



November 30, 2017

PARKER CARIBOU RANGE

BC OGRIS Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program

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REPORT



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EXECUTIVE SUMMARY

The Boreal Caribou (Parker Range) Habitat Restoration Pilot Program Plan has been developed to guide a multi-year, range scale, restoration program to restore habitats along pre-identified treatment lines with Zone 1 of 4 implementation completed between January 4 and March 17, 2017. This report evaluates seedling survival, growth, health, density of winter planted black spruce after one growing season which was determined during a field monitoring program conducted in September 2017. This report also identifies the adjacent vegetation community, any invasive species and wildlife use in the pre-determined monitoring plots as well as if access management areas were successful for deterring humans and wildlife.

The Boreal Caribou Habitat Restoration Monitoring Framework was followed in the creation of the twenty-one long-term vegetation monitoring treatment plots which have been mounded and planted or mounded, planted, and tree felled during habitat restoration implementation. Each treatment monitoring plot is associated with an adjacent paired control plot and consists of circular radii plots (30 m²) used to collect vegetation data. In addition, a low-level flyover of the access management areas was completed to determine presence/absence of motorized vehicles or other signs of humans access or wildlife use following tree felling in winter 2017.

Twenty of the 21 vegetation treatment monitoring plots were visited during the field program which occurred between September 9 and 10, 2017. Black spruce seedling survivorship was 70%, with the majority of deaths related to wildlife browsing. On the seedlings that are surviving, seedling heights were on average 23 cm with an average leader growth of 11 cm from the 1st growing season. Of the seedlings that are surviving, seventy-six percent appear healthy, with thirty-five (35%) percent browsed but not showing signs of stress. Almost a quarter of live seedlings were stressed mostly from browsing with some seedlings showing signs of necrosis and chlorosis. Live seedling density was on average 2,767 stems/ha. Little growth of other vegetation has occurred on the mounds since implementation with no invasive species identified. There were no signs of motorized vehicles along treatment lines, and heavily used game trails appear to be unused with low animal movements throughout the range except some moose activity along treatment lines. Objectives for 1st growing season as outlined in the Boreal Caribou Habitat Restoration Monitoring Framework were all met except narrowly missing the target survivorship of 70%.



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Acknowledgments

Golder Associates Ltd. would like to express our gratitude to the Fort Nelson First Nation, who provided us with the opportunity to undertake this study in Fort Nelson First Nation traditional territory. Thank you to Eva Needlay for field assistance during the monitoring program.

We are grateful for the financial support from the BC Oil and Gas Research and Innovation Society, and to the Research and Effectiveness Monitoring Board who recommended this Program for funding. The field program and reporting was completed by Caitlin Parker of Golder Associates Ltd. (Golder); with senior technical guidance provided by Paula Bentham (Golder).



1.0 INTRODUCTION

The Boreal Caribou (Parker Range) Habitat Restoration Pilot Program Plan (the Program Plan; Golder 2015a) was initiated in April 2015 by the Research and Effectiveness Monitoring Board (REMB) of the BCIP initiative, with funding for the Program Plan provided by the BC Oil and Gas Research and Innovation Society (BC OGRIS). The Program Plan is the first plan to propose application of restoration techniques over an entire boreal caribou range in Canada. The Program Plan was developed to guide a multi-year, range scale, restoration program, with field implementation commencing in January 2017 (Golder 2015a). The Program Plan is designed to guide the implementation of habitat restoration treatments along treatment areas identified during a desktop linear classification exercise and confirmed through ground-truthing, throughout the entire Parker Range.

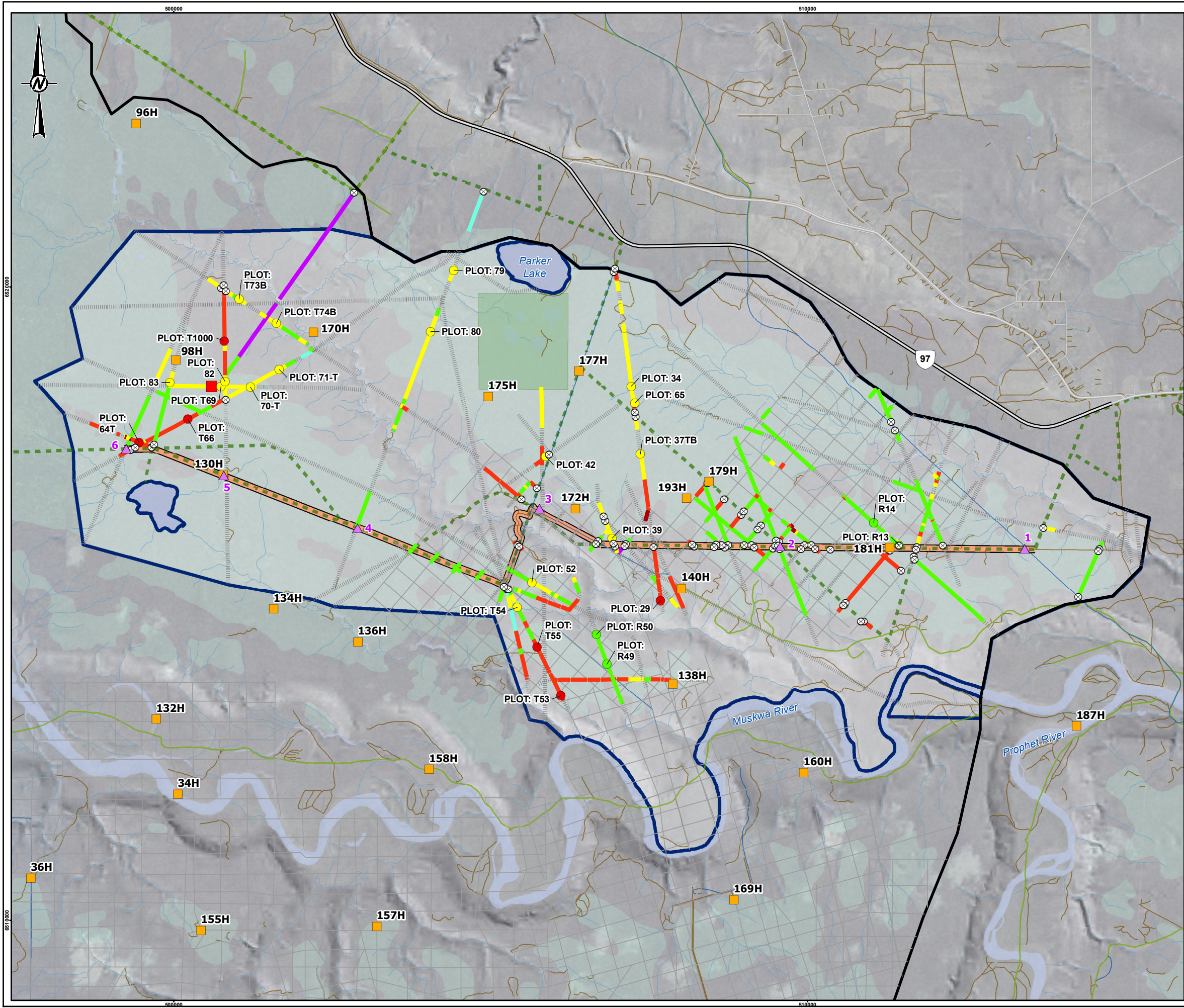
A high-level tactical plan has been included within the Program Plan to apply restoration treatments within the Parker Range. The tactical plan is based on treatment of zones within the Parker Range, numbered one to four, which have been created and prioritized based on ecological and logistical considerations associated with each zone. This Zone 1 Implementation Plan was developed to focus on treating specific areas throughout Zone 1 (Golder 2015b).

