NORTHERN MOUNTAIN CARIBOU POST FIRE HABITAT RESTORATION

PEA-F17-W-1223

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PREPARED FOR: FISH AND WILDLIFE COMPENSATION PROGRAM
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DATE: JANUARY 25, 2016

PREPARED WITH FINANCIAL SUPPORT OF THE FISH AND WILDLIFE COMPENSATION PROGRAM ON BEHALF OF ITS PROGRAM PARTNERS BC HYDRO, THE PROVINCE OF BC, FISHERIES AND OCEANS CANADA, FIRST NATIONS AND PUBLIC STAKEHOLDERS.

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EXECUTIVE SUMMARY

The Northern Mountain Caribou Post Fire Habitat Restoration Program was initiated in 2014 by Tsay Keh Dene Nation. The program is a partnership between Tsay Keh Dene Lands, Resources and Treaty Operations, Chu Cho Environmental and the British Columbia Ministry of Forests, Lands and Natural Resource Operations.

One reason for the population decline of northern mountain caribou is the alteration of critical habitat (B.C. Conservation Data Centre, 2016a). Northern mountain caribou are specialists, relying on pine – lichen habitats for forage during the winter months (Cichowski, 1993; B.C. Conservation Data Centre, 2016a). In 2014, the Mesilinka wild-fire eliminated a large portion of high value pine lichen habitat for the Chase herd. The intensity of this fire, coupled with industrial pressures and pine beetle kill has reduced the winter forage for the Chase herd. It is expected that it could take 40 - 70 years for the burned area to become productive lichen habitat naturally (Carroll and Bliss, 1982; Thomas et al., 1996; Dunford et al., 2006). Following a review of the available literature, our team concluded that seeding the area with lichen fragments and colonies could accelerate the return of the area to a productive lichen habitat in as little as 20 years (Crittenden, 1999; Duncan, 2015). The expectation is that the seeded fragments will provide a source lichen populations for the larger burned area.

In 2015, following consultation with 3 of Canada's most prominent lichenologists Dr. Richard Troy McMullin, Trevor Goward and Dr. Darwyn Coxson, our team established a rigorous experimental field design to identify techniques for establishing terrestrial lichen in a post-burn environment. The project expanded in 2016. In July of 2016, our team seeded 60 100m^2 areas (6,000m^2 in total) within the Mesilinka fire boundary with approximately 3,000 litres of forage lichen (*Cladonia mitis, C. stygia and C. uncialis*). This work is expected to enable lichen to colonize areas that are distant from source populations and accelerate the return of the area to high quality caribou winter range. Our team also incorporated an experimental design in this work to further our goal of identifying techniques for restoring terrestrial lichen communities in post burn environments.

The goal of this program is the restoration of northern mountain caribou winter habitat. However, we have a commitment to improving the science and knowledge base for restoring woodland caribou habitat. Our team emphasizes the importance of long term monitoring of this program 1, 3, 5, 10 and 20 years following establishment. This program will continue to provide valuable information on restoring woodland caribou winter habitat to both researchers and practitioners alike.

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1.0 INTRODUCTION

All caribou in British Columbia are of the woodland subspecies (*Rangifer tarandus caribou*), and can be further divided into three ecotypes based on habitat use, behaviour and migration patterns (Heard and Vagt, 1998; B.C. Conservation Data Centre, 2016a). The northern mountain caribou (*Rangifer tarandus*), or the northern caribou as it is known provincially, is one of these caribou ecotypes. The northern mountain caribou is a blue listed, species of special concern (S3) (COSEWIC, 2002; COSEWIC, 2014; B.C. Conservation Data Centre, 2016b). This means that if steps are not taken to address the factors threatening this species they are likely to become endangered in British Columbia.

Predation is a well understood cause of mortality of woodland caribou (BC MOE, 2011; Environment Canada, 2008), whereas the effects of habit alteration are more complex. Forest harvesting and human activities such as linear corridor development work to fragment and reduce habitat quality, and are associated with higher predation rates, increased human access, habitat change and potential reductions in winter food supply (B.C. Conservation Data Centre, 2016b; B.C. Conservation Data Centre, 2016c). Woodland caribou habitat in British Columbia is also being affected by the mountain pine beetle epidemic which cause changes in the overstory and understory plant community composition (Sulyma and Coxson, 2001; Goward et al., 2008; B.C. Conservation Centre, 2016b) and a short term decrease in terrestrial lichen abundance (Williston and Cichowski, 2004) that begins to reverse in 10 years (Cichowski and Haeussler, 2013). Impacts of salvage logging are likely greater than mountain pine beetle as caribou continue to select pine stands with mountain pine beatle kill (Cichowski and MacLean, 2013).

Northern mountain caribou are specialists, utilizing habitats that display a combination of low snow pack and locally abundant terrestrial lichen during winter months, when other food sources are most limited (Cichowski, 1993; B.C. Conservation Data Centre, 2016b). It has been well documented that woodland caribou across Canada rely on terrestrial lichen and arboreal lichen (Bryoria spp., Alectoria spp.) as their primary food source during the winter months (Klein, 1982; Johnson et al., 2000; Newmaster et al., 2013). These lichen abundant upland habitats are typically pine forests with moderate to poor nutrient levels and well drained coarse soils (Sulyma and Sulyma, 2008). Currently, these pine-lichen forests are relatively common in north central British Columbia. However, increased industrial pressure, changing stand dynamics resulting from mountain pine beetle, salvage harvesting activity and wild fire in the Omineca region could result in a reduction of northern mountain caribou range (B.C. Conservation Data Centre, 2016b). This pattern of habitat fragmentation and reductions in habitat quality have been observed with the southern mountain caribou, which is now critically imperiled (S1) (B.C. Conservation Data Centre, 2016d) and considered Endangered by COSEWIC (COSEWIC, 2014). Without effective habitat protection and restoration strategies, similar patterns of critical habitat alteration could lead to a decline in northern mountain caribou populations (B.C. Conservation Data Centre, 2016b).

This restoration program was initiated in 2015 by Tsay Keh Dene Nation and seeks to restore terrestrial lichen communities to areas burned by wild fire in summer 2014. Due to the alteration of critical northern mountain caribou habitat throughout the region, northern mountain caribou herds are now more susceptible to natural disturbance regimes such as wildfire. The goal of this restoration program is to restore

terrestrial lichen forage communities in the area of the Chase herd that was burned by the Mesilinka wild fire in 2014.

1.1 Fire Ecology and Lichen

Natural disturbance in low elevation pine forests in central and northern BC is typically thought to be fire driven, although there are nutrient poor habitats that may support pine lichen stands in a gap dynamic system. Scotter (1964) suggests that lichens will readily burn, and are particularly susceptible to fire disturbance because of their slow growth rate. Post-fire lichen succession is expected to follow a predictable timeline (Maikawa & Kershaw, 1976; Carroll & Bliss, 1982), returning to high quality caribou forage after 40-70 years (Carroll and Bliss, 1982; Thomas et al., 1996; Dunford et al., 2006).

Two significant wildfires burned high value pine lichen northern mountain caribou habitat designated as Ungulate Winter Range (UWR) (U-7-007) in the summer of 2014. Several of the areas burned are low elevation winter ranges, post rut aggregation, high elevation winter range and migration corridors. The immediate impact of these fires has been the elimination of caribou forage lichens across a large portion of the Chase (and to a lesser extent) Finlay herd areas. The size and location of these large fires, coupled with industrial pressures, migration barriers, and seasonal availability has drastically reduced the available winter forage for herds that have depended on the now burned areas for survival.

