TECHNICAL MEMORANDUM

DATE 18 February 2020 **Project No.** 18114181-054-TM-Rev0

TO Merle Keefe, Sabina Gold & Silver Corp.

CC Matthew Pickard, Dionne Filiatrault, Corey De La Mare

FROM Chris Shapka, Valerie Coenen **EMAIL** cshapka@golder.com

2019 Vegetation Monitoring Program

1.0 INTRODUCTION

1.1 Background

Golder Associates Ltd. (Golder) was retained by Sabina Gold & Silver Corp. (Sabina) to implement a Vegetation Monitoring Program for the winter road designed to quantify the potential impacts on vegetation.

2.0 STUDY AREA AND MONITORING LOCATIONS

The Back River Project (the Project) lies in western Nunavut in the West Kitikmeot Region within the continuous permafrost zone of the continental Canadian Arctic. The Project is composed of two main areas: the Marine Laydown Area (MLA), and the Goose Property Area, with a winter ice road (WIR) connecting the two (Figure 1). The MLA is located on the western shore of Southern Bathurst Inlet, approximately 130 kilometres (km) north of the Goose Property. A WIR will be utilized to transport supplies between the MLA and Goose Property during the winter months.

Since a formal system of ecosystem classification does not exist for the Canadian Arctic, a preliminary classification system developed by RESCAN (2013) for the Project Baseline was used for ecosite classification. This system involved incorporating data from other studies with previously developed site level ecosystem classification systems to delineate mappable ecological units with consistent vegetation associations, soil properties, and subject to a similar climate.

Broad ecosystem classes in the project area include: tundra, freshwater, marine, wetland, bedrock, riparian, and esker. Wetland/riparian ecosystems were defined according to (MacKenzie and Moran 2004), tundra was defined according to EBA (2002). Brief definitions and key characteristics of these ecosystem classes and specific vegetation associations are presented in the Back River Project: 2012 Ecosystems and Vegetation Baseline Report (Rescan 2013).

Vegetated ecosystems comprise approximately 70% of the LSA, 8% of which are wetland ecosystems. The most common ecosystem class mapped within the LSA was tundra, with the mesic dwarf-shrub tundra (TL), the dry sparse tundra (TH), and the shrubby tundra (TS) vegetation associations comprising greater than 50% of the LSA (RESCAN 2013).

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LEGEND

- WINTER ICE ROAD AS BUILT
- EXISTING GOOSE AIRSTRIP
- EXISTING GOOSE PROPERTY OR MARINE LAYDOWN AREA FOOTPRINT
- EXISTING GOOSE CAMP LAYOUT
- PROJECT AREA

0 10 20

1:400,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

Sabina GOLD & SILVER CORP.

PROJECT

SABINA BACK RIVER PROJECT

TITLE

PROJECT AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2020-02-18
DESIGNED	CS
PREPARED	SK
REVIEWED	CS
APPROVED	CD

PROJECT NO.	CONTROL	REV.	FIGURE
18114181	3000/3040	0	1

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3.0 VEGETATION MONITORING PROGRAM OBJECTIVES

The main objectives of the Vegetation Monitoring Program are:

- To measure plant species abundance and diversity at vegetation plots along the WIR, MLA and Goose site.
- Measure direct loss and indirect effects to plant communities as a result of the construction and operations of the WIR.
- Measure the distribution and abundance of non-native invasive plant species.
- Monitor and evaluate the effectiveness of mitigation measures.
- Identify unanticipated effects.
- Provide an early warning of undesirable change to the environment and to inform adaptive management strategies.

4.0 METHODS

Baseline vegetation plot establishment and data collection was initially completed from July 11 to 16, 2018. A total of 72 baseline vegetation monitoring plots were established, (36 reference and 36 experimental) using a paired plot design along the proposed WIR alignment in 2018. Sabina's construction and operation of the inaugural WIR in 2019 resulted in several small route optimizations which caused a portion of the experimental plots to fall outside of the current footprint. In 2019, a total of 15 experimental plots were relocated to coincide with the WIR alignment and provide sufficient experimental plot coverage on the WIR footprint. An additional 14 vegetation plots (7 reference and 7 experimental) were established to provide coverage in a range of vegetation types along the WIR alignment. The total number monitoring plots summarized by Project Component and Vegetation Association are presented in Table 1.

Table 1: Number of Vegetation Monitoring Plots by Project Component

Project Component	Vegetation Association	Number of Monitoring Plots*
WIR	Cottongrass Sedge Fen (WC)	2
	Dry Sparse Tundra (TH)	18
	Mesic Dwarf Tundra (TL)	18
	Raised Bog Complex (WB)	4
	Tundra Seepage (TS)	2
	Undifferentiated Tundra (TU)	2
Goose Property	Dry Sparse Tundra (TH)	2
	Mesic Dwarf Tundra (TL)	1
	Undifferentiated Tundra (TU)	2
MLA	Dry Sparse Tundra (TH)	1
	Mesic Dwarf Tundra (TL)	1
	Undifferentiated Tundra (TU)	3
TOTAL		**56**

* The number of monitoring plots is the sum of reference and experimental plots

An additional 5 unpaired vegetation monitoring plots were established in close proximity to each of the MLA and Goose Property footprints to capture any project related effects. Data was collected from July 24 to 31, 2019 from a total of 56 vegetation monitoring plots (46 paired experimental/reference, 10 stand alone experimental; Table 2).

Table 2: Summary of Vegetation Monitoring Plots

Plot Type	Pre -Existing Plot Location	Plot Location Adjusted	New Plot Locations (2019)	New Monitoring Plots		Total
				Goose Property	MLA	
Reference	16	0	7	-	-	23
Experimental	1	15	7	5	5	33
Total	**17**	**15**	**14**	**10**		**56**

Experimental plots were established within the WIR footprint and associated reference plots were established outside the WIR footprint but in close proximity, and within the same ecosystem class, vegetation association and structural stage (Figure 2). The layout for each plot consisted of a 1 x 1 m ground subplot design oriented to cardinal directions, with a unique plot ID tag placed in the northwest corner (Appendix A).

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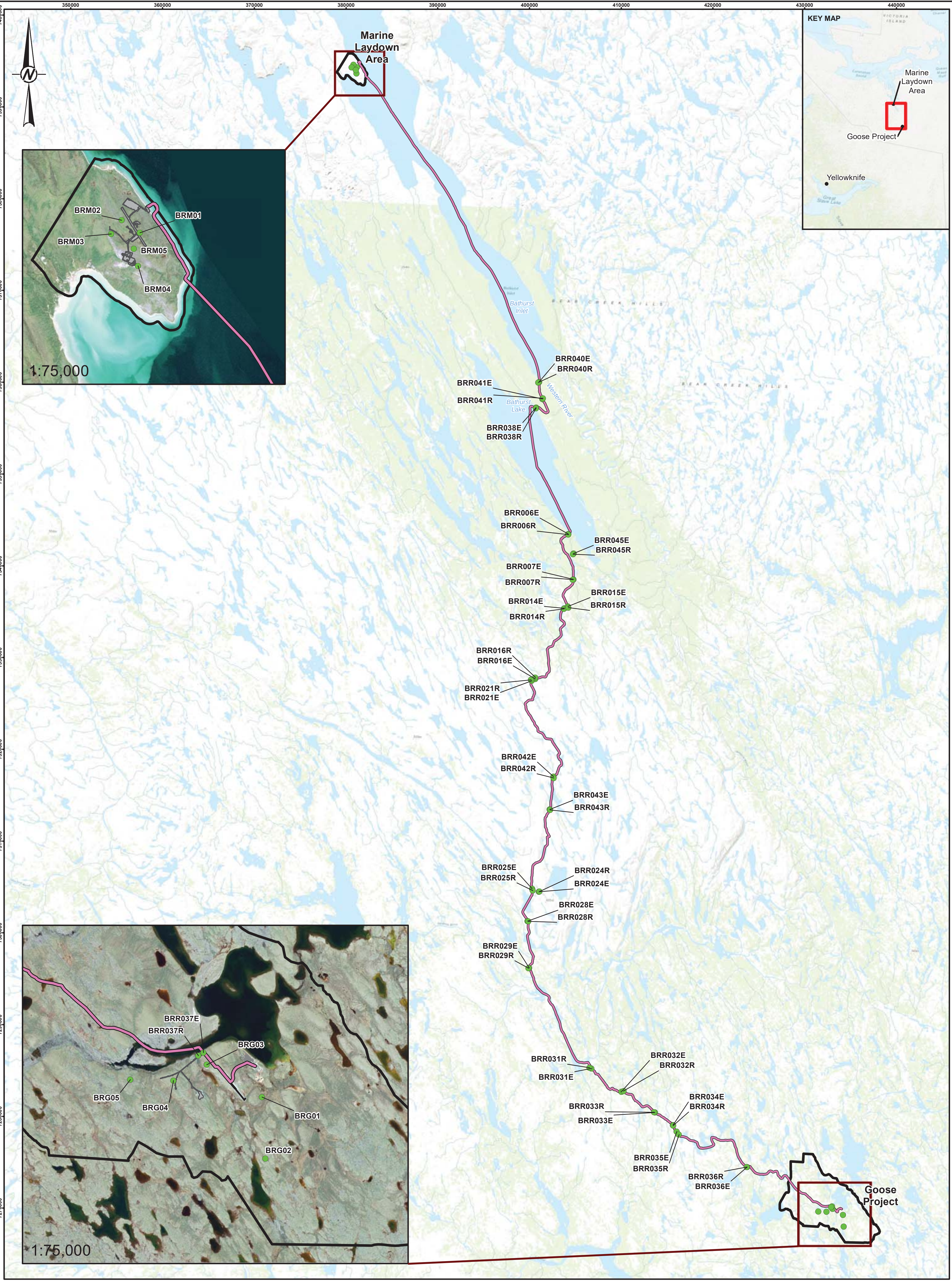

LEGEND

- 2019 VEGETATION MONITORING LOCATION
- WINTER ICE ROAD AS BUILT
- EXISTING GOOSE AIRSTRIP
- EXISTING GOOSE PROPERTY OR MARINE LAYDOWN AREA FOOTPRINT
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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

Sabina GOLD & SILVER CORP.

PROJECT

SABINA BACK RIVER PROJECT

TITLE

VEGETATION MONITORING PLOTS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-02-18
DESIGNED	CS
PREPARED	SK
REVIEWED	CS
APPROVED	CD

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18114181	3000/3040	0	2

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Sampling was conducted during the peak flowering period for most species when fruiting structures were likely to be present to allow for accurate identification. The vegetation dataset is limited to those species with pronounced fruiting structures (and characteristics) present in early summer (i.e., early July) which allowed for their identification.

Detailed plots were assessed by a vegetation ecologist and included plants species present by vegetation strata layer, ground cover, detailed site information and vegetation association data. Information collected at each site included:

- relative abundance (percent cover) of vascular plant and non-vascular species;
- average heights of plant species observed;
- vigour class or overall plant health of vascular plant species;
- relative abundance (percent cover) of surface substrate materials;
- dominant structural stage, moisture regime, and nutrient regime; and
- wildlife sign (e.g., fecal pellets, browsing/grazing, beds, digging) observations, if present.