Zone 1 restoration was implemented between January 13 and March 17, 2017 with various restoration techniques, as outlined in the Boreal Caribou Habitat Restoration Operational Toolkit (Golder 2015c). Restoration treatments included tree felling, mounding, seedling planting and/or spreading woody material. A total of 56 kilometers were restored/deactivated for access with 21 monitoring plots established. Monitoring plot establishment and design followed the Boreal Caribou Habitat Restoration Monitoring Framework (Golder 2015d).

The Zone 1 Restoration Implementation Vegetation Monitoring Program (the Monitoring Program) is the first year for vegetation monitoring in the Parker Caribou Range, occurring one growing season following implementation of habitat restoration treatments. Twenty-one pre-determined monitoring plot locations established during the 2017 winter program (Figure 1), twenty monitoring plots were visited on September 9 and 10, 2017.

The objectives of the Monitoring Program followed the Boreal Caribou Habitat Restoration Monitoring Framework (Golder 2015d) and were to:

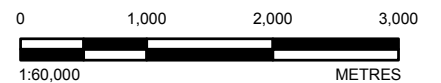
- 1) Confirm density of targeted live vegetation within treatment plots (target of 1,200 stems/ha, with minimum 840 stems/ha from winter planting, based on 70% and 90% survival, respectively) in the monitoring plots.
- 2) Assess the health of the newly planted seedlings in the monitoring plots. Identify any immediate issues such as seedling mortality due to poor seedling stock or desiccation (chlorosis), poor seed germination, or browsing.
- 3) Identify any immediate issues with invasive species in the monitoring plots.
- 4) Assess if access management areas were successful (any signs of human or wildlife use).
- 5) Document wildlife usage in the monitoring plots and along treated areas.



LEGEND

- TACTICAL PLAN TREATMENT ZONE 1
- PARKER CARIBOU RANGE
- CARIBOU HABITAT RESTORATION SIGN
- MUSTER POINT
- HELICOPTER PAD
- MATRIX HELICOPTER PAD
- MONITORING PLOT LOCATION AND SITE TREATMENT TYPE
 - MOUNDING / SEEDLING PLANTING
 - MOUNDING / TREE FELLING / SEEDLING PLANTING
 - TREE FELLING
- TREATMENT TYPE
 - TREE FELLING
 - MOUNDING / SEEDLING PLANTING
 - MOUNDING / TREE FELLING / SEEDLING PLANTING
 - TREE FELLING / MOUNDING
 - TREE FELLING / SCARIFICATION
 - TREE FELLING / COARSE WOODY DEBRIS
- OTHER
 - LEAVE FOR NATURAL
 - PARKER LAKE ECOLOGICAL RESERVE
 - WATERBODY
 - WETLANDS
 - WATERCOURSE
 - HIGHWAY
 - MAJOR ROAD
 - ACTUAL RECREATIONAL TRAIL / PRIMARY WINTER ACCESS
 - ORIGINALLY EXCLUDED LINEAR DISTURBANCES
 - LOCAL ROAD
 - RESOURCE ROAD
 - UNCLASSIFIED ROAD
 - BC OGC PETROLEUM ACCESS ROAD
 - FORESTRY SERVICE ROAD / ROAD PERMIT
 - RECREATIONAL TRAIL

DRAFT



REFERENCES
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2. 2D SEISMIC AND LIS OUTLINES AND BC OGC PETROLEUM ACCESS ROAD OBTAINED FROM BC OIL AND GAS COMMISSION.
3. ROAD/ACCESS OBTAINED FROM DIGITAL ROAD ATLAS.
4. BC OGC PETROLEUM ACCESS AND DEVELOPMENT ROAD OBTAINED FROM THE BC OIL AND GAS COMMISSION.
5. PARKER CARIBOU RANGE, RECREATIONAL TRAIL, ECOLOGICAL RESERVE AND HILLSHADE OBTAINED FROM B.C. GOV. CONTAINS INFORMATION LICENCED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT

BC OIL AND GAS RESEARCH AND INNOVATION SOCIETY

PROJECT

PARKER CARIBOU RANGE ZONE 1 MONITORING PROGRAM

TITLE

ZONE 1 2017 FALL MONITORING PLOT LOCATIONS

CONSULTANT

YYYY-MM-DD 2016-05-19



DESIGNED	CP
PREPARED	HR
REVIEWED	
APPROVED	

PROJECT NO.
P1778967

CONTROL

REV.
A

FIGURE
1



2.0 METHODS

Pre-established, treatment plots with mounding and seedling planting or mounding with seedling planting and tree felling were visited during the field Monitoring Program. Twenty of the 21 treatment plots established in winter 2017 were visited by one Golder Restoration Specialist and one Environmental Technician from Fort Nelson First Nation, both of which were involved in the winter implementation of treatments. Plots were accessed by foot, with one treatment plot aerially assessed via helicopter due to a lack of a landing site nearby. The field program occurred from September 9 to 10, 2017. Treatment areas were 25 m in length along a linear disturbance. Monitoring plots were either a singular 2.99 radii circular plot (approximately 30 m²) for linear disturbances > 8 m wide (Figure 2a) or consisted of three subplots of 1.78 m fixed radii circular plot (10 m² each) located off centre line within a 25 m length segment of the linear disturbance <8 m in width (Figure 2b) (Golder 2015d).

Treatment plots had planted seedlings tagged with a unique number and had PVC markers at plot centres from the 2017 winter program. The success indicators for re-vegetation establishment were the survival rates, total seedling density, growth rates and general health of introduced tree seedlings after the 1st growing season (maximum of 8 months growing period) (Table 2, Golder 2015d). Each plot had data collected for:

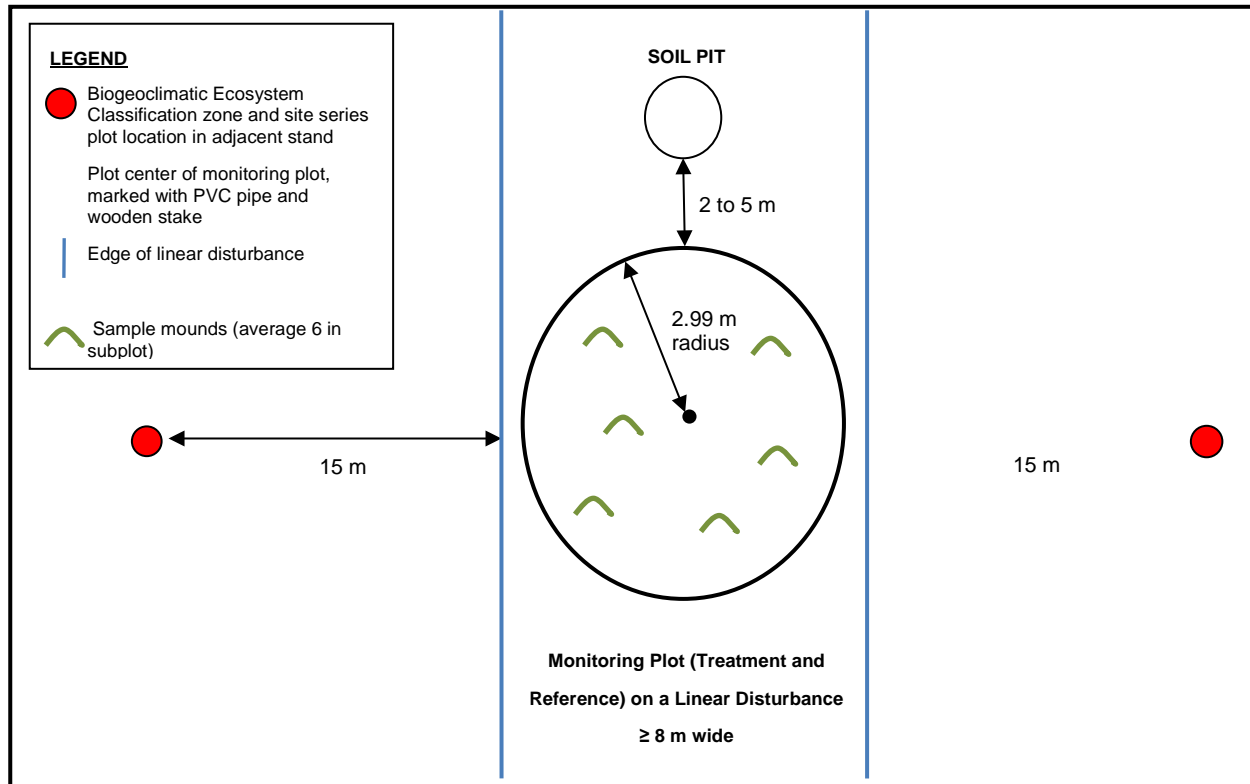
- seedling number, species, seedling health (chlorotic, cold stress, browsing), height, leader growth;
- soil moisture; and
- any animal or human use (scat, tracks, game trails).