Primary succession relies on the natural colonization and dispersal abilities of plants. The ability for terrestrial lichens to colonise disturbed areas depends on available microsites, competition with vascular plants and most importantly, a source lichen population (Webb, 1996). The lichen species seeded as part of this restoration program (*Cladonia* sub-genus *Cladina* and *Cladonia uncialis*) propagate through thallus fragmentation. This is referred to as asexual reproduction, as both the algal and fungal symbiont is present within dislodged thallus fragments. The fragment represents a viable lichen propagule. These propagules will dislodge from colonies and are distributed naturally by wind, water and animals (Goward, 2000; Brodo et al., 2001; Nash, 2008). Typically, these fragments fall within .75 meters of the colony (Heinken, 1999).

Our team suspects that because the wildfire burned with such intensity, the area has become disconnected from a source of lichen propagules. This is expected to limit community composition and the geographic species pool available for colonization during primary succession (Seabloom et al., 2003). Left to recover naturally, it may take more than 70 years for the burned area to become productive lichen habitat (Thomas et al., 1996). However, the literature indicates that the colonization process can be accelerated through lichen seeding in disturbed areas (Crittenden, 1999; Duncan, 2015). At this point, there is uncertainty whether the long distance dispersal of lichen propagules from unburned stands can restore the area to high quality woodland caribou winter habitat under a shorter timeframe than what is reported in the literature (Carroll and Bliss, 1982; Thomas et al., 1996; Dunford et al., 2006). To answer this critical question, our team incorporated an experimental design that will work to evaluate several techniques for transplanting terrestrial lichens. These techniques will be compared to the 20 control sites that were simultaneously established in 2016.

1.2 A Review of Techniques For Establishing Lichen Communities

The scientific literature indicates that both lichen fragments and mats can be employed to restore terrestrial lichen communities (Duncan, 2015). Lichen fragments can be spread over large areas by hand (Duncan 2011), using leaf blowers mounted on all terrain vehicles (Krekula 2007 in Duncan 2015), aerially dispersed by helicopter (Enns, 1998) or spread using hydromulching equipment.

It is clear that the size of the lichen fragments is also important. Roturier et al. (2007) reported a tendency for large lichen fragments (3 cm) to exhibit greater increases in growth than 1 cm fragments. The planting of entire colonies has been discouraged in areas of Sweden because mats are more susceptible to grazing reindeer (Roturier and Bergsten, 2009). Caribou are not expected to feed within the burned area within the Mesilinka fire boundary with the same intensity as the herded reindeer of Sweden.

Duncan (2015) discusses two benefits of incorporating organic amendments with terrestrial lichen fragments. These benefits include securing lichen fragments to the substrate, and increasing the moisture holding capacity at the soil surface (Duncan, 2015). Lichen growth is based on the amount of time the lichen receives light while wet (Nash, 2008). Therefore, increasing moisture levels on the soil surface could increase the lichen growth rate and overall establishment success. Similarly, research indicates that lichens on exposed sites (forest canopy cover is absent) are prone to removal by wind and water (Duncan, 2011). This is a critical component to consider when attempting to restore early seral bare ground.

The available research suggests that broadcasting moss and forest litter with *Cladonia* spp. fragments can result in an increase in lichen percent cover (Roturier et al., 2007; Duncan, 2011). Research indicates that seeding terrestrial lichen fragments resulted in a luxurious mat of *Cladonia rangiferina* and *C. stellaris* after 20 years when spread in a subarctic region of Finland (Crittenden, 1999). While lichen are frequently cited for their slow growth, a 20 year timeframe is a shorter recovery time than what is typically considered for mine closure and silviculture plans.

2.0 GOALS AND OBJECTIVES

2.1 PROJECT PRIORITY OBJECTIVES

This habitat based action project is funded and directed under the Fish and Wildlife Compensation Program (FWCP). This project aligns with the Species of Interest Action Plan. Specifically, Action 1b-1:

> Action 1b – 1: Restore function of ungulate winter range for woodland caribou herds occupying the west side of the Peace basin.

The following objectives were developed to support the above Action Plan.

> Objective 1: Enhance northern mountain caribou winter forage in the area of the Chase herd that was burned by the Mesilinka wild fire in summer 2014.
>
> Objective 2: Establish permanent bio monitoring plot through which the composition of woody forage, forbs, graminoids and terrestrial lichen can be evaluated within Caribou Ungulate Winter Range Polygons (designated under the *Forests and Range Practice Act*) within the post-burn environment.
>
> Objective 3: Evaluate techniques for establishing terrestrial lichen (*Cladonia* sub-genus *Cladina* and *Cladonia uncialis*) within a post burn environment.

3.0 Study Area

This restoration program was initiated in 2015, and was continued in 2016. The work was carried out within the Mesilinka fire boundary, just south of Chase Provincial Park (Figure 1).