Estimates of lichen percent cover were made based on their habitat, whether ground-dwelling (terricolous) or rock lichens (saxicolous). Other recorded plot attributes included dominant structural stage, moisture regime, and nutrient regime. Structural stage describes the existing dominant vegetation strata. Moisture and nutrient regimes signify the relative moisture and nutrient supply available to vegetation and are limiting factors in vegetation growth. The plant species present and soil information are used to estimate moisture and nutrient regimes.

Total vegetation abundance inclusive of all vegetation layers could add to more than 100% due to overlap in the layers (e.g., shrub layer, forb layer, graminoid layer). However, within a vegetation layer, abundance cannot add to more than 100%. Relative abundance (percent cover) of each vegetation layer was recorded for each quadrat, including:

- shrubs;
- forbs;
- graminoids (grasses and sedges);
- bryophytes (mosses, liverworts and hornworts);
- terrestrial (terricolous) lichens; and
- rock (saxicolous) lichens.

Percent cover of surface substrate materials (adding to 100%) were recorded within each quadrat, including:

- lichen (terricolous and saxicolous);
- vegetation (vascular plants);
- bryophyte;
- fungi;

- exposed mineral soil/bare ground;
- cobbles and stones;
- water;
- bare ground;
- decaying wood;
- animal pellets; and
- litter.

Qualitative analytical approaches were completed using an *in-situ* vigour class scale and are used to evaluate overall plant heath. Vigour classes closely follow the Ecological land Survey Site Description Manual (AEP 1994), as follows:

- 0 = very poor (>50% leaves necrotic);
- 1 = poor (31 to 50% leaves necrotic);
- 2 = fair (16 to 30% leaves necrotic);
- 3 = good (6 to 15% leaves necrotic); and
- 4 = very good (0 to 5% leaves necrotic).

A similar qualitative approach was also used to assign a disturbance class to each plot as follows:

- NA = No visible damage;
- Low = 0 to 25% vegetation in plot necrotic/damaged;
- Moderate = 26 to 50% of vegetation in plot necrotic/damaged;
- High = 51 to 75% of vegetation in plot necrotic/damaged, and;
- Very High = >75% of vegetation in plot necrotic/damaged, nearly no living vegetation.

Photographic examples of each disturbance class are presented in Appendix B. Vegetation plots with documented disturbance classes other than NA were considered impacted. Digital photographs were taken from the corner of each quadrat pointing toward the centre, and facing north (see Appendix A for representative plot photographs). A summary of plots by project component and vegetative characteristics is provided in Table 3.

Table 3: Location and Number of Vegetation Monitoring Plots

Project Component	Ecosystem Class	Vegetation Association	Structural Stage	Plot IDs	Plot Types
WIR	Tundra	Mesic Dwarf Tundra (TL)	Bryoid	BRR007	Paired Reference/Experimental
				BRR014	Paired Reference/Experimental
				BRR037	Paired Reference/Experimental
				BRR042	Paired Reference/Experimental
				BRR043	Paired Reference/Experimental
		Dry Sparse Tundra (TH)	Sparse/bryoid	BRR015	Paired Reference/Experimental
				BRR016	Paired Reference/Experimental
			Dwarf Shrub	BRR021	Paired Reference/Experimental
				BRR025	Paired Reference/Experimental
				BRR031	Paired Reference/Experimental
				BRR032	Paired Reference/Experimental
				BRR033	Paired Reference/Experimental
				BRR034	Paired Reference/Experimental
				BRR035	Paired Reference/Experimental
		Mesic Dwarf Tundra (TL)	Dwarf Shrub	BRR024	Paired Reference/Experimental
				BRR036	Paired Reference/Experimental
				BRR038	Paired Reference/Experimental
				BRR045	Paired Reference/Experimental
		Tundra Seepage (TS)	Graminoid-dominated	BRR040	Paired Reference/Experimental
		Undifferentiated Tundra (TU)	Dwarf Shrub	BRR041	Paired Reference/Experimental
	Wetland	Raised Bog Complex (WB)	Graminoid-dominated	BRR006	Paired Reference/Experimental
		Cottongrass Sedge Fen (WC)	Graminoid-dominated	BRR028	Paired Reference/Experimental
		Raised Bog Complex (WB)	Bryoid	BRR029	Paired Reference/Experimental
MLA	Tundra	Undifferentiated Tundra (TU)	Dwarf Shrub	BRM01	Experimental
				BRM02	Experimental
				BRM03	Experimental
		Mesic Dwarf Tundra (TL)	Dwarf Shrub	BRM04	Experimental
		Dry Spares Tundra (TH)	Dwarf Shrub	BRM05	Experimental
Goose Property	Tundra	Undifferentiated Tundra (TU)	Dwarf Shrub	BRG05	Experimental
				BRG01	Experimental
		Dry Spares Tundra (TH)	Dwarf Shrub	BRG04	Experimental
				BRG02	Experimental
		Mesic Dwarf Tundra (TL)	Dwarf Shrub	BRG03	Experimental

Several measures of vegetation species composition, abundance, structure and similarity were calculated to evaluate and compare plots. Species richness, the count or number of species present within a plot was calculated and abundance was evaluated as percent cover for each species. Plot structure was evaluated using surface substrate and stratum or layer percent cover, as well as average layer height. In order to compare differences in species composition between reference and impacted experimental plots along the WIR, the Bray-Curtis dissimilarity index was calculated for plots within the same vegetation association. The Bray-Curtis measure of dissimilarity is based on species richness and abundance and ranges from 0 to 1, with 0 being absolute similarity (all species and abundance equal) and 1 being plots have no species in common.

5.0 RESULTS

The 2019 vegetation surveys identified 59 vascular plants in the Project area, of which 53 were identified to species level and 6 were identified to genus level. A total of 36 non-vascular plants (18 bryophytes and 16 lichens) were identified during 2019 field surveys. Of these, 23 were identified to species and 13 specimens were identified to genus level. Appendix C provides a complete vascular and non-vascular species list which were recorded during field surveys, including graminoid and lichen species important for wildlife forage. The most common and widespread vascular species found were arctic dwarf birch (*Betula nana*), alpine blueberry (*Vaccinium uliginosum*) and northern Labrador-tea (*Rhododendron tomentosum*) which were observed respectively in 53, 47 and 46 of the 56 plots surveyed. The overall findings indicate that the majority of the areas surveyed consist of low-diversity vascular plant communities diversity averaging 15 or fewer species per plot. No invasive species or federally listed plant species were observed during field surveys.

Average height by vegetation strata were calculated based on vegetation association and treatment (Tables 4 and 5).

Table 4: Average Vegetation Height (cm) by Strata for all Plots

Vegetation Association & Treatment	Average Height (cm)					
	Shrub	Forb	Graminoid	Bryophyte	Lichen	Total
WIR						
Cottongrass Sedge Fen (WC)						
Experimental	6.0	7.0	11.0	1.5	N/A	7.0
Reference	6.7	1.0	14.8	1.7	2.0	5.8
Dry Sparse Tundra (TH)						
Experimental	5.3	N/A	8.9	1.1	1.9	3.6
Reference	5.0	3.4	7.9	1.2	2.0	3.3
Mesic Dwarf Tundra (TL)						
Experimental	8.7	6.7	13.2	1.3	2.1	5.7
Reference	7.3	6.4	13.3	1.4	1.9	5.4
Raised Bog Complex (WB)						
Experimental	6.6	1.0	9.5	1.3	1.6	4.6
Reference	6.3	2.6	8.8	1.4	2.4	4.7
Tundra Seepage (TS)						
Experimental	8.5	7.0	12.5	0.1	1.0	7.4
Reference	7.2	10.8	14.7	1.0	1.0	8.8

Table 4: Average Vegetation Height (cm) by Strata for all Plots

Vegetation Association & Treatment	Average Height (cm)					
	Shrub	Forb	Graminoid	Bryophyte	Lichen	Total
Undifferentiated Tundra (TU)						
Experimental	9.5	N/A	13.5	1.0	1.0	6.9
Reference	10.2	5.0	25.3	1.5	1.0	8.9
GOOSE PROPERTY*						
Dry Sparse Tundra (TH)	3.6	7.5	11.0	1.0	1.0	2.8
Mesic Dwarf Tundra (TL)	6.0	N/A	14.0	1.0	1.0	4.6
Undifferentiated Tundra (TU)	5.4	7.5	12.7	1.0	1.6	4.7
MLA*						
Dry Sparse Tundra (TH)	3.9	5.5	7.5	1.0	1.0	3.6
Mesic Dwarf Tundra (TL)	4.0	N/A	N/A	1.0	1.3	2.8
Undifferentiated Tundra (TU)	4.5	7.6	8.0	1.0	1.2	4.7
TOTALS						
Experimental	*6.4*	*7.1*	*11.2*	*1.2*	*1.7*	*4.8*
Reference	*6.3*	*5.3*	*12.2*	*1.3*	*1.9*	*4.7*
Grand Total	**6.3**	**6.2**	**11.8**	**1.3**	**1.8**	**4.7**

* Experimental Plots only, N/A – species not observed

Table 5: Average Vegetation Height (cm) by Strata of Reference Plots and Impacted Experimental Plots*

Vegetation Association & Treatment	Average Height (cm)					
	Shrub	Forb	Graminoid	Bryophyte	Lichen	Total
WIR						
Cottongrass Sedge Fen (WC)						
Experimental	6.0	7.0	11.0	1.5	N/A	7.0
Reference	6.8	1.0	13.3	1.7	2.0	6.0
Dry Sparse Tundra (TH)						
Experimental	5.6	N/A	7.4	1.2	1.9	3.6
Reference	5.1	3.2	8.5	1.2	1.8	3.4
Mesic Dwarf Tundra (TL)						
Experimental	8.8	11.7	13.4	1.1	2.1	6.3
Reference	7.5	6.7	14.2	1.2	1.7	5.4
Raised Bog Complex (WB)						
Experimental	6.2	N/A	11.0	1.5	1.3	4.6
Reference	6.3	3.0	8.7	1.1	2.0	4.6
Tundra Seepage (TS)						
Experimental	8.5	7.0	12.5	0.1	1.0	7.4
Reference	7.2	10.8	14.7	1.0	1.0	8.8

Table 5: Average Vegetation Height (cm) by Strata of Reference Plots and Impacted Experimental Plots*

Vegetation Association & Treatment	Average Height (cm)					
	Shrub	Forb	Graminoid	Bryophyte	Lichen	Total
Undifferentiated Tundra (TU)						
Experimental	9.5	N/A	13.5	1.0	1.0	6.8
Reference	10.2	5.0	25.3	1.5	1.0	8.9
TOTALS						
Experimental	*7.1*	*9.0*	*11.3*	*1.1*	*1.9*	*5.1*
Reference	*6.7*	*5.9*	*13.1*	*1.2*	*1.7*	*5.0*
Grand Total	**6.8**	**6.5**	**12.5**	**1.2**	**1.8**	**5.0**

N/A – species not observed

* Impacted Experimental Plots are experimental Plots assigned a disturbance class other than NA. Unaffected experimental plots are not included.