Access management treatment areas were accessed from the air. Data were recorded on the presence/absence of motorized vehicles or other signs of human access or wildlife use.



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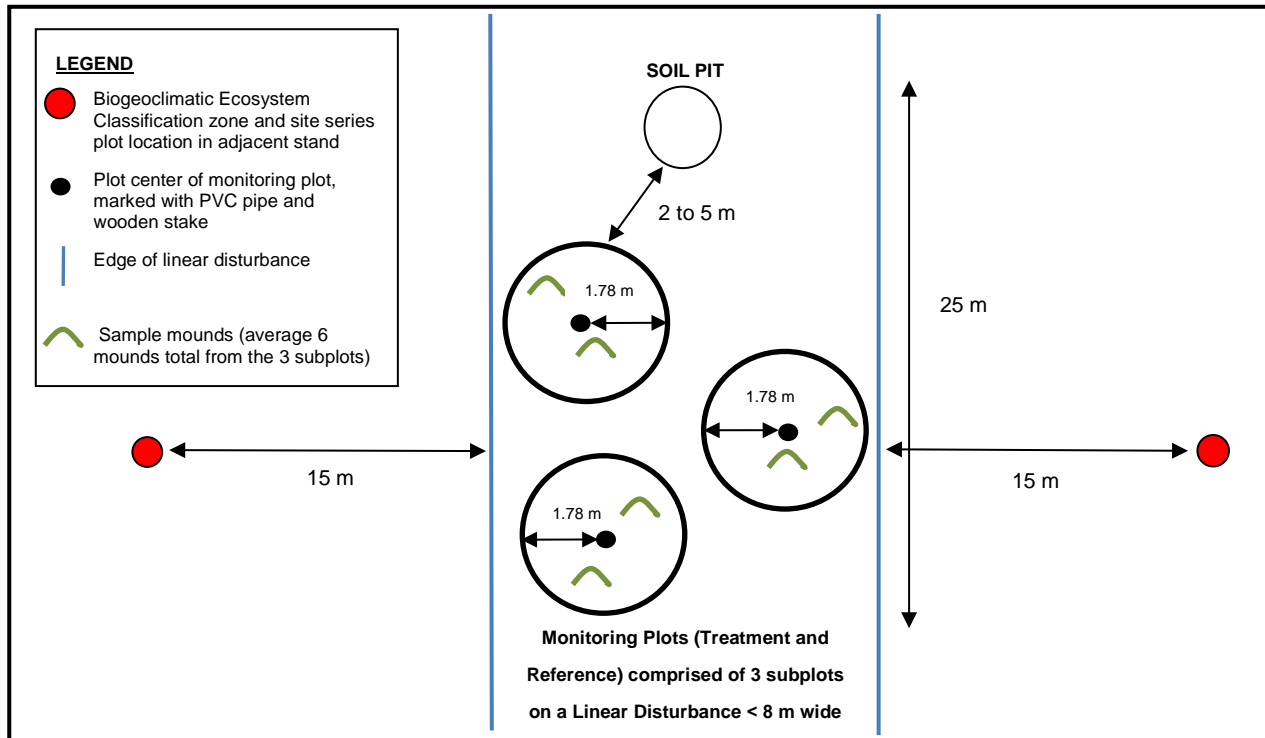
Figure 2 A: Restoration Monitoring Sample Plot Layout on Linear Disturbances less than 8 m wide.





BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Figure 2B: Restoration Monitoring Sample Plot Layout on Linear Disturbances greater than 8 m wide.



3.0 RESULTS AND DISCUSSION

Twenty of the 21 mounding with seedling planting and mounding/seedling planting tree-felling plots established were surveyed. All plots were planted with black spruce seedlings, seedling heights ranged from 15 - 29 cm but generally averaged 22 cm. Photos of a sample of the monitoring plots displaying good re-growth, poor re-growth, browsing, tree felling and slash rollback are provided in Appendix A.

3.1 Vegetation Monitoring

A number of habitat restoration programs have been implemented, however, few have completed monitoring on the work (Pyper et al. 2014). Effectiveness monitoring is essential to ensure seedlings survive beyond the life of the nutrient plug (3 to 5 years). Table 1 provides a summary of the monitoring plots including the number of planted seedlings, total surviving planted seedlings, total seedling density, planted seedling survival rate, average height and leader growth of the seedlings, average mound height, depth to water and any evidence of wildlife or human use after one growing season.



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 1: Summary of Monitoring Plot Data for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program

Monitoring Plot ID	Easting	Northing	Date of Survey	Site Type	Site Series ^(d)	Completed Growing Season	Number of Planted Seedlings	Total Surviving Planted Seedling	Total Planted Seedling Density	Planted Seedling Survival	Average Height (cm)	Average Leader Growth	Average Mound Height	Depth to Water ^(a)	Evidence Wildlife/Human Use	Comments
									stems/ha	Rate %	cm	cm	cm	cm		
29	507680	6515049	10-Sep-17	Transitional	101\$6b.1	1	7	4	1,333	57	34.5	16	18	>100	Seismic line heavily browsed. Deer tracks.	Transitional site, soils appear to be culprit of poor re-growth
																Initial planted seedling density: 2,333 stems/ha
																Soil: organics 0-50cm and clay at 50-100cm).
																A lot of natural regeneration between mounds
37TB	507360	6517363	10-Sep-17	Lowland	Wb03	1	24	22	7,333	92	31	9	32	47	Moose, caribou and bear tracks	Initial planted seedling density: 8,000 stems/ha
																Soil: organics 0-100cm
39	506917	6516003	10-Sep-17	Lowland	Wb03	1	20	20	6,333	100	33	18	30	10	No recent activity, however seedlings browsed	Really great growth
																Initial planted seedling density: 6,333 stems/ha
																Soil: organics 0-100cm
42	505867	6517324	10-Sep-17	Lowland	Wb03	1	22	17	5,667	77	28	10	30	13	No recent activity, however seedlings browsed	Initial planted seedling density: 7,333 stems/ha
																Soil: organics 0-90cm and clay 90-100cm
52	505648	6515337	10-Sep-17	Lowland	Wb09	1	9	6	2,000	67	10	n/a ^(b)	17	45	Seismic line heavily browsed. Deer tracks.	Soil appears to be one reason of poor re-growth. Difficult to insert moisture probe on west side. Lodgepole pine in adjacent site series. Adjacent and intersecting seismic lines. Mound height is low.
																Initial planted seedling density: 3,000 stems/ha
																Soil: organics 0-70 cm, silt 70-80 cm and 80-100 cm silt and clay
T53	506105	6513547	10-Sep-17	Lowland	Wb09	1	6	2	667	33	3.5	n/a ^(b)	19	5	No recent activity, however seedlings browsed	Initial planted seedling density: 2,000 stems/ha
																Soil: organics 0-100 cm
																34 naturally regenerating black spruce