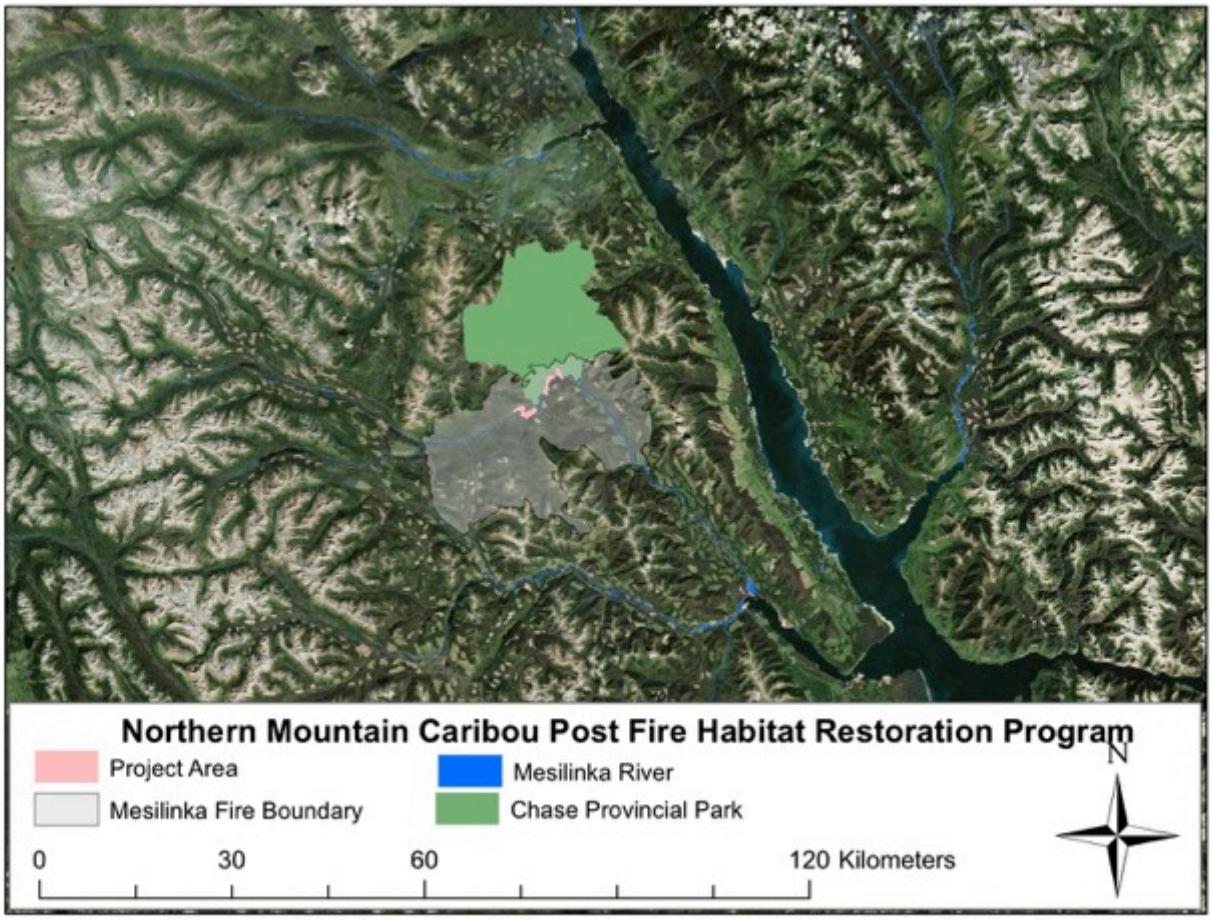

Figure 1: Map of the project area.

4.0 METHODS

The project consists of 3 components, each aimed at creating a better understanding of how to restore post-burn environments to northern mountain caribou winter habitat.

COMPONENT 1 – EXPERIMENTAL FIELD TRIAL

Component 1 was initiated by Tsay Keh Dene Lands, Resources and Treaty Operations and established in July 2015. This component was a pilot project in which our team evaluated varying techniques for the establishment of terrestrial lichen communities under post-burn conditions. An experimental field design was employed to evaluate the ecological requirements for establishing terrestrial lichen mats and fragments in the burned area (FWCP project number PF16-W30). Candidate areas were selected within the burned area (UWR 6b 002) based on the characteristics of the burn and topography. Three block transects were established (Figure 2), in 3 combinations of post fire conditions: intense burn on hillcrest, intense burn and flat, less intense burn and flat. In all, the team established 180 $1m^2$ experimental units, through which 6 varying treatments combinations can be evaluated (Table 1).

Table 1: Varying treatment combinations applied.

Treatment (n = 30 replicates each)
Lichen mat (100g)
Lichen mat + Forest Floor Litter (100g)
Lichen fragments (100g)
Lichen fragments + Forest Floor Litter (100g)
Control (plot empty)
Control (forest floor litter only)

Photography and ocular estimates are used to track lichen retention and growth within experimental units. Data collection was carried out on July 9th and July 10th 2016. In addition to lichen percent cover, ocular measurements of species percent cover of woody shrubs, forbs, graminoids, lichens and mosses were recorded during the establishment of the trial in July 2015.

On July 9th and 10th, 2016, the following data was collected from each experimental unit:

1. Document percent cover of lichen,
2. Photograph 150 cm above experimental unit,
3. Positive signs of lichen growth identified through the presence of pycnidia and/or apothecia,
4. Lichen migration/dispersal, and
5. General description of lichen health.

In order to calibrate ocular estimates between years, a 20cm x 20cm clear grid was used as an aid. The clear grid helps to ensure greater accuracy during the data collection stage. Estimates of percent cover are made in 1% increments from 1-10%, and in 5% increments from 10 – 100% as needed.

Figure 2: Burned pine flats with experimental blocks.

Component 2 – Habitat Restoration

Component 2 of this restoration program was implemented in July 2016. The work focused on seeding terrestrial lichen fragments and colonies within the Caribou Ungulate Winter Range polygons (6b 002, 6b 003 and 6b 009) within the 2014 Mesilinka fire boundary.

Locations for collecting terrestrial lichens were identified using biogeoclimatic zone mapping and associated terrestrial ecosystem mapping to identify nutrient poor xeric stands with a high potential for lichen. Conversations with individuals familiar with the region were used to confirm our candidate locations as suitable for collections. On July 5, 2016, terrestrial lichens were collected at 3 locations (see table 2) near Wittisichica Creek.

Table 2: Locations of lichen collections on July 5, 2016.

SiteID	Latitude	Longitude
Collection1	55.04326402	-124.228299
Collection2	55.04717904	-124.231958
Collection3	55.04545799	-124.229015

All lichen biomass was collected by hand (Figure 2), and technicians were instructed to collect <20% of the total lichen community. The value of <20% was selected based on recommendations for a sustainable harvest outlined by Kauppi (1979). The collection area was an even aged pine forest (*Pinus contorta ssp. latifolia*) in the moist cool sub boreal spruce biogeoglimatic zone (SBSmk1), with an open canopy (50% cover) and an understory dominated by terrestrial lichen and bunchberry (*Cornus canadensis*), twinflower (*Linnaea borealis*) and kinnikinnick (*Arctostaphylos uva-ursi*) indicating a 02 site series.

Technicians targeted lichen mats during collection (Figure 3), which are considered to be patches of continuous lichen the size of an outstretched hand. Technicians collected large mats of *Cladonia mitis, C. stygia* and *C. uncialis*, and noted the conspicuous absence of *Cladonia rangiferina* in the collection area. Field

technicians used the dichotomous keys in Brodo et al., (2001) and McMullin et al. (2011) to determine species.

Technicians collected an estimated 3,000 litres of terrestrial lichen in 159 litre Husky contractor clean-up bags (Figure 3). Each bag was filled to 2/3 full. In summary, it took 1 technician an average of 30 minutes to collect approximately 100 litres of terrestrial lichen. At the time of collection, the terrestrial lichen species were noted as being damp and resistant to fragmentation. This could be attributed the precipitation on the day prior to collection. Ten bags of lichen were collected from each of the Collection areas (Table 2). Bags were tied closed and transported by truck to the seeding locations where they were stored in the minimal shade of the burned area for 2 - 5 nights.

Figure 3: Chu Cho Environmental technician collecting terrestrial lichen.

A field camp was established within UWR 6b-002, which provided vehicle access along the West Main Forest Service Road to points intersecting UWR polygons 6b 009 and 6b 003 within the Mesinlinka fire boundary. These UWR's were selected for seeding because Tsay Keh Dene Lands, Resources and Treaty Operations (TKD LRTO) technicians identified these sites as having extensive terrestrial lichen carpets prior to the 2014 wildfire. Based on this knowledge it was assumed that transplanted lichen would also thrive on the site, as the substrate had previously supported a lichen community.

It is important to note the heterogeneity of burn intensity within the fire boundary, or within the UWR polygons. Non-burned and partially burned spruce and pine stands are a common occurrence in the project area. Sites deemed suitable for seeding by TKD LRTO were based on the following criteria:

1. Knowledge of the local topography and potential access points.
2. >50m from a wetland or riparian habitat
3. Avoid partially burned spruce or pine stands.
4. Avoid the toes of slopes (receiving areas), depressions, and areas where rainwater is expected to flow and pool in higher volume.
5. Slope angle <10^{o}.
6. >50m from forest roadways.
7. >50m from remnant terrestrial lichen community.

