds) by closing access to an area where a maternal penning project has operated since 2014. The maternal pen is jointly managed by the West Moberly First Nations, the BC government, and a number of wildlife consultants, stakeholders, and industry partners. Closing the road was intended to discourage recreationalists and prevent predators from using the former roadway.

Portions of the road were illegally 'reactivated' in the fall of 2017, which restored access to critical caribou habitat and hampered ongoing efforts to recover the Klin-se-Za caribou herd. Heavy equipment was used to remove logs and level out soil barriers on approximately two-thirds of the deactivated road network before the activity was discovered. The road has since been deactivated again at an additional cost of approximately $46,000 (not included in Table 2).

Bigmouth Creek Road Deactivation Project – Columbia North Herd

The Bigmouth Creek project was the first linear restoration initiative to occur in the mountainous regions of southern British Columbia and is a leading example of a project to restore critical caribou habitat in southern BC.

This project was implemented in late 2017 to address predation concerns on the

Southern Mountain Caribou populations in the Columbia North herd range. The project was completed on a section of road in the Bigmouth River drainage, approximately 130 km north of Revelstoke, BC. The general restoration approach followed strategies that have been successfully implemented in the boreal regions of northern Alberta and British Columbia.

The area of interest was removed from the harvestable land-base in an effort to secure critical mountain caribou habitat. The first phase of this project involved the permanent deactivation of approximately 5.4 km of the upper-most portion of the Bigmouth Forest Service Road. The deactivation process was led by BC Timber Sales (BCTS) in partnership with the Splatsin First Nation and the Ministry of Forests, Lands, and Natural Resource Operations and Rural Development.

The first phase of this project used a series of treatment techniques to functionally restore the road surface to reduce predator and alternate prey movement. The intent was to increase the surface roughness of the road surface using a mixture of treatment types adapted for mountainous terrain. These included:

- Full pullback and re-contouring of the candidate road;
- The road profile was inverted and mounded;
- Forested alluvial fans in gentle terrain were inverted and mounded;
- The de-compacted road bed was mounded (flatter terrain and raised road-beds); and
- Avalanche and other woody debris was scattered and piled.

Approximately 8,000 tree seedlings will be planted during a subsequent project phase to restore the structural attributes of the site.

Restoration Costs

Restoration program costs are influenced by a wide array of variables including: the duration and difficulty of planning activities, monitoring needs, access constraints, remote nature of the sites, distance from the nearest community, the need for camp and safety infrastructure, the field season, and the availability of resources – including labour, machinery, and materials.

Costs can be greatly reduced through advanced planning and through efficient program delivery. Completing planning activities and securing adequate resourcing and project funding in time to access sites early in the season can extend the operating season and reduce overall costs. Larger projects enjoy an economy of scale which greatly reduces the per km costs. Finally, coordinating treatments and maximizing staff and equipment efficiency has been shown to reduce costs.

The actual and estimated costs for the four BC projects were grouped into six common categories (Table 2). These include:

- Planning;
- Project management;
- Stakeholder engagement;
- Implementation;
- Monitoring; and
- Reporting.

Average costs, for the four restoration project detailed above, ranged from about $12,155/km to about $32,375/km. While this cost range is useful, it is important to note that each restoration program is based on differing political and ecological priorities as well as different cost tracking and reporting methods. The high end of the cost range involved restoring priority road segments to achieve the specific objective of reducing risk for the Klin-se-Za maternal pen, within a short period of time. By contrast, the boreal caribou program in the Parker herd range was designed to restore linear features in the entire herd area through comprehensive planning and cost-effective program implementation.

Given these examples, it is intuitive that lower costs can be achieved by focusing restoration efforts on larger-scale operational programs and by increasing coordination/collaboration to create cost efficiencies. For example, the Cenovus Project in Alberta (Appendix 3) is targeting operational costs of $11,000/km for the restoration of seismic lines (Cody pers. com.). Reported costs from the Boreal Caribou Restoration Program were about $13,000/km. In more complex mountainous terrain within the South Peace and Columbia regions increased restoration costs ranged from about $22,000 to $32,000/km (Table 2).