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Table 1: Summary of Monitoring Plot Data for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program

Monitoring Plot ID	Easting	Northing	Date of Survey	Site Type	Site Series ^(d)	Completed Growing Season	Number of Planted Seedlings	Total Surviving Planted Seedling	Total Planted Seedling Density	Planted Seedling Survival	Average Height (cm)	Average Leader Growth	Average Mound Height	Depth to Water ^(a)	Evidence Wildlife/Human Use	Comments
									stems/ha	Rate %	cm	cm	cm	cm		
T54	505416	6514943	10-Sep-17	Lowland	Wb03	1	7	1	333	14	3.5	n/a ^(b)	14	74	Caribou and moose tracks	Initial planted seedling density: 2,333 stems/ha
																Initial planted seedling density: 8 naturally regenerating black spruce
T55	505729	6514313	10-Sep-17	Lowland	Wb03	1	6	4	1,333	67	25	7.5	24	56	Caribou tracks	Initial planted seedling density: 2,000 stems/ha
																Soil: organics 0-100 cm
																55 naturally regenerating black spruce
64T	499447	6517548	9-Sep-17	Lowland	Wb06	1	8	8	2,667	100	28	13	24	8	Moose tracks	Mounds have lowered and high water table likely reasons for stressed seedlings
																Initial planted seedling density: 2,667 stems/ha
																Soil: organics 0-100 cm
65	507255	6518164	10-Sep-17	Lowland	Wb03	1	24	9	3,000	38	23	14	31	10	No recent activity, however seedlings browsed	10 naturally regenerating black spruce
																Initial planted seedling density: 8,000 stems/ha
																Soil: organics 0-100 cm
T66	500219	6517916	9-Sep-17	Lowland	Wb03	1	8	4	1,333	50	13.5	n/a ^(b)	40	27	Caribou tracks, seedlings browsed	76 naturally regenerating black spruce
																Although organics are to 100 cm, the mounds have are silty clay with organics, mounds have cracked, very hard to get accurate moisture reading.
																Initial planted seedling density: 2,667 stems/ha
T69	500741	6518428	9-Sep-17	Lowland	Wb03	1	5	4	1,333	80	30	5	35	35	No recent activity, however one seedling browsed	Soil: organics 0-100 cm
																Initial planted seedling density: 1,667 stems/ha
																2 naturally regenerating black spruce (likely prior to treatment)



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 1: Summary of Monitoring Plot Data for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program

Monitoring Plot ID	Easting	Northing	Date of Survey	Site Type	Site Series ^(d)	Completed Growing Season	Number of Planted Seedlings	Total Surviving Planted Seedling	Total Planted Seedling Density	Planted Seedling Survival	Average Height (cm)	Average Leader Growth	Average Mound Height	Depth to Water ^(a)	Evidence Wildlife/Human Use	Comments
									stems/ha	Rate %	cm	cm	cm	cm		
70-T	501205	6518422	9-Sep-17	Lowland	Wb03	1	7	6	2,000	86	35	9	23	50	Lightly used game trail to north (mounds not close enough to forest line).	Most seedlings were slightly stressed, plot structure changed during field program
																Initial planted seedling density: 2,333 stems/ha
																Soil: organics 0-100 cm (top 30 cm sphagnum)
71-T	501660	6518702	9-Sep-17	Lowland	Wb06	1	7	7	2,333	100	40	14	30	38	Two moose tracks	Looks really good, moisture sucked up and keeping mounds moist but no saturated. Islands need to be knocked down between mounds. Aspen stand 50 m north.
																Initial planted seedling density: 2,333 stems/ha
																Soil: organics 0-100 cm 3 naturally regenerating black spruce
T73B	501029	6519812	9-Sep-17	Lowland	Wb03	1	11	4	1,333	36	16	4.5	45	10	Moose and caribou tracks, seedlings heavily browsed	Plot missing many tagged seedlings, likely due to freeze/thaw
																Initial planted seedling density: 3,667 stems/ha
																Soil: organics 0-100cm
T74B	501614	6519427	9-Sep-17	Lowland	Wb03	1	7	6	2,000	86	21	10	40	5	Moose, elk and caribou tracks, lynx scat	Clay begins at 5 cm, however, seedlings are almost all alive and non-stressed
																Initial planted seedling density: 2,333 stems/ha
																Soil: organics 0-5 cm, clay 5-100cm
79	504416	6520270	10-Sep-17	Lowland	Wb09	1	14	8	2,667 ^(c)	57	n/a ^(c)	n/a ^(c)	n/a ^(c)	n/a ^(c)	No recent activity	Aerial survey, this is an estimate of survived planted seedling
																Initial planted seedling density: 4,666 stems/ha
T80	504049	6519298	10-Sep-17	Lowland	Wb03	1	12	11	3,667	92	22	10	21	20	No recent activity, however seedlings browsed	Initial planted seedling density: 3,667 stems/ha
																Soil: organics 0-100cm
																15 naturally regenerating black spruce



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 1: Summary of Monitoring Plot Data for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program

Monitoring Plot ID	Easting	Northing	Date of Survey	Site Type	Site Series ^(d)	Completed Growing Season	Number of Planted Seedlings	Total Surviving Planted Seedling	Total Planted Seedling Density	Planted Seedling Survival	Average Height (cm)	Average Leader Growth	Average Mound Height	Depth to Water ^(a)	Evidence Wildlife/Human Use	Comments
									stems/ha	Rate %	cm	cm	cm	cm		
T82	500805	6518507	9-Sep-17	Lowland	Wb03	1	4	4	1,333	100	29	11.5	40	47	No recent activity	Initial planted seedling density: 1,333 stems/ha
																Soil: organics 0-100cm
																7 naturally regenerating black spruce
T1000	500875	6519148	09-Sep-17	Lowland	Wb03	1	5	2	667	40	17	n/a ^(b)	43	38	Caribou tracks	All mound holes are filled with water
																Initial planted seedling density: 1,667 stems/ha
																1 naturally regenerating black spruce
Total Seedlings/Survival & Average Growth							213	149	2,467	70	23	11	29	–	–	–

101\$6b.1: green alder - highbrush - cranberry or Populus tremuloides - Alnus viridis spp. crispa - Viburnum edule (DeLong et al. 2011)
Wb03: Black spruce - Ligonberry - Peat-moss (DeLong et al. 2011)
Wb06: Tamarack - Water sedge - Fen Moss (DeLong et al. 2011)
Wb09: Black spruce - Common horsetail - Peat-moss (DeLong et al. 2011)
n/a - not applicable
(a) Measured from original surface level to groundwater
(b) Seedlings were browsed or dead therefore no leader growth on planted seedlings
(c) Plot was surveyed from air therefore seedling density is an estimation and ground measurements could not be taken
(d) Site series for Biogeoclimatic Ecosystem Classification (BEC) for Boreal White and Black Spruce BWBSmk - Moist Cool Subzone (DeLong et al 2011)



3.1.1 Density and Survival

The target for seedling survival in the monitoring plots was 70% with a target density of 1,200 stems/ha (Golder 2015d). Average survival rate was 70% and average live seedling density was 2,467 stems/ha. Nine of 20 plots had over 70% survival rate and 17 of the 20 were >1,200 stems/ha.

Where seedling mortality occurred, it was determined that a majority of the mortality was due to browsing. The ten (10) dead seedlings that remained in the ground throughout the monitoring plots had 1 – 2 cm stubs above-ground with clear evidence of browsing. Other potential reasons for survival rate numbers are summarized below.