TKD LRTO technicians noted that the seeded areas were more concentrated within the UWR polygons then originally intended, because potential sites were excluded based on the criteria outlined above. Lastly, in fire skips and areas that the forest floor partially burned, remnant terrestrial lichen patches were identified (Figure 4). While these remnant lichen patches were rare on the landscape, there presence is encouraging for the natural regeneration of the caribou winter forage in the area.

Figure 4: Partially burned *Cladonia* ssp. *Cladina* within the Mesilinka fire boundary.

Plot centres (Figure 5) were identified within stands deemed suitable based on our site assessment criteria. Crews established circular plots with a 5.64m radius (100m^{2}) 50m north, south, east and west of centre for a total of 4 plots at each site. Steel stakes and labels were used to permanently mark the centre of each plot and the geographic coordinates were recorded. Vegetation surveys were then carried out within each plot

(see page 13 – Component 3). Following the completion of the vegetation surveys, 3 of 4 plots at a site were seeded with terrestrial lichen, with each plot receiving one of 3 treatments (Table 3).

Lichen fragments and mats were distributed by hand, with technicians placing colonies near logs and stumps (Figure 5). These obstacles are expected to create varying micro habitat conditions with regards to humidity, sun and wind exposure that may influence the growth of lichen. Lichen mats also had the soil pulled up to the edge (gardened) to help reduce movement and moisture retention. This is in contrast to the fragment treatment, in which mats and remnant fragments in the bag were shredded by hand and broadcast throughout the plot. The fragment treatment was considerably more efficient then the placement of mats, as technicians did not take time to orientate the individual lichen stalks or to obstacle the fragments.

Table 3: Lichen treatments applied.

Direction	Treatment
North	Control (no lichen)
East	Lichen mats only (100L)
South	Lichen mats (50L) and fragments (50L)
West	Lichen fragments only (100L)

The final step was the implementation of the plot monitoring protocols. Terrestrial lichen percent cover was estimated within each plot and recorded by species. Photographic records were also taken at each plot.

Figure 5: Tsay Keh Dene Lands, Resources and Treaty Operations field crew and volunteers establishing seeding locations and permanent monitoring plot network within the fire boundary.

Component 3 - Monitoring

The final step in this restoration program was the long term monitoring of plant communities in the burned area. This data is critical because it will allow our team to track and compare lichen establishment and growth between treatments, but also evaluate the ecological trajectory of the vascular plant community within our permanent plots. All sites were surveyed for vascular plant and cryptogram communities immediately following the establishment of the plot. The surveys were carried out prior to the lichen seeding to reduce the influence of foot traffic on the lichen treatments.

Sampling protocols followed the ocular estimate protocols from the Ministry of Forests, Lands and Natural Resource Operations for vegetation - Field Manual for Describing Terrestrial Ecosystems - Land Management Handbook 25 (2nd ed.). Vegetation layers were assessed, with standing snags of the pre fire canopy tree layers recorded as A1, A2 or B1 by species based on morphology or remaining cones. Cover estimates for snags was given for the bole as most were clean of branches and remaining branches provided no effective cover. Low shrub (B2), herb (C), and moss, lichen (prior to lichen seeding), liverwort and seedling (D - cryptogram) layers were collected to species. Deciduous trees were included in the "B" layers. Species were recorded using the 4-3-1 code (Meidinger et al 1998), with tree species recorded using the 2 letter tree species codes for *Pinus contorta* (Pl), *Picea englemannii* x *glauca* (Sx), and *Populus tremelodes* (At). Where field identification was not possible samples were collected for further examination and identification. Mosses that were just beginning to colonize sites and showed no structures that permitted field identification were collectively group as "moss spp." and assigned cover values as observed. Classification of the growing substrates in the "D" layer was not undertaken.

Percent cover estimates for the $100m^2$ plots were calibrated using a 1m x 1m frame (1%). Cover estimates below 1% were recorded as < 1%. Cover estimates between 1% and 10% were estimated in 1% intervals with fractions of 1% rounded down. Cover >11% was estimated in 5% increments. All members of the data collection crew completed 8 plots as a group to calibrate estimates and generate an initial plant species list. Additional coding information included in LMH 25 was not used. Alpha diversity and Whittaker's Beta diversity ($\beta = \gamma/\alpha$) was calculated for each plot.

5.0 RESULTS AND OUTCOMES

COMPONENT 1 – EXPERIMENTAL FIELD TRIAL

Comparison between July 2015 and 2016 data indicates that treatment has had a significant effect on lichen cover ($P < 0.01$), while block does not. Fragment and mat treatments have a significantly greater percent cover ($P < 0.001$) then the control, but there is no significant difference between the fragment and mat treatment in percent cover. It appeared that applying forest floor material has had no immediate effect on lichen retention within experimental units, as there has been little to no lichen movement between experimental units. Visible pycnidia/apothecia have been observed on both lichen fragments and mats alike on September 17, 2015 and July 10, 2016. Pycnidia is a positive sign of lichen health and growth.

Our team will continue to monitor Component 1 into the future. This will provide valuable information on the role of soil amendments in transplanted lichen establishment and growth, and work to identify the best methods of establishing lichen in a post-burn environment. The results of this experimental field trial will be compared with the results of Component 2. The larger number of experimental units in Component 1 provides our team with greater experimental power through which our research questions can be answered. Component 1 provided great value for informing component 2, and will continue to be used as a point of comparison of methods and as an independent academic study site.

COMPONENT 2 – HABITAT RESTORATION

In all, lichen colonies have been established in 60, 100m^2 islands within caribou UWR's within the Mesilinka fire boundary. Seven sites (n=21) were established within UWR 6b-002 (appendix 2), 5 sites within (n=15) UWR 6b-009 (appendix 3), and 8 sites within (n=24) UWR 6b-003 (appendix 4). Twenty replicates of each lichen treatment type was applied:

1. Fragments only (100 L),
2. Colonies only (100 L),
3. Mats (50L) and colonies (50L), and
4. Control (no lichen applied).

A total of 3,000 litres of terrestrial lichen has been seeded over 6,000m^2 within the Mesinlinka fire boundary. Table 4 provides information on the average ocular percent cover of each lichen species by treatment type. *Cladonia mitis* was the most common terrestrial lichen seeded in this project, representing 56% of all lichen seeded. Whereas *Cladonia uncialis* was 26%, *Cladonia stygia* 17% and *Cladonia stellaris* 0.001%.

Average ocular percent cover of islands receiving the mat treatment was 2.01%, compared with 3.78% cover in the hybrid mat and fragment treatments, and 4.78% cover in fragment only treatments. Control plots were found to have an average terrestrial lichen percent cover of 0%.

Table 4: *Cladonia* sub-genus *Cladina* and *Cladonia uncialis* percent cover by species within seeded islands.

Treatment	*Cladonia mitis*	*Cladonia stygia*	*Cladonia uncialis*	*Cladonia stellaris*	Total
Mats Only	1.27%	0.38%	0.35%	0.01%	2.01%
Control	0.00%	0.00%	0.00%	0.00%	0.00%
Mats and Fragments	2.62%	0.63%	2.27%	0.00%	3.78%
Fragments Only	3.05%	1.03%	0.65%	0.01%	4.78%

COMPONENT 3 - MONITORING

Our team identified 34 species of vascular plants, 3 mosses and 4 lichen species within our established permanent plot network. The species list and rank abundance information is provided in Appendix 5, with data on the number of plots in which each species was identified in 2016. Alpha and Whittaker's Beta diversity values are presented in Appendix 6. Alpha diversity was found to be greatest (22 species) in 009-1-S, and lowest (7 species) in 003-7-N.