Overall average heights of shrub, graminoid, bryophyte and lichen strata appear to be similar regardless of vegetation association. The largest differences in vegetation heights were observed in the forb strata. Total average heights for all strata across all vegetation associations for experimental and reference plots were also very similar.

Percent cover of the surface substrate was summarized by vegetation association present along the WIR alignment, and at the MLA and Goose Property for all plots (Table 6).

Table 6: Average Surface Substrate (%) by Vegetation Association (all plots)

Vegetation Association	Saxicolous Lichen	Terricolous Lichen	Vegetation	Moss	Fungi	Bare Ground	Rock	Water	Litter	Animal Pellets
WIR										
Cottongrass Sedge Fen (WC)										
Experimental	0	0	35.0	60.0	0	0	0	0	5.0	<1
Reference	0	3.0	49.0	54.0	0	0	0	0	2.0	<1
Dry Sparse Tundra (TH)										
Experimental	<1	35.2	37.2	8.5	0	4.5	<1	0	13.4	0
Reference	4.0	36.8	43.6	10.7	0	<1	<1	0	2.2	0
Mesic Dwarf Tundra (TL)										
Experimental	<1	12.8	46.3	32.3	0	<1	0	0	8.2	0
Reference	<1	15.4	42.7	33.8	0	<1	0	<1	6.8	0
Raised Bog Complex (WB)										
Experimental	0	7.0	29.5	37.5	<1	5.5	0	0	20.5	0
Reference	0	1.1	44.5	53.5	<1	0	0	0	1.0	<1
Tundra Seepage (TS)										
Experimental	0	<1	63.0	10.0	0	<1	0	0	27.0	0
Reference	0	1.0	60.0	35.0	0	0	0	0	4.0	0.0

Table 6: Average Surface Substrate (%) by Vegetation Association (all plots)

Vegetation Association	Saxicolous Lichen	Terricolous Lichen	Vegetation	Moss	Fungi	Bare Ground	Rock	Water	Litter	Animal Pellets
Undifferentiated Tundra (TU)										
Experimental	0	0.1	43.0	30.0	0	0	0	0	30.0	0.1
Reference	0	3.0	66.0	25.0	0	0	0	0	6.0	0.0
GOOSE PROPERTY*										
Dry Sparse Tundra (TH)										
Experimental	0.5	48.0	43.5	6.0	0	0	0	0	2.1	0
Mesic Dwarf Tundra (TL)										
Experimental	0	18.0	40.0	40.0	0	0	0	0	2.0	0
Undifferentiated Tundra (TU)										
Experimental	0	14.0	52.0	29.5	0	0	0	0	4.6	0
MLA*										
Dry Sparse Tundra (TH)										
Experimental	0	20.0	65.0	3.0	0	0	0	0	12.0	0
Mesic Dwarf Tundra (TL)										
Experimental	0	5.0	79.0	6.0	0	0	0	0	10.0	0
Undifferentiated Tundra (TU)										
Experimental	0	19.7	57.0	14.0	0	0	0	0	6.0	0

* Experimental plots only

Overall differences in surface substrate between experimental and reference plots appear minor, and likely due to natural variability between plots. Table 7 below, excludes non-impacted experimental plots and contrasts average surface substrate by vegetation association for reference and impacted experimental plots on the WIR alignment.

Table 7: Average Surface Substrate (%) by Vegetation Association for Reference and Impacted Experimental Plots*

Vegetation Association	Saxicolous Lichen	Terricolous Lichen	Vegetation	Moss	Fungi	Bare Ground	Rock	Water	Litter	Animal Pellets
WIR										
Cottongrass Sedge Fen (WC)										
Experimental	0	0	35.0	60.0	0	0	0	0	5.0	0.1
Reference	0	3.0	49.0	54.0	0	0	0	0	2.0	<1
Dry Sparse Tundra (TH)										
Experimental	1.2	30.2	34.5	10.7	0	6.7	0.6	0	16.5	0
Reference	4.0	36.8	43.6	10.7	0	<1	<1	0	2.2	0
Mesic Dwarf Tundra (TL)										
Experimental	0.3	9.0	47.3	36.5	0	0	0.1	0.0	6.8	0
Reference	<1	15.4	42.7	33.8	0	<1	0	<1	6.8	0

Table 7: Average Surface Substrate (%) by Vegetation Association for Reference and Impacted Experimental Plots*

Vegetation Association	Saxicolous Lichen	Terricolous Lichen	Vegetation	Moss	Fungi	Bare Ground	Rock	Water	Litter	Animal Pellets
Raised Bog Complex (WB)										
Experimental	0	7.0	27.0	22.0	0	11.0	0	0	33.0	0
Reference	0	1.1	44.5	53.5	<1	0	0	0	1.0	<1
Tundra Seepage (TS)										
Experimental	0	0.1	63.0	10.0	0	0.1	0	0	27.0	0
Reference	0	1.0	60.0	35.0	0	0	0	0	4.0	0
Undifferentiated Tundra (TU)										
Experimental	0	0.1	43.0	30.0	0	0	0	0	30.0	0.1
Reference	0	3.0	66.0	25.0	0	0	0	0	6.0	0

* Impacted Experimental Plots are experimental Plots assigned a disturbance class other than NA. Unaffected experimental plots are not included.

The impacted plots have substantially higher litter coverage and lower terricolous lichen cover in the dry sparse tundra (TH), raised bog complex (WB), tundra seepage (TS), and undifferentiated tundra (TU) vegetation associations. The cover of bare ground in the dry sparse tundra (TH) and raised bog complex (WB) vegetation associations is also greater in impacted plots as compared to reference plots.

Species richness was compared between experimental plots (both impacted and non-impacted) and reference plots by vegetation association (Table 8).

Table 8: Comparison of Species Richness By Vegetation Association in Experimental and Reference Plots

Vegetation Association	Species Richness		
	Experimental Plots (non-impacted)	Experimental Plots (Impacted)*	Reference Plots
WIR			
Cottongrass Sedge Fen (WC)	-	12	14
Dry Sparse Tundra (TH)	21	35	39
Mesic Dwarf Tundra (TL)	42	33	53
Raised Bog Complex (WB)	19	12	22
Tundra Seepage (TS)	-	11	15
Undifferentiated Tundra (TU)	-	13	21
GOOSE PROPERTY			
Dry Sparse Tundra (TH)	20	-	-
Mesic Dwarf Tundra (TL)	14	-	-
Undifferentiated Tundra (TU)	23	-	-
MLA			
Dry Sparse Tundra (TH)	17	-	-
Mesic Dwarf Tundra (TL)	9	-	-
Undifferentiated Tundra (TU)	30	-	-
TOTAL[1]	**67**	**60**	**76**

- = No Plots, [1] Totals may not equal sums as totals only consider unique species

* Impacted Experimental Plots are experimental Plots assigned a disturbance class other than NA.

Comparing the overall (i.e. all layers or strata present within plots) species richness at impacted experimental plots to reference plots, impacted experimental plots species richness is lower by 16. Overall species richness is greatest in mesic dwarf tundra (TL) and dry sparse tundra (TH) vegetation associations for reference, and experimental plots, regardless of impacts to vegetation. The lowest species richness was observed in the cottongrass sedge fen (WC) vegetation association for the reference plots, and in the tundra seepage (TS) vegetation association for the experimental plots. Plots in the mesic dwarf tundra (TL) vegetation association had the largest species richness difference between reference and impacted plots, where impacted plots had 20 fewer species than reference plots. The difference in species richness between impacted and reference plots in the cottongrass sedge fen (WC) vegetation association was smallest, with a difference of two species.

Table 9: Comparison of Species Richness By Vegetation Association and Strata in Experimental and Reference Plots

Vegetation Association/Strata	Species Richness		
	Experimental Plots (non-impacted)	Experimental Plots (Impacted)	Reference Plots
WIR			
Cottongrass Sedge Fen (WC)			
Bryophyte	-	2	3
Forb	-	1	1
Graminoid	-	4	3
Lichen	-	0	2
Shrub	-	5	5
Total	-	*12*	*14*
Dry Sparse Tundra (TH)			
Bryophyte	3	7	8
Forb	0	0	3
Graminoid	2	3	3
Lichen	10	12	13
Shrub	6	13	12
Total	*21*	*35*	*39*
Mesic Dwarf Tundra (TL)			
Bryophyte	10	10	10
Forb	3	3	8
Graminoid	5	3	8
Lichen	12	6	13
Shrub	12	11	14
Total	*42*	*33*	*53*
Raised Bog Complex (WB)			
Bryophyte	5	2	5
Forb	1	0	2
Graminoid	5	1	5
Lichen	4	3	3
Shrub	4	6	7
Total	*19*	*12*	*22*

Table 9: Comparison of Species Richness By Vegetation Association and Strata in Experimental and Reference Plots

Vegetation Association/Strata	Species Richness		
	Experimental Plots (non-impacted)	Experimental Plots (Impacted)	Reference Plots
Tundra Seepage (TS)			
Bryophyte	-	1	1
Forb	-	3	4
Graminoid	-	2	3
Lichen	-	1	1
Shrub	-	4	6
Total	-	*11*	*15*
Undifferentiated Tundra (TU)			
Bryophyte	-	4	4
Forb	-	0	2
Graminoid	-	2	3
Lichen	-	1	3
Shrub	-	6	9
Total	-	*13*	*21*
GOOSE PROPERTY			
Dry Sparse Tundra (TH)			
Bryophyte	-	-	2
Forb	-	-	2
Graminoid	-	-	1
Lichen	-	-	8
Shrub	-	-	7
Total	-	-	*20*
Mesic Dwarf Tundra (TL)			
Bryophyte	-	-	3
Graminoid	-	-	2
Lichen	-	-	4
Shrub	-	-	5
Total	-	-	*14*
Undifferentiated Tundra (TU)			
Bryophyte	-	-	4
Forb	-	-	4
Graminoid	-	-	3
Lichen	-	-	6
Shrub	-	-	6
Total	-	-	*23*
MLA			
Dry Sparse Tundra (TH)			
Bryophyte	-	-	1
Forb	-	-	2

Table 9: Comparison of Species Richness By Vegetation Association and Strata in Experimental and Reference Plots

Vegetation Association/Strata	Species Richness		
	Experimental Plots (non-impacted)	Experimental Plots (Impacted)	Reference Plots
Graminoid	-	-	2
Lichen	-	-	4
Shrub	-	-	8
Total	-	-	*17*
Mesic Dwarf Tundra (TL)			
Bryophyte	-	-	1
Lichen	-	-	3
Shrub	-	-	5
Total	-	-	*9*
Undifferentiated Tundra (TU)			
Bryophyte	-	-	3
Forb	-	-	8
Graminoid	-	-	2
Lichen	-	-	5
Shrub	-	-	12
Total	-	-	*30*
Grand Total	**67**	**60**	**76**

\- No plots

Differences in species richness between impacted and reference plots was smallest in the bryophyte layer. The strata showing the largest difference in species richness between impacted and reference plots was the shrub layer.