- Plots 29, 52, T66 had clay mixed with organic soils during treatment. Where clay was mixed into the mounds the seedlings appeared stressed or dead. If the site was a transitional site, the seedlings survived on the mound hinge.
- Plot 64T, the mounds subsided substantially coupled with a high water table may have caused the seedlings to suffocate.
- Plots T73 and T1000 had heavy browsing and a large number of seedlings and seedling tags missing, it is likely that freeze/thaw within the mounds was the reason for the disappearance of seedlings and tags.
- Plot 79 was aerially surveyed which made it difficult to assess seedlings from air, and there is likely a larger number of seedlings that survived. Plot 80 is located south of Plot 79 and had a 92% survival rating which is more probable than the 57% that could be visually assessed.
- Although seedlings were kept in a snow cache and under a blanket during winter planting, seedlings may have been affected by cold temperatures between cache and planting, as many treatment days were around the -30°C during field implementation.

The higher planting densities appeared to be more uniform with the surrounding environment versus the lower 1,200 stems/ha planting rate initially implemented at the start of the program especially on seismic lines >6.0 m. The higher density of planting will allow for some mortality while still providing enough cover in future years.

3.1.2 Health and Vigor

Tables 2 and 3 provide the individual seedling health, height, leader growth, soil moisture and mound height for September 9 and 10, respectively. The Tables are separate as there was a major rain event in the evening of September 9th therefore soil moisture percent is not comparable across all monitoring plots.

Black spruce seedling survivorship at survey plots varied from 14% - 100% (average over all plots 69%; total 70% for number of seedlings survived over total seedlings planted in the plots). Seedling heights varied from 3 to 44 cm (average of 25 cm) and leader growth varied from 0 to 23 cm (average 11cm). Fifty-five percent of the seedlings are alive and doing well, twenty-nine (29%) percent were browsed but do not show signs of stress. Where browsing did not occur, planted seedlings reached up to 44 cm height, with a leader growth up to 23 cm.

A summary is provided from two winter planting treatment and monitoring programs in northeastern Alberta for comparison.

- 100% black spruce seedling survival (n=2 plots 8 seedlings in Treed Fen) from winter planting with an average height of 19 cm and an average leader growth of 8 cm leader growth in one growing season, however planted trees were not tagged during planting and therefore survival rates may be skewed (CNRL 2015a).



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

- 99% black spruce seedling survival (n=4 plots with 42 seedlings in Wooded Bog) from winter planting with an average height of 19 cm and average leader growth of 7 cm with 29% of the seedlings browsed after two years of planting, however planted trees were not tagged during planting and therefore survival rates may be skewed (CNRL 2015b).

During the Monitoring Program, fifteen (15%) percent of live seedlings were stressed:

- Sixteen (16) of 32 seedlings were browsed; and/or
- Fifteen (15) of 32 seedlings showed varying signs of necrosis; and/or
- Five (5) of 32 seedlings showed varying signs of chlorosis.

A few of the seedlings occurred on mounds that cracked during settling which had exposed the root collars. Deaths due to mound settling was expected.

Table 2: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 9, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
64T	608	Stressed	31	14	11	30	Chlorotic tip
	609	Stressed	42	16	14	30	Bottom 1/4 slightly necrotic
	610	Alive	30	10	13	30	–
	611	Stressed	22	8	11	10	Chlorotic
	612	Alive	24	9.5	14	25	–
	613	Stressed	26.5	12	6	25	Bottom 1/2 necrotic
	614	Alive	37	3	14	20	–
	no tag ^(b)	Stressed	14.5	n/a ^(a)	10	20	–
	Average		28	13	12	24	–
T66	487	Dead	n/a	n/a	22	40	–
	492	Dead	n/a	n/a	37	40	Browsed
	481	Stressed	7	n/a ^(a)	23	40	–
	490	Alive	12	n/a ^(a)	18	40	Soil cracked around seedling
	491	Stressed	22	n/a ^(a)	16	40	Soil cracked around seedling
	484	Alive	13	n/a ^(a)	9	40	Soil cracked around seedling
	485	Dead	n/a	n/a	0	40	No seedling
	489	Dead	n/a	n/a	15	40	Root collar still moist
	Average		13.5	n/a	17.5	40	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 2: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 9, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
T69	686	Alive	28	2.5	10	35	–
	690	Dead	n/a	n/a ^(a)	9	35	–
	689	Alive	37	3.5	10	35	–
	687	Alive	25.5	4.5	4	35	–
	688	Alive	27.5	10.8	8	35	–
	Average		30	5	8	35	–
70-T	493	Alive	30.5	n/a ^(a)	6	20	–
	603	Alive	27	3	8	25	Root collar exposed, soil cracked around seedling
	604	Stressed	35	14.5	7	15	Bottom 1/2 necrotic
	601	Dead	n/a	n/a	9	15	–
	602	Stressed	37	10	8	26	Bottom 1/2 necrotic
	605	Stressed	36.5	8	8	30	Bottom 1/4 necrotic
	606	Stressed	44	10	7	30	Bottom 1/4 necrotic
	Average		35	9	8	23	–
71-T	721	Alive	29	3	8	30	–
	722	Alive	46	15	12	30	–
	no tag	Alive	46	22.5	11	30	–
	720	Alive	38.5	10	11	30	–
	719	Stressed	34	9.5	7	30	Some chlorotic needles; soil cracked around seedling, 5 cm of root collar exposed
	717	Alive	47.5	25	14	30	–
	719	Alive	41	11	12	30	–
	Average		40	14	11	30	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 2: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 9, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
T73B	706	Stressed	3	n/a ^(a)	10	45	–
	705	Dead	n/a	n/a ^(a)	4	45	–
	no tag	Stressed	26	n/a ^(a)	10	45	West plot, south PVC (likely 703 or 704)
	no tag	Alive	22	4.5	13	45	West plot, far east side (likely 703 or 704)
	no tag	Alive	13	n/a ^(a)	19	45	Middle plot, on 1.79 west edge
	no tag	Dead	n/a	n/a	19	45	Middle plot, by PVC
	no tag	Dead	n/a	n/a ^(a)	12	45	Middle plot, on 1.79 east edge
	no tag	Dead	n/a	n/a	15	45	East plot, on 1.79 west edge
	no tag	Dead	n/a	n/a	19	45	East plot, by PVC. No seedling visible.
	no tag	Dead	n/a	n/a	1	45	East plot, on east side PVC
	713	Dead	n/a	n/a	16	45	East plot, on 1.79 east edge
	Average		16	4.5	13	45	–
T74B	794	Alive	12.5	4	n/a	40	–
	no tag	Alive	19	12	n/a	40	–
	no tag	Alive	18	10.5	n/a	40	–
	793	Alive	26	13	n/a	40	–
	no tag	Alive	16	13	n/a	40	–
	795	Alive	34	10	n/a	40	–
	no tag	Dead	n/a	n/a	n/a	n/a	no tag, no tree
	Average		21	10	n/a	40	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 2: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 9, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
T82	692	Alive	37	12.5	13	40	–
	607	Alive	33	9	10	40	–
	616	Alive	24.5	11.5	11	40	Appears 2 seedlings planted, typically done when one root collars break
	615	Alive	22.5	13	10	40	–
	Average		29	11.5	11	40	–
T1000	724	Stressed	6.5	n/a ^(a)	n/a	43	–
	725	Stressed	18	n/a ^(a)	n/a	43	–
	726	Dead	25.5	n/a ^(a)	n/a	43	–
	723	Dead	n/a	n/a	n/a	n/a	No sign of seedling or tag
	727	Dead	n/a	n/a	n/a	n/a	No sign of seedling or tag
	Average		17	n/a	n/a	43	–