Table 2: Summarized costs for four linear restoration programs and projects in BC

Activity	*Parker - Boreal*	**Quintette – Central Mountain*	*Bickford – Central Mountain*	*Bigmouth – Southern Mountain*
Planning	$10,616.05	$18,145.00	$41,473.28	$9,383.00
Project Management	$43,421.00	$8,000.00	$33,766.67	$16,067.00
Engagement	$21,758.08	$9,600.00	$922.88	n/a
Implementation	$636,970.17	$363,392.00	$124,662.65	$130,362.50
Monitoring	n/a	n/a	$16,559.96	$18,700.00
Reporting	$12,000.00	n/a	$6,000.00	$2,100.00
Total (no GST)	**$724,765.30**	**$339,137.00**	**$223,385.44**	**$176,612.50**
Area Restored	56km	~22.9km	**2.3km	8.0km
Average $ per km	$12,942/km	$14,809/km	$32,375/km	$22,077/km

*Costs are educated estimates, at this time, as this project remains in the planning stages. Estimates from Golder Associates, a consultant with extensive restoration experience were used.

**A 30m wide right-of-way was reportedly treated for a total area of 6.9ha. This can be considered the equivalent of a 6.9km road using an average right-of-way width of 10m. This was factored into the average $ per km treated for the Bickford project.

It is also important to note that each restoration program used different assumptions and different methods to track and report costs. Developing a standardized way of reporting on program costs would help clarify variances in costs between different programs and projects, and more accurately identify where efficiencies lay.

Conclusion

The restoration of linear disturbance features has been highlighted as a key component critical to the conservation of caribou in British Columbia. There is a large and growing body of information pertaining to the restoration of linear features in boreal landscapes. Most of this information originates from restoration experiences in northern Alberta, but it is applicable and is actively being adapted to guide restoration activities in both boreal and mountain caribou habitats in BC.

In 2017, four projects were implemented to restore linear features in caribou habitat in BC. In this report, we have compiled a summary of current restoration practices and provided a brief review of four completed and ongoing restoration programs. There are substantial differences between these four projects in terms of location, size, scope, geography, and topography, which in turn influence the specific practices and treatment types used for each project.

There is considerable uncertainty around calculating and reporting the costs associated with restoration programs. This report grouped similar reported and estimated costs to calculate the total and average cost across the four projects. We found that larger, well-planned restoration projects, such as the Parker and Quintette projects, were more cost-effective, with costs that range from about $13,000 to about $15,000 per linear km. In contrast, smaller, one-off projects, designed to address more immediate caribou-related priorities incurred dramatically higher costs ranging from about $22,000 to $32,000 per km.

Development of a standardized metric for reporting on program costs is recommended to help understand the cost variance between programs. Developing a standardized system and process to consistently document and report on treatment types, conditions during treatment, and the location and spatial extent of treatments is also recommended. Such a system will improve the collection and storage of knowledge, which would greatly expedite the rate and efficiency of planning and funding of future restoration programs.

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Appendix 1: Approximate Costs for Four Caribou Linear Restoration Projects in BC

Boreal Caribou Habitat Restoration Pilot Program – Parker Herd

Activity	*Estimated Cost*
Access Creation	$68,699.44
Project Management	$43,421.00
Planning	$10,616.05
Reporting	$12,000.00
Extension	$5,000.00
Road Deactivation	$568,270.73
Stakeholder Engagement	$16,758.08
Total (no GST)	**$724,765.30**
Total Area Restored	56km
Average per km	$12,942.24/km

Quintette Caribou Restoration Project – Quintette Herd

Activity	*Estimated Cost*
Project Management	$8,000.00
Approvals and Authorizations	$11,545.00
Meetings and Engagement	$9,600.00
Sowing Request	$60,000.00
Tendering	$6,600.00
Road Deactivation	$91,363.00
Tree Felling	$146,029.00
Signage	$6,000.00
Total (no GST)	**$339,137.00**
Total Area Restored	27.9km
Average per km	$12,155 per km

Bickford Road Deactivation Project – Moberly Herd

Activity	*Actual Cost*
Project Management	$33,766.67
Supervision/Monitoring	$16,559.96
Reporting	$6,000.00
Prescriptions	$41,473.28
Road Deactivation/Restoration	$92,770.65
Reforestation	$31,892.00
Extension	$922.88
Total (no GST)	**$223,385.44**

Total Area Restored	2.3km
Average per km	$97,124/km

Bigmouth Creek Road Deactivation Project –Columbia North Herd

Activity	*Estimated Cost*
Administration	$1,383.00
Project Management	$7,275.00
Monitoring	$18,700.00
Reporting	$2,100.00
Other	$8,792.00
Professional Fees	$8,000.00
Rehab Work	$27,152.50
BCTS Deactivation	$103,210.00
Total (no GST)	**$176,612.50**
Total Area Restored	8.0km
Average per km	$22,077/km