A disturbance summary at vegetation plot locations by vegetation association and project component is presented in Table 10.

Table 10: Summary of Disturbance Level by Vegetation Association and Project Component

Vegetation Association	Disturbance Level					Total
	None	Low	Moderate	High	Very High	
WIR						
Cottongrass Sedge Fen (WC)	1	-	1	-	-	**2**
Dry Sparse Tundra (TH)	12	2	2	1	1	**18**
Mesic Dwarf Tundra (TL)	14	4	-	-	-	**18**
Raised Bog Complex (WB)	3	-	-	1	-	**4**
Tundra Seepage (TS)	1	-	1	-	-	**2**
Undifferentiated Tundra (TU)	1	-	-	-	1	**2**
GOOSE PROPERTY						
Dry Sparse Tundra (TH)	2	-	-	-	-	**2**
Mesic Dwarf Tundra (TL)	1	-	-	-	-	**1**
Undifferentiated Tundra (TU)	2	-	-	-	-	**2**

Table 10: Summary of Disturbance Level by Vegetation Association and Project Component

Vegetation Association	Disturbance Level					Total
	None	Low	Moderate	High	Very High	
MLA						
Dry Sparse Tundra (TH)	1	-	-	-	-	**1**
Mesic Dwarf Tundra (TL)	1	-	-	-	-	**1**
Undifferentiated Tundra (TU)	3	-	-	-	-	**3**
Grand Total	**42**	**6**	**4**	**2**	**2**	**56**

Generally, the lowest disturbance to vegetation was documented in the dry sparse tundra (TH) and mesic dwarf tundra (TL) vegetation associations. Moderate disturbance was documented in cottongrass sedge fen (WC), dry sparse tundra (TH), and tundra seepage (TS) vegetation associations. High and very high disturbances were observed in dry sparse tundra (TH), raised bog complex (WB) and undifferentiated tundra (TU) vegetation associations.

The Bray-Curtis dissimilarity index between the impacted experimental plots and non-impacted reference plots of each vegetation association is presented below (Table 11).

Table 11: Dissimilarity Index Between Impacted Experimental and Reference Plots within Vegetation Association

Vegetation Association	Bray-Curtis Dissimilarity Index*
Cottongrass Sedge Fen (WC)	0.42
Dry Sparse Tundra (TH)	0.45
Mesic Dwarf Tundra (TL)	0.44
Raised Bog Complex (WB)	0.64
Tundra Seepage (TS)	0.52
Undifferentiated Tundra (TU)	0.46

*Dissimilarity index number between 0-0.25 indicates no dissimilarity, 0.26-0.50 low dissimilarity, 0.51-0.75 moderate dissimilarity and 0.76-1.0 strong dissimilarity.

Dissimilarity was low (0.26-0.50) for plots established in cottongrass sedge fen (WC), dry sparse tundra (TH), mesic dwarf tundra (TL) and undifferentiated tundra (TU) vegetation associations. The dissimilarity index in plots established in raised bog complex (WB) and tundra seepage (TS) vegetation associations was moderate (0.51-0.75).

6.0 RECOMMENDATIONS

Overall, the results of the 2019 field surveys of the WIR show impacts to the vegetation ranging from low to very high, with the majority (75%) of vegetation plots surveyed showing low to no disturbance with 75% of plots exhibiting no disturbance. A number of measures should continue to be implemented to help mitigate the effects of WIR on local vegetation including:

- Minimizing WIR footprint thereby minimizing disturbance to terrestrial environment;
- All vehicle traffic restricted to designated road surfaces including consideration of additional WIR route demarcation;
- Load allowance do not exceed design of WIR;
- Vehicles driven at designated speeds along WIR; and
- Travel on WIR only when conditions permit.

It is recommended that vegetation monitoring along the WIR continue to monitor changes to vegetation – photographic monitoring to be conducted annual, and vegetation surveys completed every 3 years as per vegetation monitoring plan.

7.0 CLOSURE

This technical memo was prepared and reviewed by the undersigned.

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Principal, Senior Ecologist

CS/VC/CDL/jr/jlb

https://golderassociates.sharepoint.com/sites/101666/technical work/3000_vegetation/03_reporting/2019 tech memo/rev0/18114181-054-tm-2019vegetationmonitorprogram-rev0.docx

8.0 REFERENCES

Alberta Environment and Parks (AEP) (formerly ESRD). 1994 Ecological Land Survey Site Description Manual. Alberta Environmental Protection. Resource Information Branch, Finance, Land Information and Program Support Services. Edmonton, Alberta.

EBA. 2002. Tibbett to Contwoyto Winter Road Ecological Land Classification. Prepared for Tibbett to Contwoyto Winter Road Joint Venture:

MacKenzie and Moran. 2004. Wetlands of British Columbia - A Guide to Identification. Victoria, BC: Land management handbook 52. BC Ministry of Forests Research Branch.

Rescan. 2013. Back River Project: 2012 Ecosystems and Vegetation Baseline Report. Prepared for Sabina Gold & Silver Corp. by Rescan Environmental Services Ltd.