cm = centimeter; n/a = not applicable; Sb = black spruce

(a) Seedlings were browsed



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 3: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 10, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
29	430	Alive	29.5	n/a ^(a)	18	18	Planted on hinge
	425	Dead	n/a	n/a	n/a	n/a	No tag, no tree
	461	Alive	44	15.5	15	18	Planted on hinge
	470	Alive	39	16	11	18	Planted on hinge
	424	Alive	25.5	n/a ^(a)	8	18	Planted on natural ground
	459	Dead	n/a	n/a	n/a	n/a	No tag, no tree
	472	Dead	n/a	n/a ^(a)	21	18	–
	Average		34.5	16	14.6	18	
37TB	125	Alive	24	10	n/a	29	–
	126	Alive	36	16	n/a	29	–
	127	Alive	30	14	n/a	29	–
	128	Alive	28	10	n/a	29	–
	129	Alive	23	7	n/a	29	–
	130	Alive	35	12	n/a	29	–
	131	Alive	33	11.5	n/a	29	–
	no tag	Alive	19	2	n/a	29	Moose stepped on seedling
	no tag	Alive	26	6	n/a	29	–
	133	Alive	40	11.5	n/a	29	–
	134	Alive	32	8.5	n/a	29	–
	136	Alive	35	13	n/a	29	–
	135	Alive	36	11.5	n/a	29	–
	137	Alive	35	8.5	n/a	29	–
	138	Alive	43	17	n/a	29	–
	no tag	Dead	n/a	n/a	n/a	38	–
	139	Alive	34.5	8	n/a	38	–
	140	Alive	26	2	n/a	38	–
	141	Stressed	24.5	2	n/a	38	Bottom 1/4 and tip necrotic
	142	Alive	33	10	n/a	38	–
	143	Alive	25.5	4	n/a	38	–
	144	Stressed	27	n/a ^(a)	n/a	38	Bottom 1/4 necrotic
	146	Alive	34.2	n/a ^(a)	n/a	38	–
	145	Dead	n/a	n/a	n/a	38	–
	Average		31	9	n/a	32	



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 3: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 10, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
39	460	Alive	33.5	11.5	9	20	–
	475	Alive	38	14.5	12	30	–
	452	Alive	41	19.5	12	40	–
	478	Alive	40.5	16.5	10	15	–
	454	Alive	41.5	19	13	15	–
	480	Alive	40.5	23	10	10	–
	422	Stressed	24	n/a ^(a)	11	10	–
	426	Alive	29	n/a ^(a)	12	20	Yellow vs green, starting to be chlorotic
	457	Alive	29	n/a ^(a)	12	35	–
	422	Stressed	4	n/a ^(a)	9	35	Main stem necrotic from browsing
	482	Alive	38	20	12	35	–
	418	Alive	25	n/a ^(a)	12	30	–
	413	Alive	35.5	18	11	35	–
	419	Alive	34.5	16	10	40	–
	429	Alive	37	15.5	16	45	–
	no tag	Alive	41	16	12	30	–
	no tag	Alive	43.5	19	11	30	–
	458	Alive	44	22.5	11	40	–
	431	Alive	21.5	n/a ^(a)	10	45	–
	463	Alive	28.5	n/a ^(a)	14.6	45	–
	Average		33	18	11	30	–
42	163	Alive	22	n/a ^(a)	17	30	–
	162	Alive	21	n/a ^(a)	17	30	–
	161	Alive	26.5	n/a ^(a)	16	30	–
	157	Alive	32	n/a ^(a)	14	30	–
	158	Alive	27	n/a ^(a)	15	30	Soil cracked around seedling
	159	Dead	21	n/a	15	30	–
	160	Dead	n/a	n/a	n/a	n/a	No tag, no tree
	154	Dead	n/a	n/a	n/a	n/a	No tag, no tree
	155	Alive	25.4	n/a ^(a)	16	30	–
	156	Alive	26.4	7	15	30	–
	187	Alive	16	n/a ^(a)	12	30	–
	185	Alive	27	5.5	12	30	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 3: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 10, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
	189	Dead	n/a	n/a	15	30	Hole is empty, seedling on ground about 2 m away, likely pulled out
	186	Alive	30.5	15.5	13	30	–
	188	Alive	24	n/a ^(a)	10	30	–
	153	Dead	35	n/a	n/a	30	–
	152	Alive	40	19	17	30	–
	151	Alive	29.1	6	15	30	–
	150	Alive	32	n/a ^(a)	25	30	–
	149	Alive	33.5	8	16	30	–
	148	Alive	34	9	16	30	Was on ground surface, placed back in hole
	147	Alive	33	n/a ^(a)	18	30	Near death
	Average		28	10	15	30	–
52	415	Stressed	6	n/a ^(a)	23	25	Chlorotic, stiff clay
	412	Alive	18.5	n/a ^(a)	12	25	–
	302	Alive	9	n/a ^(a)	24	25	–
	407	Dead	n/a	n/a	25	20	In stiff clay
	618	Alive	19.5	n/a ^(a)	17	20	–
	449	Stressed	2	n/a ^(a)	17	20	–
	448	Stressed	2.5	n/a ^(a)	13	5	–
	406	Dead	n/a	n/a	14	5	–
	303	Dead	n/a	n/a	12	5	–
	Average		10	n/a	17	17	–
T53	447	Alive	6	n/a ^(a)	n/a	20	–
	417	Dead	n/a	n/a	n/a	20	–
	446	Dead	n/a	n/a	n/a	15	–
	466	Stressed	1	n/a ^(a)	n/a	15	–
	443	Dead	n/a	n/a ^(a)	n/a	22	–
	450	Dead	n/a	n/a	n/a	22	–
	Average		3.5	n/a	n/a	19	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 3: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 10, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
T54	101	Dead	n/a	n/a	n/a	10	–
	194	Dead	n/a	n/a	n/a	10	–
	427	Dead	n/a	n/a	n/a	10	–
	195	Stressed	3.5	n/a ^(a)	n/a	10	–
	197	Dead	n/a	n/a	n/a	10	–
	198	Dead	n/a	n/a	n/a	23	–
	196	Dead	n/a	n/a	n/a	23	–
	Average		3.5	n/a	n/a	14	–
T55	405	Alive	29	6.5	n/a	27	–
	445	Alive	36.5	14.5	n/a	30	–
	444	Stressed	10	n/a ^(a)	n/a	30	3/4 necrotic
	451	Stressed	24	1.5	n/a	19	Middle is necrotic
	440	Dead	n/a	n/a	n/a	19	–
	416	Dead	n/a	n/a	n/a	19	Soil cracked around seedling
	Average		25	7.5	n/a	24	–
65	116	Dead	n/a	n/a	8	34	–
	117	Alive	3	n/a ^(a)	8	34	Stem browsed
	118	Alive	0.5	n/a ^(a)	4	34	Stem browsed
	119	Dead	n/a	n/a	9	34	–
	120	Dead	n/a	n/a ^(a)	8	34	Stem browsed
	121	Dead	n/a	n/a ^(a)	8	34	Stem browsed
	122	Dead	n/a	n/a ^(a)	9	34	Stem browsed
	123	Dead	n/a	n/a ^(a)	9	34	Stem browsed
	124	Dead	n/a	n/a	n/a	34	–
	110	Alive	25	33	8	46	–
	190	Dead	n/a	n/a	9	46	–
	111	Stressed	41.5	17	8	46	Bottom 1/4 necrotic
	112	Dead	n/a	n/a	8	46	–
	113	Dead	n/a	n/a	4	46	In crack, root collar visible
	114	Dead	n/a	n/a	6	46	–
	115	Alive	28	8	6	46	Bottom 1/4 missing needles
	no tag	Stressed	19	9	n/a	0	–
	104	Alive	37	13	9	18	–



BC OGRIS ZONE 1 HABITAT RESTORATION IMPLEMENTATION VEGETATION MONITORING PROGRAM

Table 3: Summary of Individual Seedling Health and Vigor for the Zone 1 Habitat Restoration Implementation Vegetation Monitoring Program (September 10, 2017).