The overstory within field sites was formerly dominated by *Pinus contorta* ssp. *latifolia*, however the A1 and A2 layer had been burned in entirety, with only stems remaining. The shrub layer is currently dominated by *Rosa acicularis, Salix* spp.*, Sheperdia canadensis* and *Populus tremuloides*, and *Linneae borealis* and *Arctostaphylos uva ursi*. *Corydalis sempervirens, Geranium bicknellii, Oryzopsis pungens* and *Carex* cf. *brunnescens* ssp. sphaerostachya are abundant. The forest floor and duff layer has been burned off in most areas, with a limited forest floor community consisting of *Polytrichum* spp. and *Ceratodon purpureus*.

Continued monitoring will allow our team to provide practitioners with the understanding necessary to carry out a large scale woodload caribou winter habitat restoration program, with information on the limitations and challenges associated. Component 1 and Component 2 have laid a framework through which varying methods of establishing lichen in a post-burn environment can be evaluated. Continued monitoring will help our team to address the knowledge gap between small scale academic trials and an operational scale habitat restoration program.

6.0 DISCUSSION

The project teams expect several short and long term benefits of this project. This includes the restoration of northern mountain caribou habitat, but also a stronger partnership between Tsay Keh Dene, Chu Cho Environmental and the Ministry of Forests Lands and Natural Resource Operations moving forward. This partnership ensures the project team can continue to build on this project.

6.1 SHORT TERM BENEFITS

1. The establishment of Lichen colonies in 60 100m^2 islands within caribou UWR's in the burned region. Approximately 3,000 litres of lichen were seeded in 2016.

2. Seeding lichen islands is expected facilitate the recovery of terrestrial lichen by simulating the natural process of forest recovery; where colonies 1. establish and 2. spread outwards. Within 12-24 months our team expects to see lichen fragments disperse naturally by wind, rain and animals beyond the edge of the seeded islands.

3. Lichen colonies are available as an immediate food source for northern mountain caribou. The willingness of caribou to graze recently seeded lichen colonies has been demonstrated by reindeer herders in Fenno-Scandinavia. Therefore, the transplanted lichen mats and fragments represent an immediate food source to northern mountain caribou.

4. Lichen provide habitat and food to other fauna such as squirrels. Lichen contribute to biogeochemical rock weathering, which aids soil formation, soil stabilization and nutrient cycling regimes. It is clear that lichen restoration and conservation can play a key role in maintaining the ecological integrity of natural environments in British Columbia.

5. This restoration program has established a permanent plot network within the Mesilinka Fire Boundary to track success of the program. This plot network will allow our team to track lichen establishment and growth, but also the presence of non vascular plant species. Our team is concerned that if left unchecked, the production of deciduous browse in the burned area could increase the abundance of moose, and as a result, predators in the area. This plot network will allow us to track the establishment and growth of woody browse in the project area.

6.2 LONG TERM BENEFITS

1. The restoration of critical habitat: The primary goal of this restoration program is to restore high quality northern mountain caribou winter habitat for the Chase herd. Our belief is that lichen succession in the burned area is dispersal limited, and transplanting viable lichen propagules to the burned area is expected to accelerate the natural succession process. Natural colonization by lichen is expected to take 40-70 years (Carroll and Bliss, 1982; Thomas et al., 1996; Dunford et al., 2006),

and based on the literature, seeding lichen could restore high quality caribou winter habitat in 20 years (Crittenden, 1999; Duncan, 2015). When compared to the closure and planting plans developed for the mining and forestry industries, 20 years is well within the accepted expectations for returning an area to high quality wildlife habitat.

2. Improve science and knowledge: Our team plans to continue monitoring this restoration program in year 1, 3 5, 10 and 20 following establishment. The team has invested in-kind time and finances into component 1, 2 and 3 of this program because we see the value in restoring critical caribou winter habitat in the region, and across Canada. It is our goal to avoid the pitfalls of previous lichen restoration programs where long term monitoring plans were not implemented. Our team believes that each of the techniques applied (with the exception of the control) is a viable method of establishing terrestrial lichen. However, the degree to which the results will vary between treatments over the long term is unclear. It is our goal to continue providing clear analysis of the results and lessons learned from this program for academics and practitioners alike looking restore woodland caribou habitat. This process of extension has started. The project will be featured in the FWCP newsletter, the project coordinator attended and presented the project at the 16th North American Caribou Workshop, and a project proposal for continued monitoring in 2017 has been submitted.

3. Achieve a high level of community engagement: Our project team includes the Tsay Keh Nation. Luke Gleeson has been integral to the development of this program. He has provided in kind resources in the form of vehicles and technicians to this program since 2014. The TKD LRTO team has also been invaluable in providing advice on how to increase the involvement of Tsay Keh Dene membership. The community engagement work carried out to date is detailed in Section 6.3.

6.3 EXTENSION

Our team has carried out extension work in a variety of ways. This includes:

1. Year 1 Report: PF16-W30 Northern Mountain Caribou Post-Fire Lichen Habitat Restoration Work Summary Report. This report was prepared and submitted to the Fish and Wildlife Compensation Program in spring 2016. The report detailed the field work completed in July 2015 to establish component 1 of this program.

2. Educational pamphlet: Chu Cho Environmental worked with illustrators and designers at Coffee & Pixel to design an educational pamphlet (see appendix 7). The printed pamphlet provided background information on the project, and information on how membership from Tsay Keh Dene and Kwadacha could get involved with the restoration program. The pamphlets were successful in raising awareness of the conservation status of northern mountain caribou, and opened up a dialogue with prospective volunteers. The pamphlet was also distributed to the board of directors of the Society for Ecosystem Restoration in northcentral British Columbia. This component of the extension work was funded through support from the Society for Ecosystem Restoration in northcentral British Columbia.

3. Educational signage: The project team worked to design and print an educational sign (see appendix 8) that will be erected at the project field site in spring 2017. The sign includes information on the project background, methods, contact information, and project supporters. The goal is to inform land users in the area of the scientific research in progress, and direct those interested on where they can learn more about the project. This component of the extension work was funded through support from the Society for Ecosystem Restoration in northcentral British Columbia.

4. Presentation at the 16th North American Caribou Workshop: This conference was held in May 2016 in Thunder Bay, Ontario. Sean Rapai delivered a presentation titled 'Restoring Woodland Caribou Winter Habitat' at the conference. During this presentation, details of both components 1 and 2 of this project were explored. The NACW is the foremost conference of its kind addressing caribou biology, research and management. With a focus on North American caribou, it enjoys international attendance and media coverage. This component of the extension work was provided with in-kind support from Chu Cho Environmental.

5. Career Fair in Tsay Keh Dene: Chu Cho Environmental regularly attends open houses, career fairs and other forums in Tsay Keh Dene. These forums represent an important method through which project goals and results are presented to the community. On March 7, 2016, Sean Rapai of Chu Cho Environmental attended a career fair in Tsay Keh Dene. The career fair acted as a forum through which the northern mountain caribou restoration program was introduced to Tsay Keh Dene membership. Sean Rapai was able to answer questions related to the program and engage those interested in participating in the project. More than 50 educational pamphlets were distributed at the career fair. This component of the extension work was funded through support from the Fish and Wildlife Compensation Program and the Society for Ecosystem Restoration in northcentral British Columbia.