APPENDIX A

Photographic Log

Photo 1. Plot number: BRR006E – Raised Bog Complex

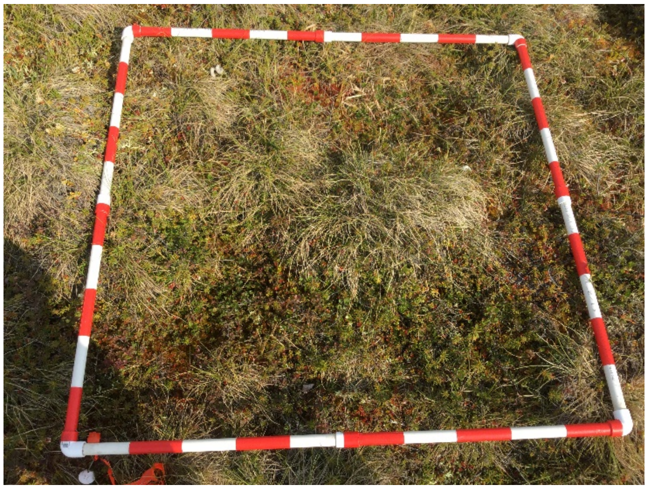

Photo 2. Plot number: BRR006R – Raised Bog Complex

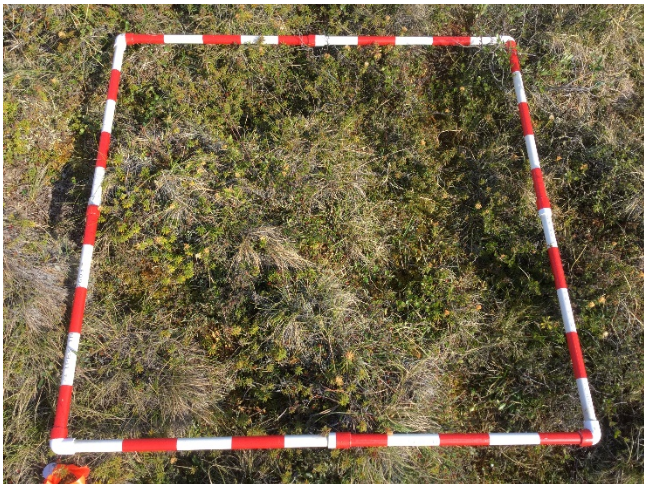

Photo 3. Plot number: BRR007E – Mesic Dwarf Tundra

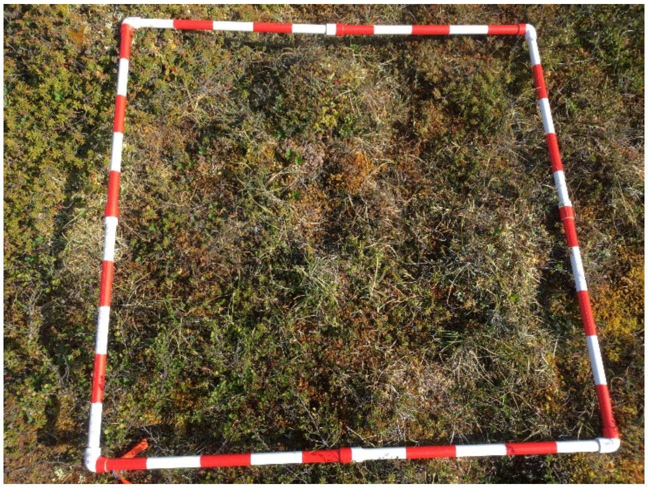

Photo 4. Plot number: BRR007R – Mesic Dwarf Tundra

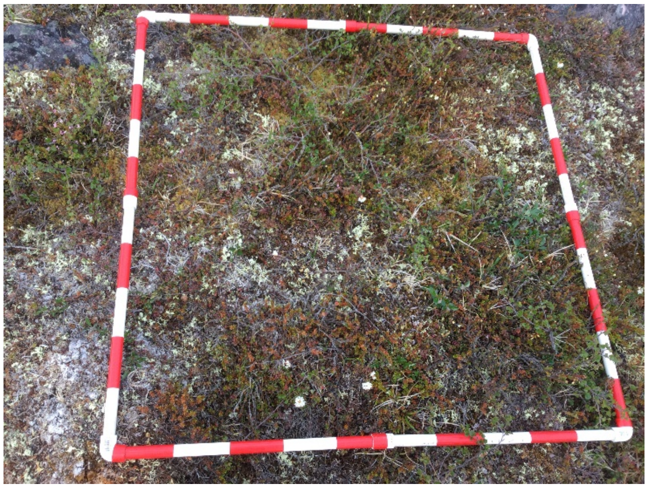

Photo 5. Plot number: BRR014E – Mesic Dwarf Tundra

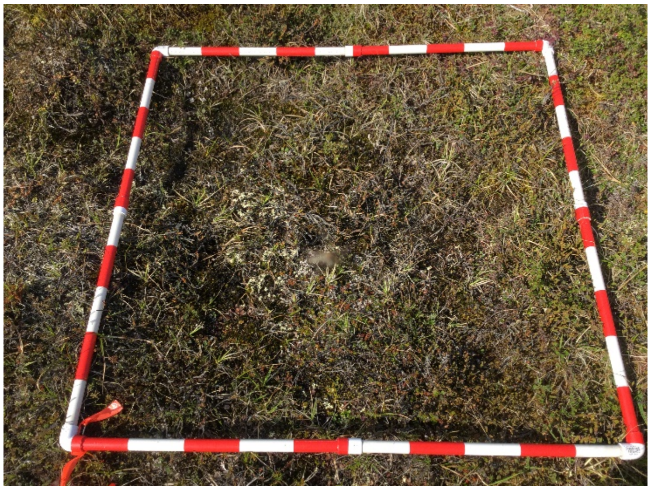

Photo 6. Plot number: BRR014R – Mesic Dwarf Tundra

Photo 7. Plot number: BRR015E – Dry Sparse Tundra

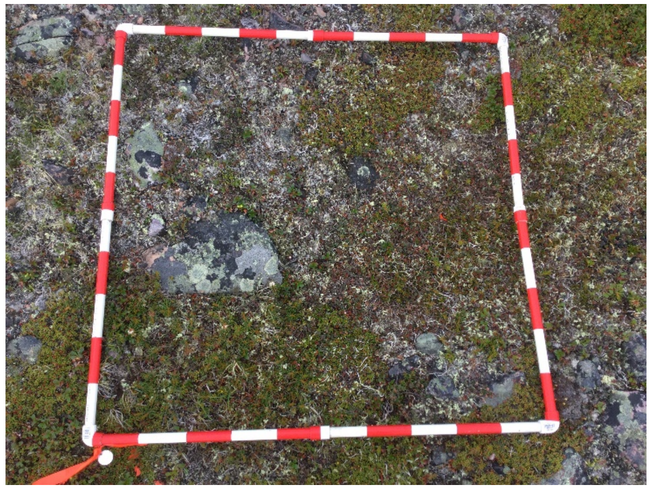

Photo 8. Plot number: BRR015R – Dry Sparse Tundra

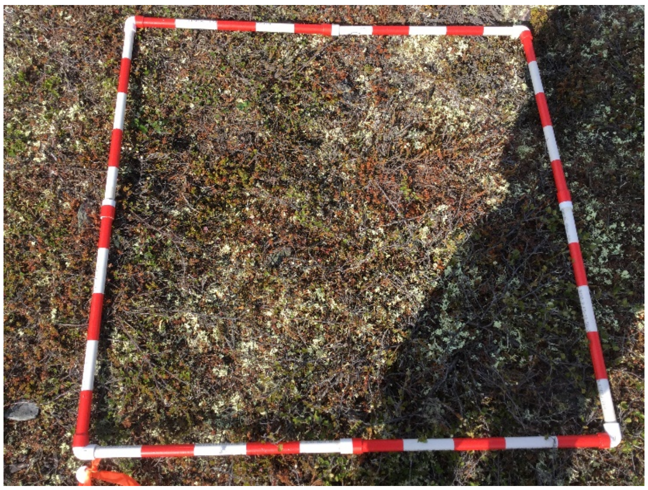

Photo 9. Plot number: BRR016E – Dry Sparse Tundra

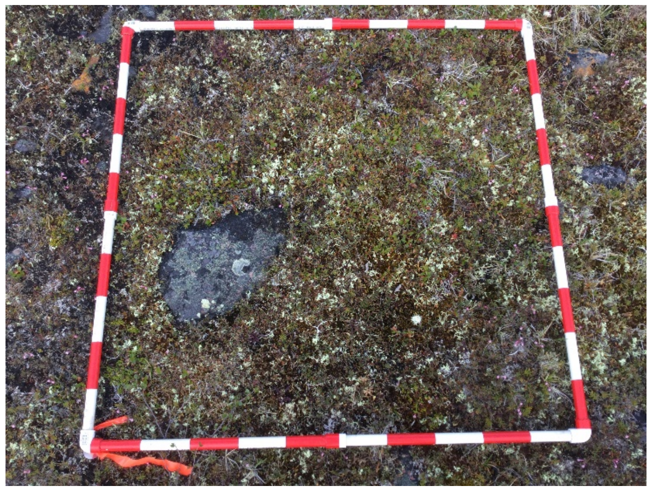

Photo 10. Plot number: BRR016R – Dry Sparse Tundra

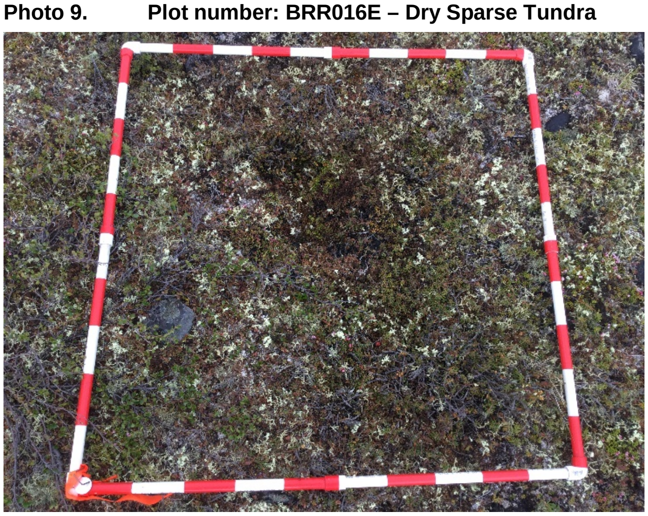

Photo 11. Plot number: BRR021E – Dry Sparse Tundra

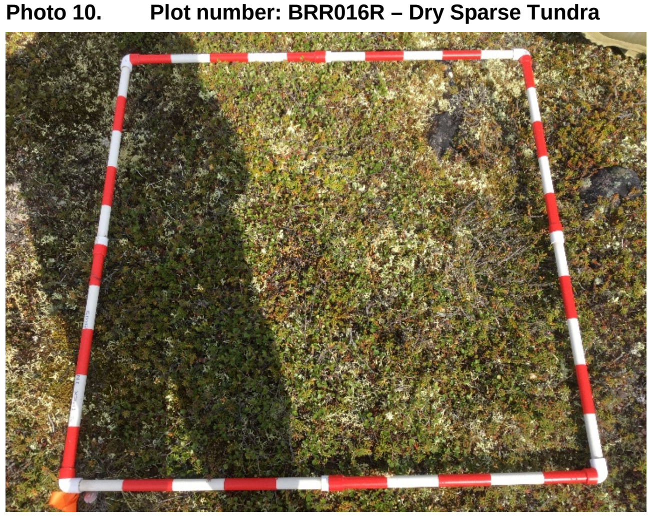

Photo 12. Plot number: BRR021R – Dry Sparse Tundra

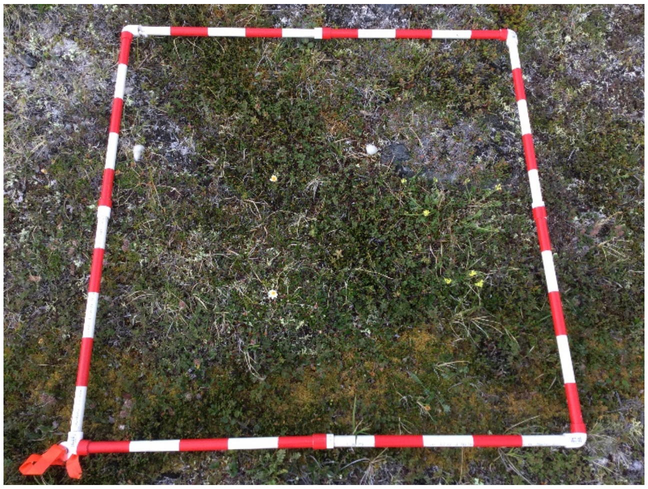

Photo 13. Plot number: BRR024E – Mesic Dwarf Tundra

Photo 14. Plot number: BRR024R – Mesic Dwarf Tundra

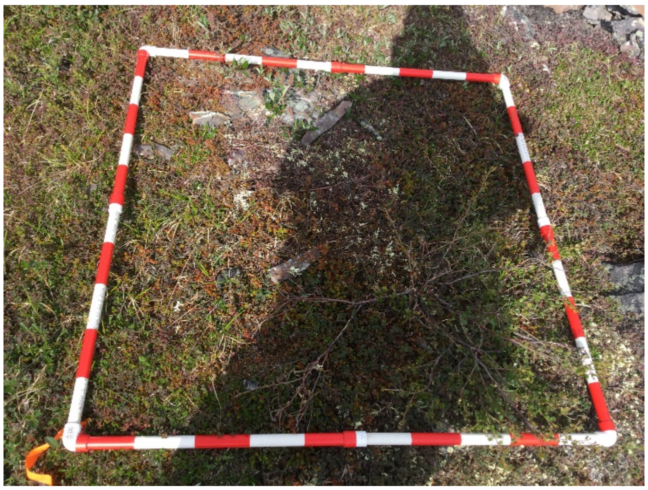

Photo 15. Plot number: BRR025E – Dry Sparse Tundra