Monitoring Plot	Tag Name	Health	Sb Height (cm)	Sb Leader growth (cm)	Soil Moisture (%)	Mound Height (cm)	Comments
	103	Stressed	25	8.5	10	18	Chlorotic, sparse needles on the bottom 1/4
	105	Stressed	27.5	7	11	18	Bottom 1/4 necrotic
	106	Dead	n/a	n/a	12	18	–
	107	Dead	n/a	n/a	11	18	–
	108	Dead	n/a	n/a	9	18	–
	109	Dead	n/a	n/a	10	18	–
	Average		23	14	8	31	–
79	n/a	n/a	n/a	n/a	n/a	n/a	–
	Average		n/a	n/a	n/a	n/a	Aerial plot, can visually see 9 surviving seedlings of 14 planted. Aerial plot was hard to determine survival.
T80	676	Alive	10	n/a ^(a)	13	23	–
	679	Alive	29	3	13	23	–
	683	Alive	22.5	n/a ^(a)	14	23	–
	621	Alive	17	n/a ^(a)	12	23	–
	678	Alive	2.5	n/a ^(a)	12	20	–
	685	Stressed	28	16	10	20	Bottom 1/2 necrotic
	680	Alive	31	10.5	11	20	–
	682	Alive	27.5	10	10	20	–
	675	Alive	30	21 ^(a)	13	20	Browsed but leader continued to grow
	677	Alive	23	9	13	20	–
	784	Alive	21.4	n/a ^(a)	9	20	–
	681	Alive	19.5	n/a ^(a)	9	20	–
	Average		22	10	12	21	–

cm = centimeter; n/a = not applicable; Sb = black spruce

(a) Seedlings were browsed



3.1.3 Vegetation Community

The vegetation community (i.e., trees, shrubs, forbs, graminoids, lichens and mosses) has had little time for re-establishment since the Year 1 Implementation Program. The monitoring plots generally has a surface substrate of organic matter with no other vegetation occurring except the planted seedlings (Appendix A) and a few naturally regenerating seedlings in some plots (Table 1).

3.1.4 Invasive Species

No invasive species were noted during the survey. However, it was noted that the first mounds in contact with grassy control plots were invaded by grasses already.

3.2 Access Management

There were no signs of human access along linear disturbances treated for access management using tree felling or mounding, seedlings planting and tree felling. This was expected as Zone 1 is generally very wet in during non-frozen conditions. Despite the lack of human access, it was noted visually that some of the tree felling access controls could have been applied thicker for longer distances to improve the visual deterrent or human access impairment. Since access management was aerially assessed, it is difficult to assess wildlife use of the lines, however section 3.4 details wildlife use on the treated lines.

3.3 Wildlife Use of Treated Lines

The crews observed treated lines in the west end of Zone 1 between monitoring plots during foot access. Areas that were not treated to match adjacent site series were very active in animal tracks but diminished to only moose tracks along treatment lines. Caribou appear to not walk on treatment lines but come out of the forest to browse on the seedlings. Treatment lines with deep game trails were lightly used by deer, moose and caribou. Tree-felling appeared mostly successful, with moose hard to deter.

4.0 NEXT STEPS

The monitoring of habitat restoration treatments is recommended to occur over a 1, 5, 10 and 15 year post treatment time periods (Golder 2015d). The next monitoring period for the Parker Range Zone 1 treatments would be the 5th growing season, and would meet the same objectives and collect the same data as the 1st growing season. This will include density of live seedlings of planted and naturally regenerating seedlings, vigour of live seedlings and species/cover of invasive species (Golder 2015d). The fifth growing season would also calculate the percent cover of live seedlings, and include a more detailed vegetation community composition including percent cover of trees, shrubs, forbs, graminoids, lichens and mosses and would compare treatment plots to adjacent paired control plots. Targets for vegetation establishment for year 5 include:

- at least 50% survival of seedlings/ha;
- seedlings demonstrate sustained growth trends between 1st and 5th monitoring periods;
- >80% of surviving seedlings in treatment plot are considered well-spaced;
- natural vegetation is regenerating, including at least 2 characteristic species (vascular and/or non-vascular) as indicators as healthy vegetation treed-lowland community or monitoring plots mimic adjacent stand type in community composition for transitional sites;



- Minimum of 2,000 stems/ha for lowlands and 800-1,400 stems/ha on transitional sites (includes planted and naturally regenerating seedlings); and
- No evidence of chlorosis.

In addition to treatment plots having data collected, the paired control plots which were established during field implementation will also have the same data collected as above. The data from the control plot will be used to complete statistical inferences using the standard metrics for a paired reference on the same linear disturbance with similar factors influencing the ability for revegetation to occur.

In year 5, access control should continue to demonstrate that humans are prevented from using the line or at low levels with no evidence of motorized access.

Monitoring should also continue for year 10 and 15 with vegetation establishment and access control targets described in the Restoration Monitoring Framework (Golder 2015d).

5.0 SUMMARY

Twenty monitoring plots were visited between September 9 and 10, 2017. Vegetation establishment and access management results from the monitoring plots were:

- total survival rate was 70%;
- where seedling mortality occurred, it was determined that a majority of the mortality was due to browsing;
- average live seedling density was 2,467 stems/ha which is above the target of 1,200 stems/ha;
- fifty-five percent of the seedlings that are surviving are in good health, browsing was the major cause of poor seedlings health;
- the vegetation community composition (trees, shrubs, forbs, graminoids, lichens and mosses) have yet to be developed and surface substrate is generally organic matter;
- no invasive species were observed;
- no evidence of motorized vehicles was observed on any of the treatment lines; and
- the major pre-treatment game trails appear to be unused with low animal movements, usually moose, through the treated habitat restoration areas.



6.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or comments regarding the content of this proposal, please contact the undersigned at pbentham@golder.com.

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CP/PB/pls

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7.0 REFERENCES

- CNRL (Canada Natural Resource Limited) 2015a. Wildlife Habitat Enhancement Program 2014 Summary for CNRL Project Number 14-1372-0002-3000-3020. May 6, 2015.
- CNRL 2015b. Kirby Linear Restoration Activities memo prepared for CNRL Project Number 1405973. December 23, 2015.
- Delong, C., Banner, A., MacKenzie, W., Rogers, B., and Kaytor, B. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Ministry of Forests and Range, For. Sci. Prog., Victoria, B.C. Land Management. Handbook Number 65.
- Golder (Golder Associates Ltd.) 2015a. Parker Caribou Range: Boreal Caribou Restoration Pilot Program Plan. Submitted to the British Columbia Oil and Gas Research and Innovation Society's Research and Environmental Monitoring Board. November 30, 2015.
- Golder. 2015b. Parker Range Restoration: Zone 1 Implementation Plan. Prepared for British Columbia Oil and Gas Research and Innovation Society's Research and Environmental Monitoring Board BCIP-2016-02. Report number 1529978-003-Rev0-8000. Available at: <http://www.bcogris.ca/sites/default/files/bcogrisyear1implementationplanfinal31dec15.pdf>
- Golder 2015c. Boreal Caribou Habitat Restoration Operational Toolkit for British Columbia. Prepared for BC Science and Community Environmental Knowledge Fund's Research and Effectiveness Monitoring Board. Report number 1313720037. Available at: <http://scek.ca/sites/default/files/bcip-2015-05-restoration-toolkit-28final29-jan-2115.pdf>.
- Golder 2015d. Boreal Caribou Habitat Restoration Monitoring Framework. Prepared for British Columbia Oil and Gas Research and Innovation Society's Research and Environmental Monitoring Board BCIP-2016-02. Report number 1529986-001-Rev0. Available at: <http://www.bcogris.ca/sites/default/files/bcip-2016-02-restoration-monitoring-framework-final-dec151.pdf>
- Pyper, M., Nishi, J., and McNeil, L. 2014. Linear Feature Restoration in Caribou Habitat: A summary of current practices and a roadmap for future programs. Prepared for Canada's Oil Sands Innovation Alliance. December 29, 2014.