6. Open house in Tsay Keh Dene. Chu Cho Environmental and TKD LRTO carried out community engagement sessions on November 29 and 30, 2016. This event was hosted in Tsay Keh Dene over multiple days. Discussions and presentations with Tsay Keh Dene membership at this open house frequently focused on this habitat restoration program and caribou conservation. We believe that hosting these events over multiple days increases the number of community members that are able to attend the event. We believe this leads to more one-on-one discussions regarding collaborative projects of Chu Cho Environmental and TKD LRTO. This one-on-one format allows for a process of knowledge sharing and discussion that is rarely attainable through formal power point presentations. This component of the extension work was funded through support from the Fish and Wildlife Compensation Program and the Society for Ecosystem Restoration in northcentral British Columbia.

7. Volunteers in the field: Volunteers from Tsay Keh Dene were also able to lend a hand during the lichen seeding portion of this work. Two young members of Tsay Keh Dene joined the field team, and were accompanied by TKD LRTO technicians. The involvement of volunteers from Tsay Keh

Dene speaks to the high level of community engagement that this project has been able to attain. Involving membership at a young age also means that our collaborative team can help to confirm the importance of environmental stewardship and habitat protection for the northern mountain caribou.

7.0 RECOMMENDATIONS

While much of the community engagement to date has been focused in Tsay Keh Dene, our team intends to extend our public engagement efforts in the future. One such opportunity is coming in the form of a feature article in the Fish and Wildlife Compensation Program newsletter. This article is currently in press, and is expected to raise awareness of the project, and provide information on how to contact the project proponents to learn more. As the project matures, it is our ultimate goal to engage with communities, restoration practitioners and scientists alike who are looking to incorporate these methods in future habitat restoration programs. Ongoing monitoring of this program will be critical in providing these practitioners with the information they need to carry out a successful caribou habitat restoration program of their own.

8.0 ACKNOWLEDGEMENTS

Chu Cho Environmental gratefully acknowledges the financial support of the Fish and Wildlife Compensation Program for its contribution to the Northern Mountain Caribou Post Fire Habitat Restoration program. www.fwcp.ca. The FWCP is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and public stakeholders to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams.

Chu Cho Environmental also gratefully acknowledges the financial support from the Society for Ecosystem Restoration in northcentral British Columbia (SERNbc) for ongoing extension work related to the Nothern Mountain Caribou Post Fire Habitat Restoration Program. Ongoing monitoring and extension is a critical component of all restoration programs, and we are thankful for SERNbc's recognition and support of monitoring.

The project team would also like to thank all of our volunteers, and Tsay Keh Dene for the in-kind support in the form of technicians, field accommodations and the invaluable advice for enhancing community engagement in this project. Without the in-kind support of Tsay Keh Dene Lands Resources and Treaty Operations Department this project would not have been possible.

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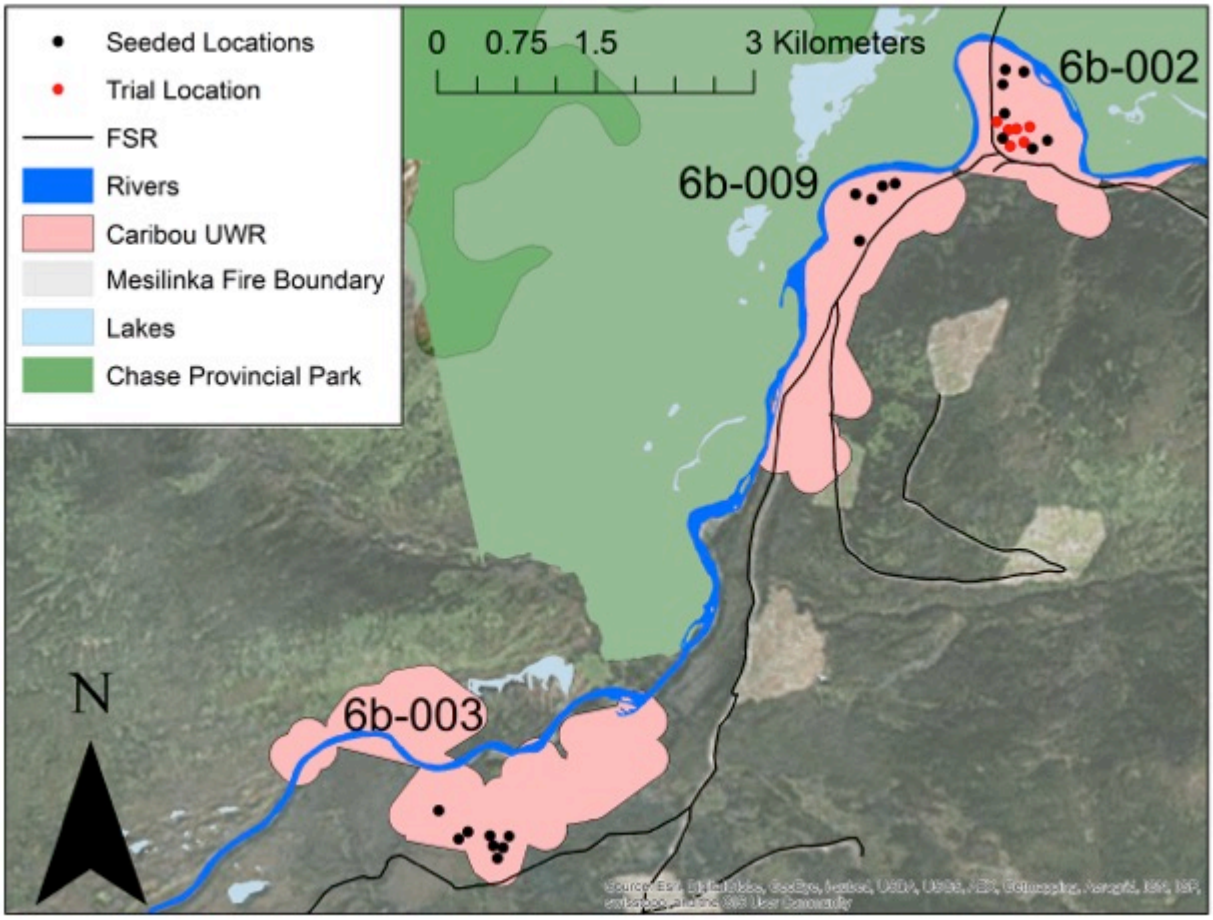
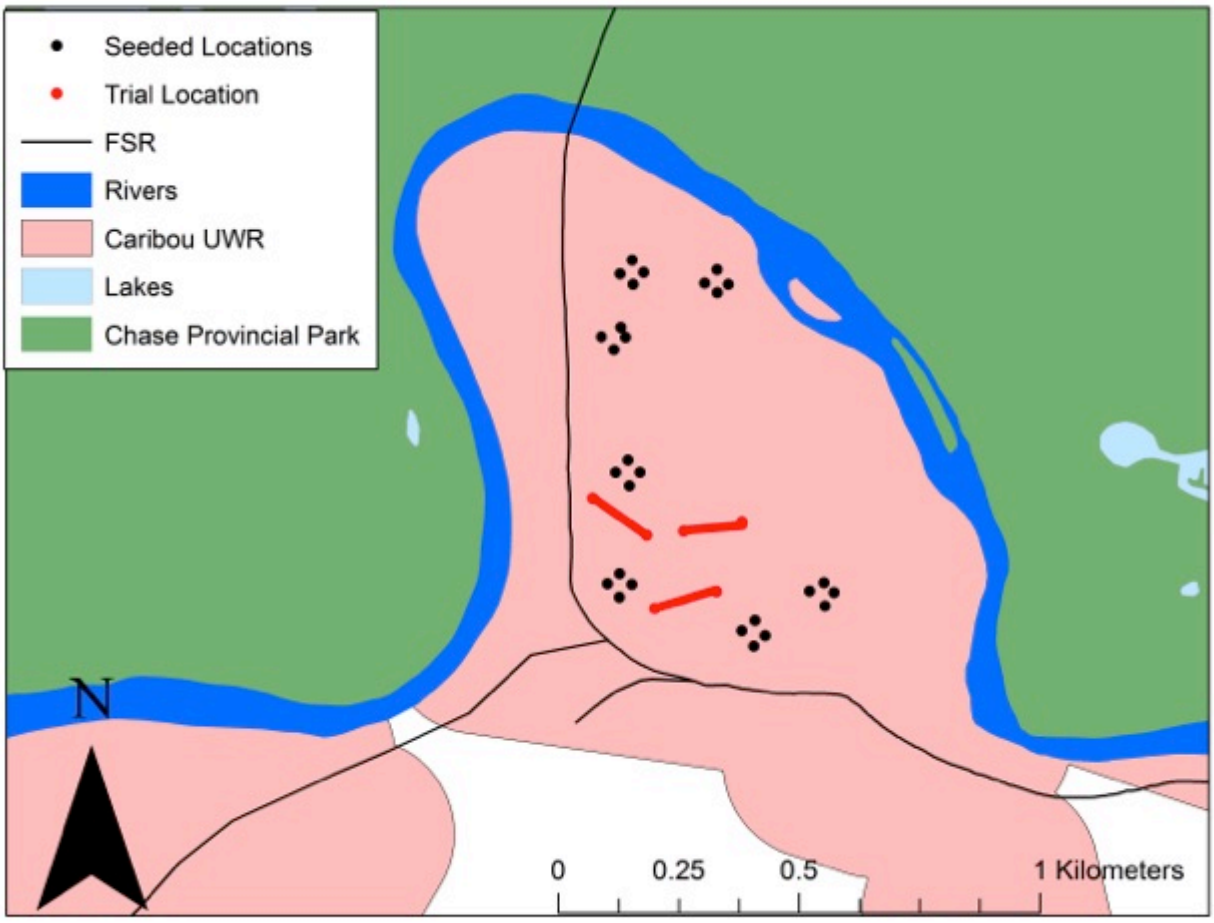
10.0 APPENDICES