Photo 16. Plot number: BRR025R – Dry Sparse Tundra

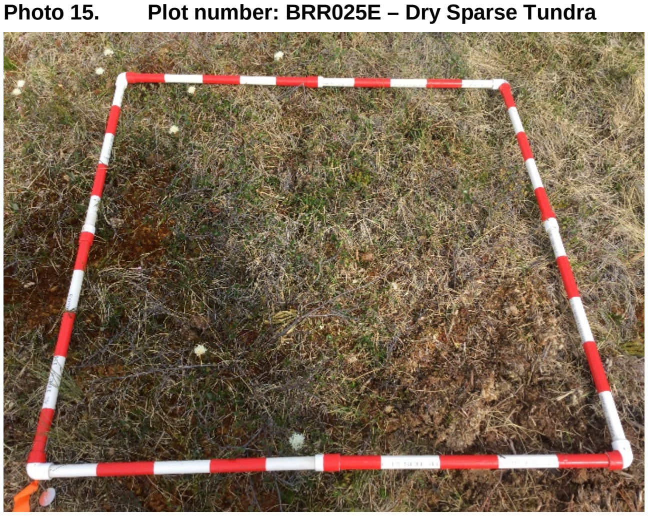

Photo 17. Plot number: BRR028E – Cottongrass Sedge Fen

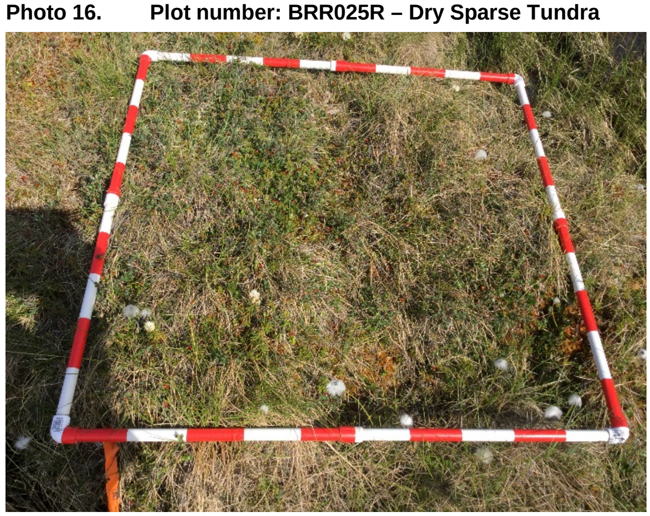

Photo 18. Plot number: BRR028R – Cottongrass Sedge Fen

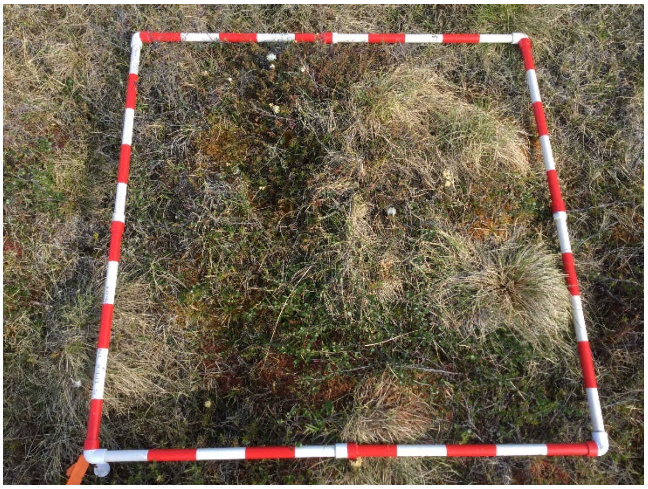

Photo 19. Plot number: BRR029E – Raised Bog Complex

Photo 20. Plot number: BRR029R – Raised Bog Complex

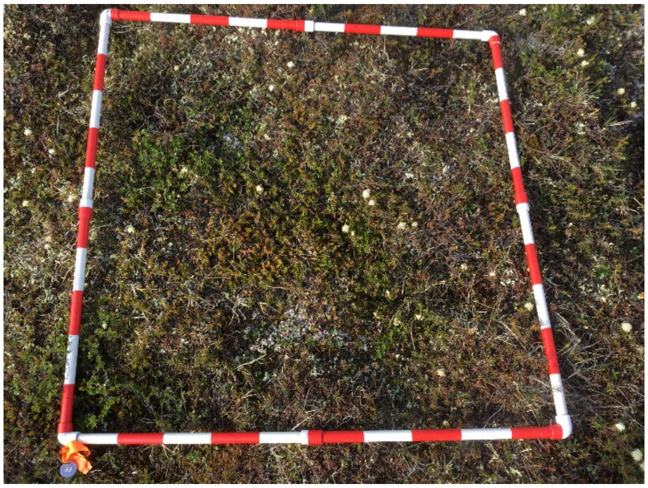

Photo 21. Plot number: BRR031E – Dry Sparse Tundra

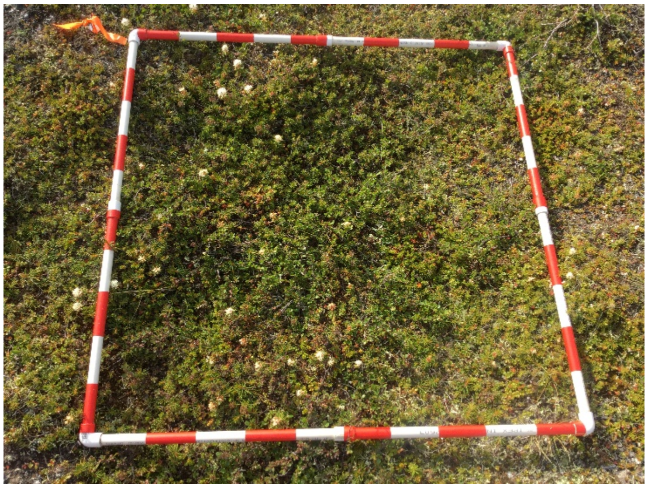

Photo 22. Plot number: BRR031R – Dry Sparse Tundra

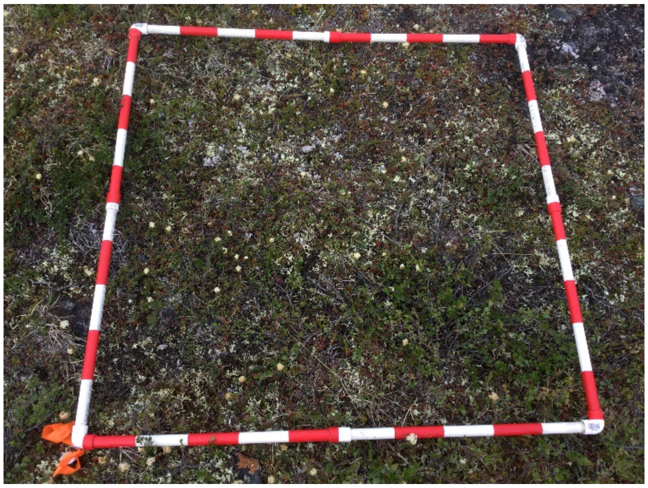

Photo 23. Plot number: BRR032E – Dry Sparse Tundra

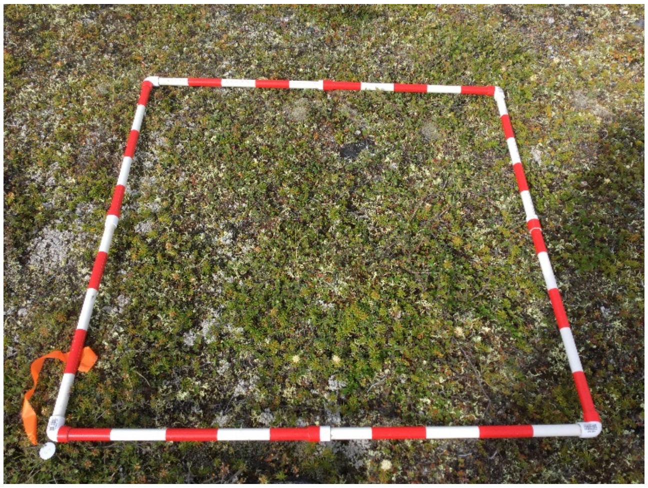

Photo 24. Plot number: BRR032R – Dry Sparse Tundra

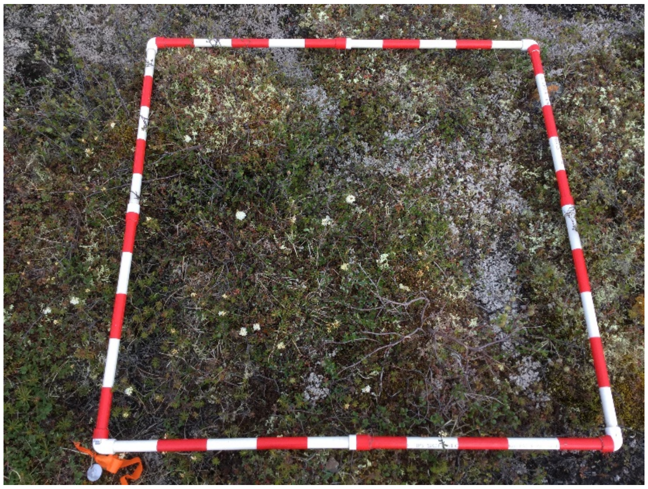

Photo 25. Plot number: BRR033E – Dry Sparse Tundra

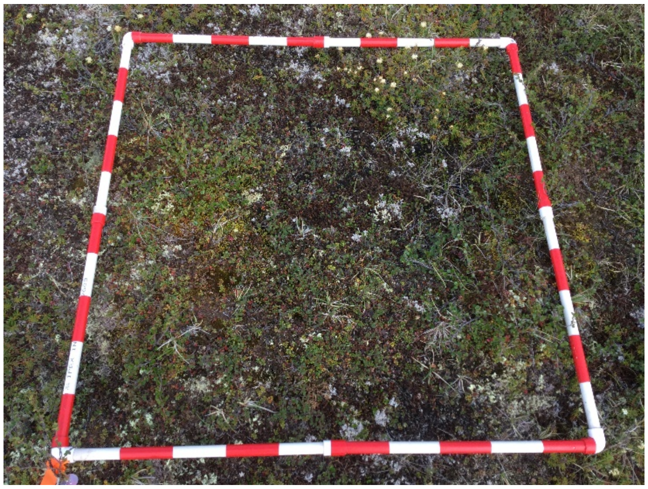

Photo 26. Plot number: BRR033R – Dry Sparse Tundra

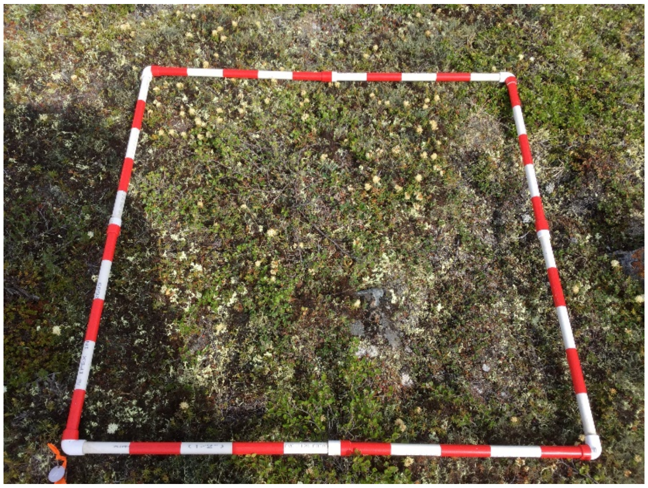

Photo 27. Plot number: BRR034E – Dry Sparse Tundra

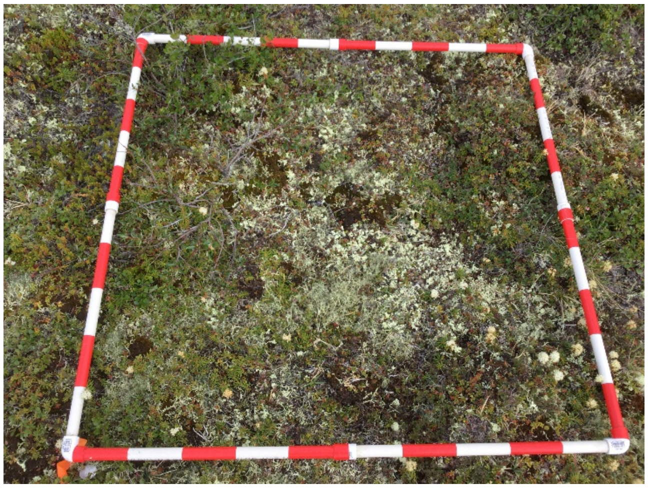

Photo 28. Plot number: BRR034R – Dry Sparse Tundra

Photo 29. Plot number: BRR035E – Dry Sparse Tundra

Photo 30. Plot number: BRR035R – Dry Sparse Tundra

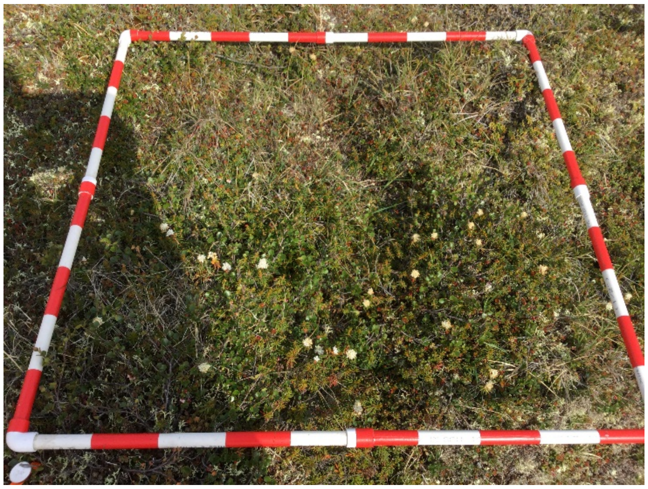