APPENDIX A

Photographs



APPENDIX A: PHOTOGRAPHS

Photographs

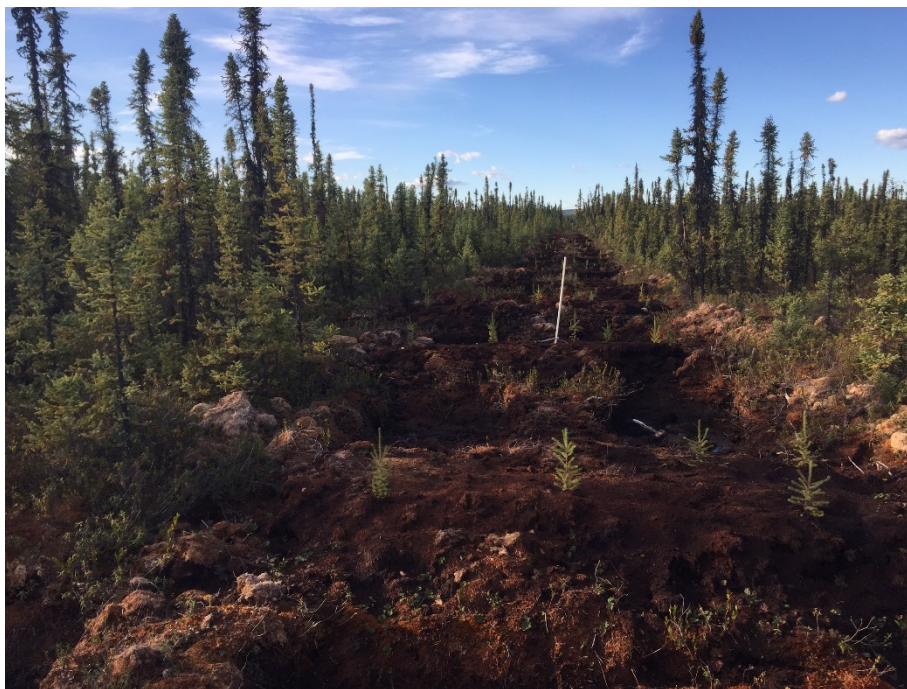


Photo 1: Looking north at plot 39 from middle plot at strong re-growth of winter planted black spruce (September 10, 2017).



Photo 2: Looking at healthy winter planted black spruce seedling 458 in plot 39 (September 10, 2017).



APPENDIX A: PHOTOGRAPHS

Photographs

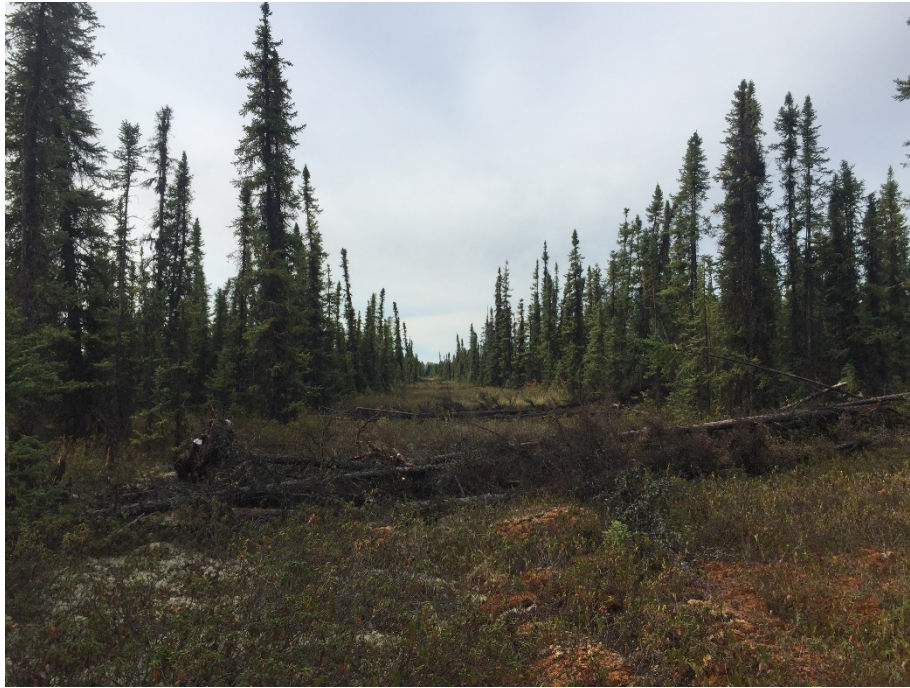


Photo 3: Looking south at tree felling implemented in winter 2016/2017 in a lowland (September 09, 2017).



Photo 4: Looking west at tree felling implemented in winter 2016/2017 in an upland (September 09, 2017).



APPENDIX A: PHOTOGRAPHS

Photographs



Photo 5: Looking northeast at slash rollback implemented in winter 2016/2017 (September 09, 2017).



Photo 6: Aerial view of plot 79, assessed seedling survival by air (September 10, 2017).



APPENDIX A: PHOTOGRAPHS

Photographs



Photo 7: Aerial view of plot 52 before ground-truthing, plot suffered from browsing and poor soil conditions (September 10, 2017).



Photo 8: Looking at browsed winter planted black spruce seedling 302 in plot 52 and typical lateral growth after browsing (September 10, 2017).



APPENDIX A: PHOTOGRAPHS

Photographs



Photo 9: Looking at browsed winter planted black spruce seedling 406 in plot 52 which is dead (September 10, 2017).



Photo 10: Looking at soil type in plot 52 which is expected to have inhibited seedling growth along with serious browsing (September 10, 2017).



APPENDIX A: PHOTOGRAPHS

Photographs



Photo 11: Looking at dead winter planted black spruce seedling 472 in transitional plot 29 on a mound (September 10, 2017).

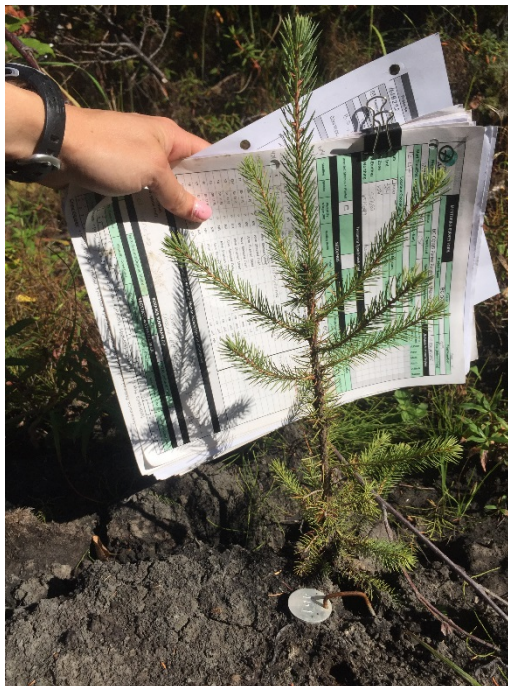


Photo 12: Looking at healthy winter planted black spruce seedling 461 in transitional plot 29 planted on a hinge of a mound

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