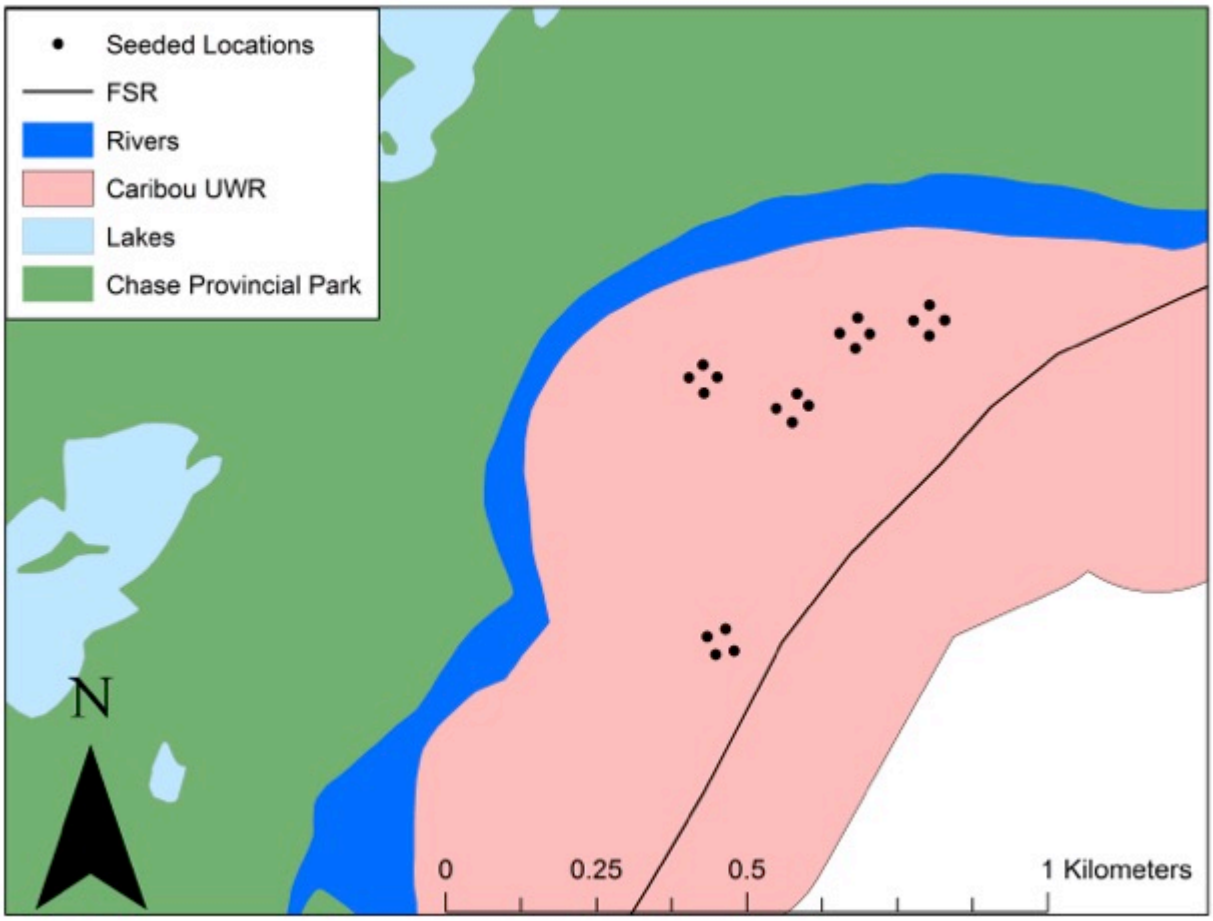
Appendix 1: Location of all sites seeded in July 2015 and 2016. Sites seeded in in 2016 are indicated in black, and the lichen trial seeded in 2015 is indicated in red.