Photo 31. Plot number: BRR036E – Mesic Dwarf Tundra

Photo 32. Plot number: BRR036R – Mesic Dwarf Tundra

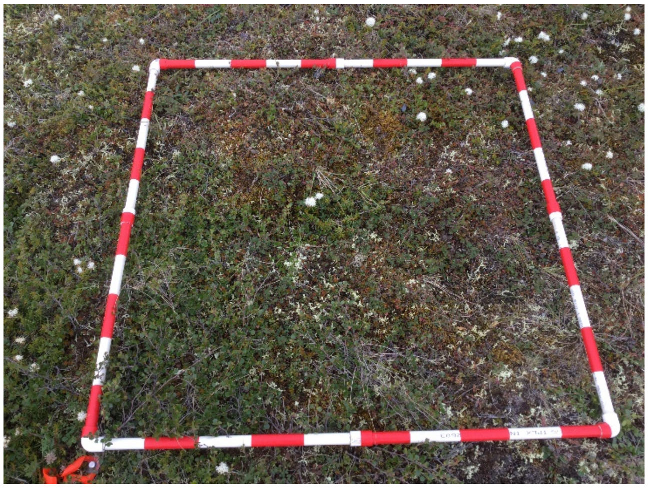

Photo 33. Plot number: BRR037E – Mesic Dwarf Tundra

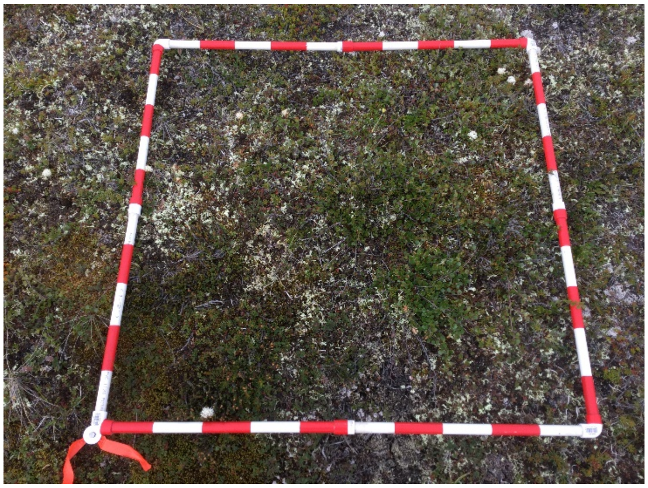

Photo 34. Plot number: BRR037R Mesic Dwarf Tundra

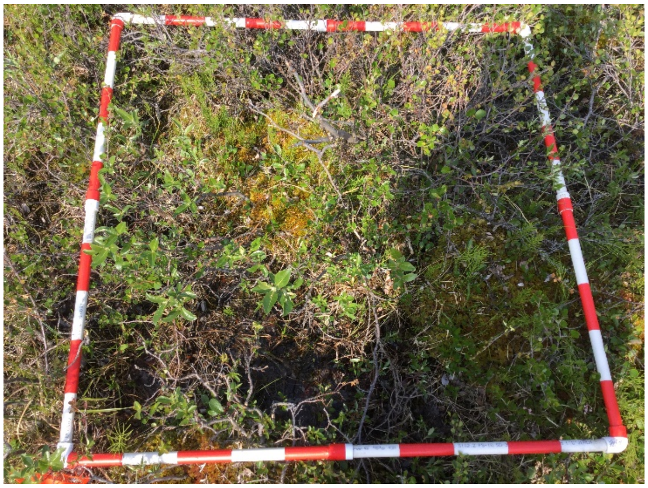

Photo 35. Plot number: BRR038E – Mesic Dwarf Tundra

Photo 36. Plot number: BRR038R – Mesic Dwarf Tundra

Photo 37. Plot number: BRR040E – Tundra Seepage

Photo 38. Plot number: BRR040R – Tundra Seepage

Photo 39. Plot number: BRR041E – Undifferentiated Tundra

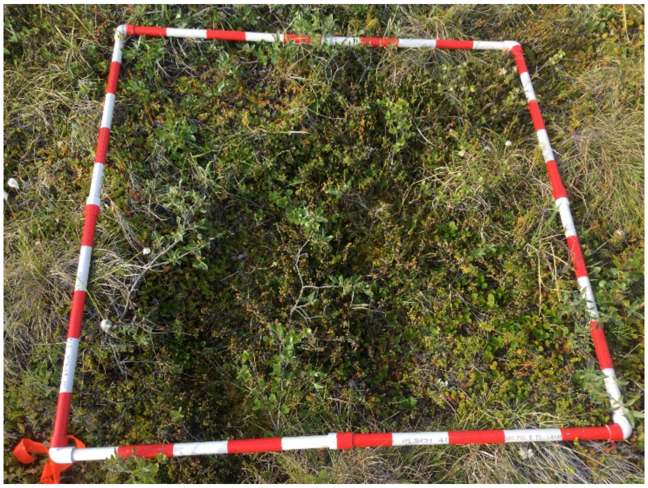

Photo 40. Plot number: BRR041R – Undifferentiated Tundra

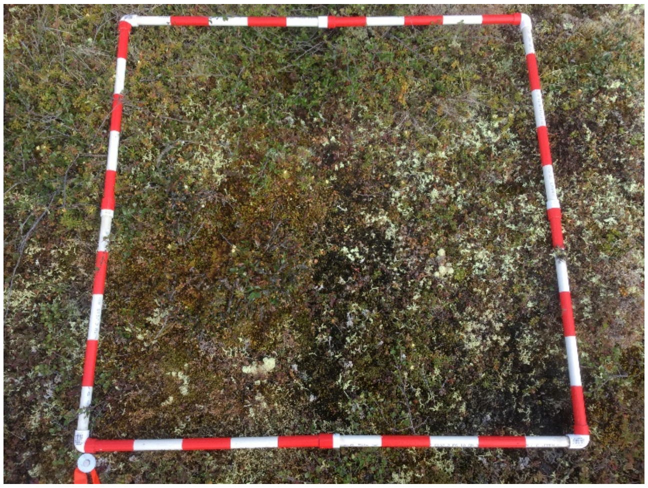

Photo 41. Plot number: BRR042E – Mesic Dwarf Tundra

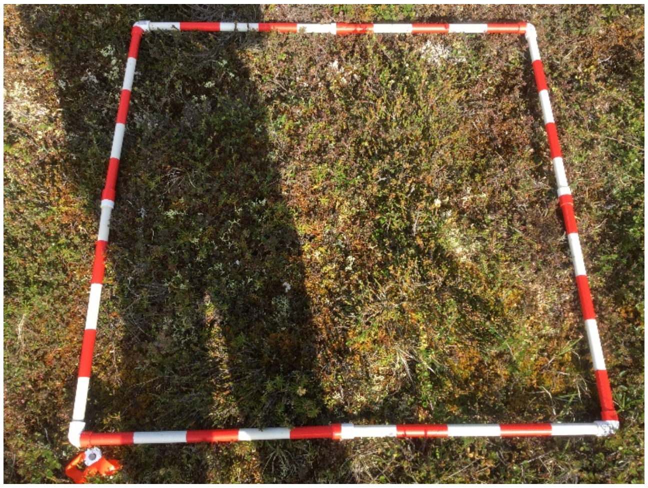

Photo 42. Plot number: BRR042R – Mesic Dwarf Tundra

Photo 43. Plot number: BRR043E – Mesic Dwarf Tundra

Photo 44. Plot number: BRR043R – Mesic Dwarf Tundra

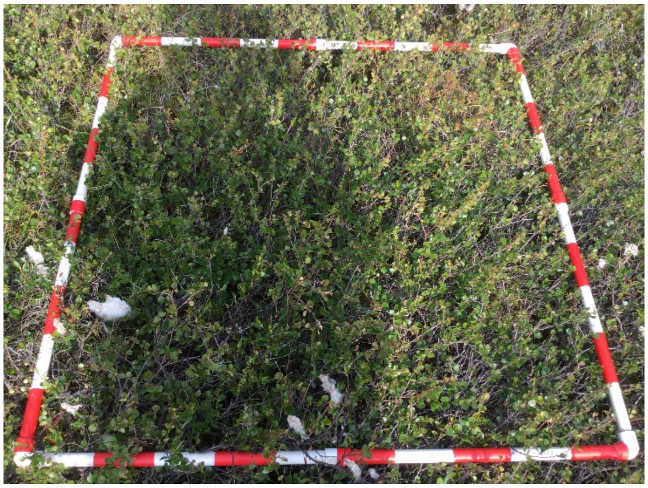

Photo 45. Plot number: BRR045E – Mesic Dwarf Tundra

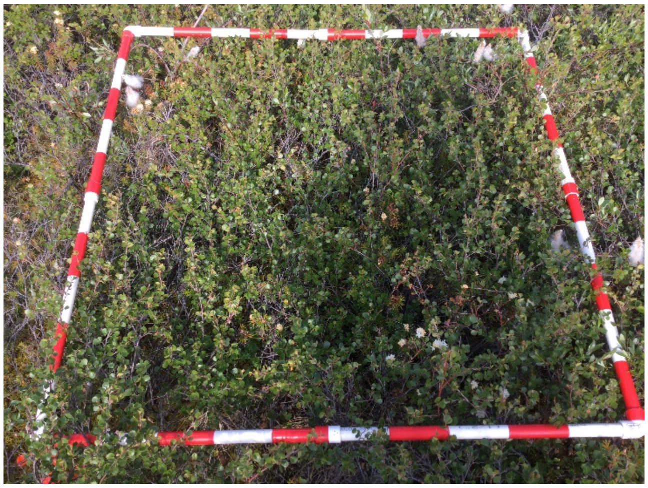

Photo 46. Plot number: BRR045R – Mesic Dwarf Tundra

Photo 47. Plot number: BRG01 – Undifferentiated Tundra

Photo 48. Plot number: BRG02 – Dry Sparse Tundra