Appendix 2: Summary of Lichen Seeding Projects in BC

The artificial dispersal of lichen fragments has been studied as a reclamation tool after major disturbances caused by wildfire, mining, and forest harvesting. In 2017, two terrestrial lichen restoration trials were initiated within burned portions of the home range of the Tweedsmuir-Entiako and the Chase caribou herds in central BC. The study sites were located on the traditional territories of the Cheslatta Carrier Nation and the Tsay Keh Dene First Nations, respectively. Lichen mats and fragments were dispersed by ground and aerial application to test whether lichen fragment distribution could be an effective means of accelerating lichen recovery on favorable sites and to explore means of implementation at the operational scale.

The objectives of the projects were to: 1) accelerate the return of terrestrial lichen winter forage in the area disturbed by wildfire by transplanting terrestrial lichen fragments and mats; 2) evaluate techniques for the transplanting of terrestrial lichen within a post wildfire forest environment; and, 3) inform forest managers, restoration practitioners, and academics on the feasibility of, and methods for, transplanting terrestrial lichen within a post wildfire forest environment.

The Chase project collected and spread 6000L of lichen mats and fragments over 80x100m^2 units or a total area of 0.8ha. The Tweedsmuir project was of a slightly larger scale and involved the collection and distribution of lichen fragments 3000L of lichen over 8x2,000m^2 (100mx20m) long transects for a total of 1.6ha. Both project involved the use of experimental design standards and the installation of monitoring plots. Depending on the desired application rate it's worth noting that approximately 4,000L (or approximately 40 bags) of lichen are needed to seed 1 hectare and, depending on lichen abundance at the collection site, 1 hour is needed to collect one bag of lichen.

Cost Summary for Lichen Seeding – Tweedsmuir-Entakio and Chase Herd Areas

Activity	*Chase*	*Tweedsmuir-Entakio*
Labour	$23,400.00	$47,000.00
Materials, Equipment, Transportation, and Expenses	$12,875.00	$17,000.00
Reporting/Administration	$702.00	$5,000.00
Total (no GST)	$36,977.00	$69,000.00
Total Area	0.8 ha	1.6ha
Average per ha	$46,221/ha	$43,125/ha

Appendix 3: Summary of Large-Scale Linear Restoration Programs in Northern Alberta

There is a large and growing body of information pertaining to the restoration of linear features in boreal landscapes. Most of this information originates from restoration experiences in northern Alberta, but it is applicable and is actively being adapted to guide restoration activities in both boreal and mountain caribou habitats in BC.

Three major initiatives are addressing legacy linear disturbances and restoring caribou habitat in the boreal forest in northern Alberta. The first two major linear restoration projects were the Algar Historic Restoration Project (Algar) and the Linear Deactivation Project (LiDea), which both focused on the rehabilitation of seismic lines. The two projects involved different approaches and methodologies and their results are being actively monitored.

The third initiative is the Cenovus Caribou Habitat Restoration Project, which benefits from the learnings of earlier projects and expands habitat restoration to the landscape scale. This project is the largest single area of caribou habitat restoration work undertaken by any company anywhere in the world and has benefitted from the participation of a number of operators in the area.

The Algar Project

The Algar Project used an integrated regional approach, with six companies working together, to repair fragmented habitat across an area of land outside of their license areas. The project includes a five-year program to replant trees and shrubs along the linear footprint within the Algar Region, covering an area approximately 570 km^2 southwest of Fort McMurray. Since the Algar Region consists largely of bogs and wetlands, planting was completed in the winter months using winter planting techniques successfully tested in 2011 in collaboration with the Government of Alberta and Grand Prairie Regional College.

The LiDea Project

Between 2013 and 2015, the LiDea Project used innovative techniques to restore linear disturbances in forested environments. During the spring and summer, conifer seedlings were planted along older seismic lines using mounds treatments. LiDea also experimented with forest stand modification, which involves bending tree stems from the adjacent forest across the seismic line to create physical barriers and reduce sightlines along the linear corridor.

The Cenovus Project

The Cenovus Caribou Habitat Restoration Project was launched in 2016 on the Cold Lake caribou range. This program is a $32 million; 10-year initiative intended to build on the success of LiDea. The goal of the project is to treat approximately 3,500 linear kilometres of seismic lines, access roads and other linear features within an area of approximately 3,900 square kilometres. This project applies the learnings from previous projects at the scale of the herd range.