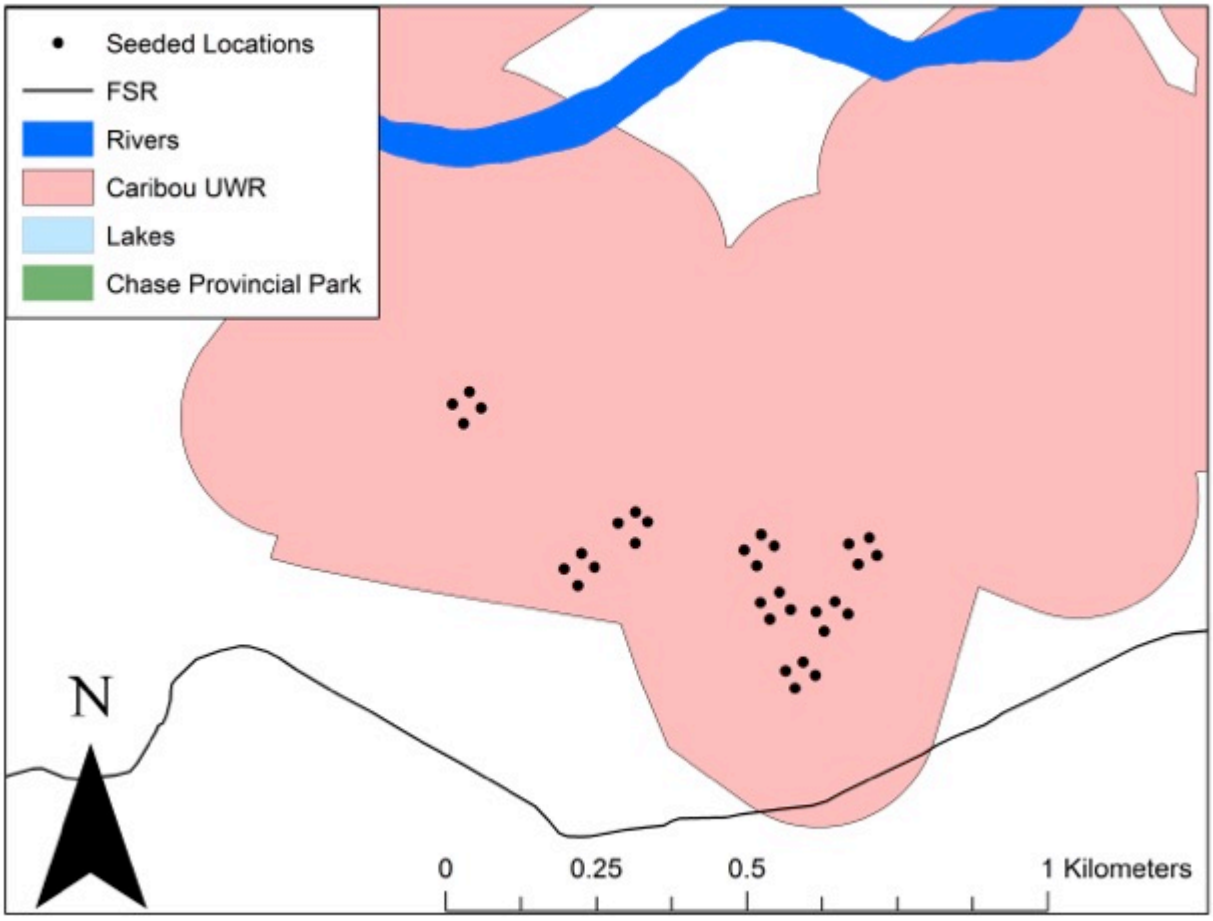
Appendix 2: Seeded locations within Caribou UWR 6b-002.



Appendix 3: Seeded locations within Caribou UWR 6b-009.



Appendix 4: Seeded locations within Caribou UWR 6b-003.



Appendix 5: List of species identified within permanent plots established within the burned area.

Species	Rank Abundance
Amelanchier alnifolia	4
Anenome multifida	5
Arctostaphylos uva ursi	37
Calamagrostis canadensis	37
Carex cf. *brunnescens* ssp. sphaerostachya	58
Carex sp 2.	24
Ceratodon purpureus	73
Chamerion angustifolium	33
Cladonia mitis	59
Cladonia stellaris	2
Cladonia stygia	58
Cladonia uncialis	58
Cornus canadensis	38
Corydalis aurea	1
Corydalis sempervirens	65
Equisetum scirpoides	2
Erigeron acris	1
Galium trifidum	1
Geranium Bicknellii	60
Hieracium gracile	4
Ledum glandulosum	1
Linneae Borealis	77
Marchanta polymorpha	4
Oryzopsis asperifolia	11
Oryzopsis pungens	56
Packera cf. *streptanthifolia*	21
Petasites palmatus	1
Pinus contorta ssp. latifolia	78
Polytrichum spp.	75
Populus tremuloides	41
Potentilla sp.	1
Rosa acicularis	73
Salix spp.	51
Sheperdia canadensis	46
Solidago sp. 2	1
Solidago spathulata	8
Vaccinium craspitosum	6
Vaccinium vitis idaca	1
Viburnum edule	1
Vicia americana	1
Viola canadensis	16

Appendix 6: Alpha and Whittaker's Beta diversity ($\beta = \gamma/\alpha$) values for plots surveyed in 2016.

Plot	Alpha Diversity	Beta Diversity
002-1-N	15	2.73
002-1-E	16	2.56
002-1-S	16	2.56
002-1-W	18	2.28
002-2-N	13	3.15
002-2-E	18	2.28
002-2-S	18	2.28
002-2-W	18	2.28
002-3-N	14	2.93
002-3-E	16	2.56
002-3-S	17	2.41
002-3-W	18	2.28
002-4-N	17	2.41
002-4-E	18	2.28
002-4-S	18	2.28
002-4-W	19	2.16
002-5-N	11	3.73
002-5-E	18	2.28
002-5-S	17	2.41
002-5-W	17	2.41
002-6-N	14	2.93
002-6-E	17	2.41
002-6-S	16	2.56
002-6-W	15	2.73
002-7-N	11	3.73
002-7-E	15	2.73
002-7-S	16	2.56
002-7-W	12	3.42
009-2-N	13	3.15
009-2-E	17	2.41
009-2-S	14	2.93
009-2-W	15	2.73
009-1-N	12	3.42
009-1-E	16	2.56
009-1-S	22	1.86
009-1-W	18	2.28
009-3-N	15	2.73
009-3-E	17	2.41

009-3-S	18	2.28
009-3-W	12	3.42
009-4-N	14	2.93
009-4-E	13	3.15
009-4-S	18	2.28
009-4-W	19	2.16
003-1-N	11	3.73
003-1-E	19	2.16
003-1-S	20	2.05
003-1-W	16	2.56
003-2-N	14	2.93
003-2-E	17	2.41
003-2-S	18	2.28
003-2-W	8	5.13
003-3-N	11	3.73
003-3-E	19	2.16
003-3-S	15	2.73
003-3-W	18	2.28
003-S-N	9	4.56
003-5-E	16	2.56
003-5-S	12	3.42
003-5-W	14	2.93
003-4-N	8	5.13
003-4-E	12	3.42
003-4-S	17	2.41
003-4-W	12	3.42
009-5-N	13	3.15
009-5-E	15	2.73
009-5-S	17	2.41
009-5-W	16	2.56
003-6-N	12	3.42
003-6-E	11	3.73
003-6-S	11	3.73
003-6-W	13	3.15
003-7-N	7	5.86
003-7-E	12	3.42
003-7-S	14	2.93
003-7-W	17	2.41
003-8-N	9	4.56
003-8-E	9	4.56
003-8-S	14	2.93
003-8-W	13	3.15

Appendix 7: Educational pamphlet distributed in spring 2016.

Appendix 8: Educational sign that will be installed at the field site in spring 2017.