Photo 49. Plot number: BRG03 – Mesic Dwarf Tundra

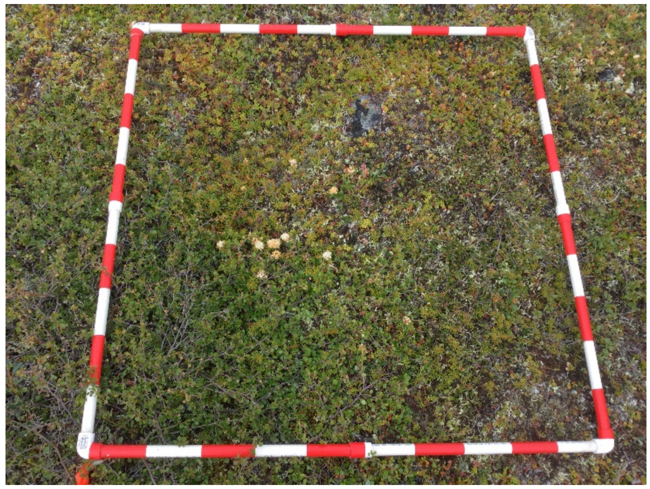

Photo 50. Plot number: BRG04 – Dry Sparse Tundra

Photo 51. Plot number: BRG05 – Undifferentiated Tundra

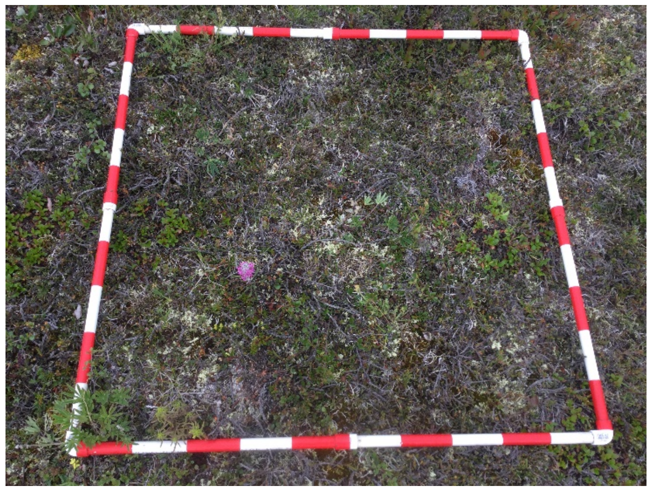

Photo 52. Plot number: BRM01 – Undifferentiated Tundra

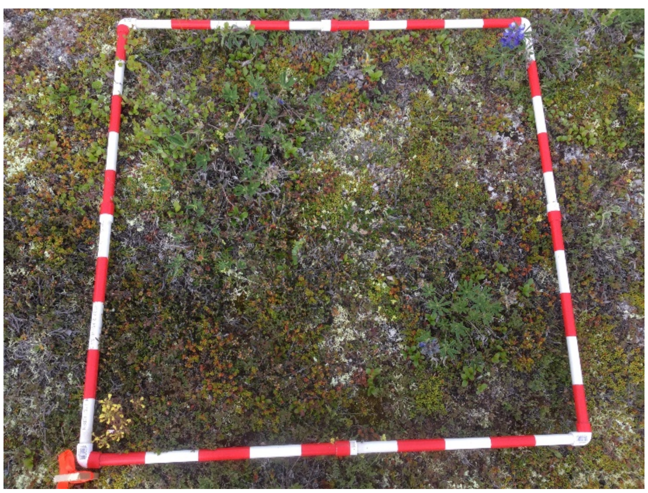

Photo 53. Plot number: BRM02 – Undifferentiated Tundra

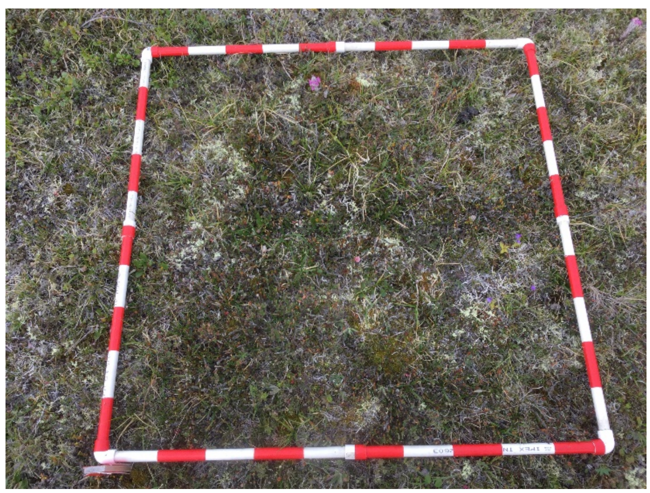

Photo 54. Plot number: BRM03 – Undifferentiated Tundra

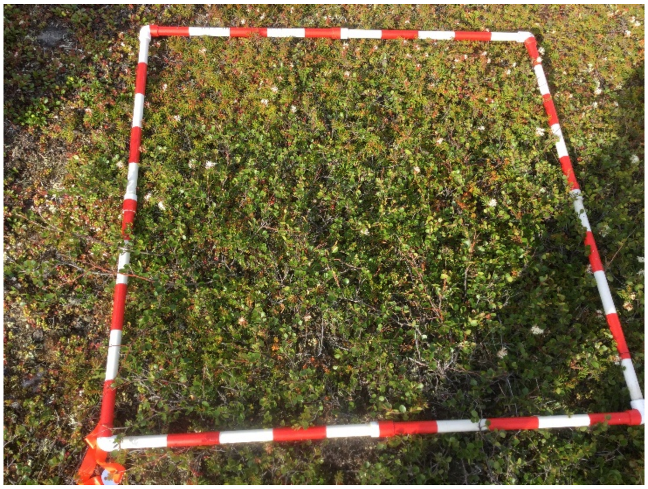

Photo 55. Plot number: BRM04 – Mesic Dwarf Tundra

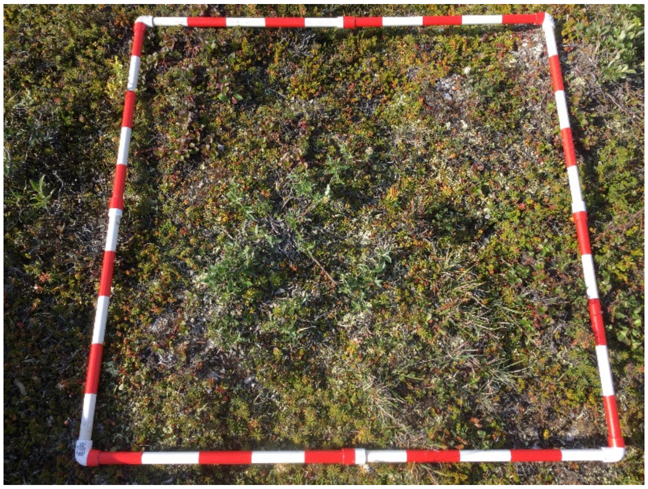

Photo 56. Plot number: BRM05 – Dry Sparse Tundra

APPENDIX B

Disturbance Classes

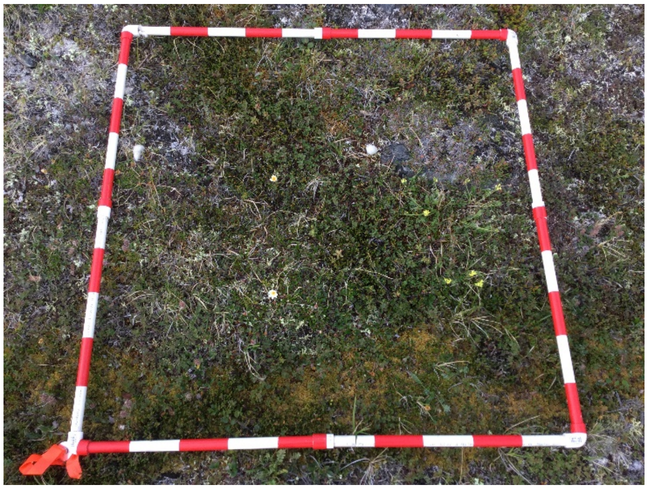

Photo 1. Low Disturbance – Plot Number: BRR024 E

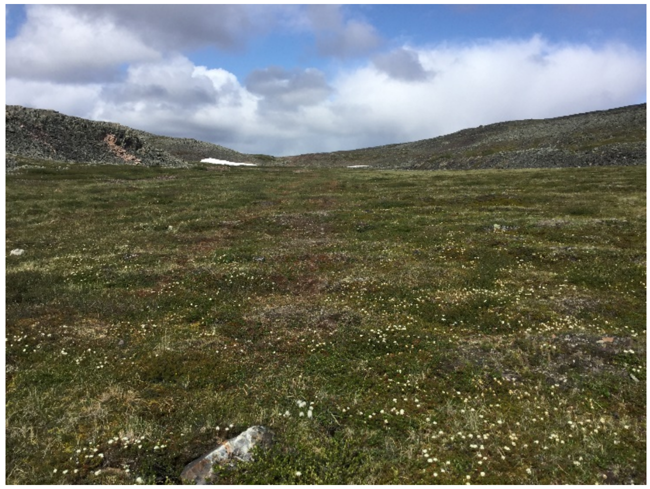

Photo 2. Low Disturbance

Photo 3. Low Disturbance

Photo 4. Moderate Disturbance – Plot number: BRR028E

Photo 5. Moderate Disturbance

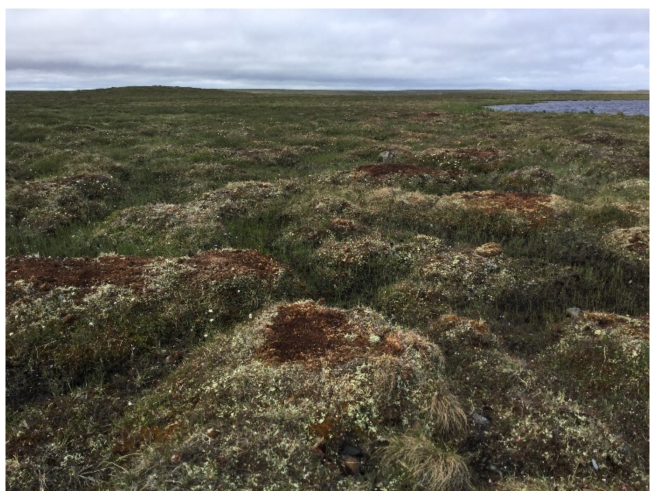

Photo 6. Moderate Disturbance

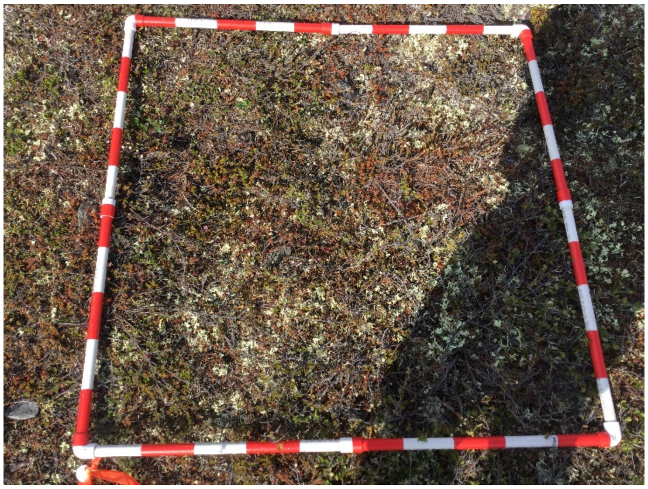

Photo 7. High Disturbance – Plot number: BRR016E

Photo 8. High Disturbance

Photo 9. High Disturbance

Photo 10. Very High Disturbance – Plot number: BRR015E

Photo 11. Very High Disturbance

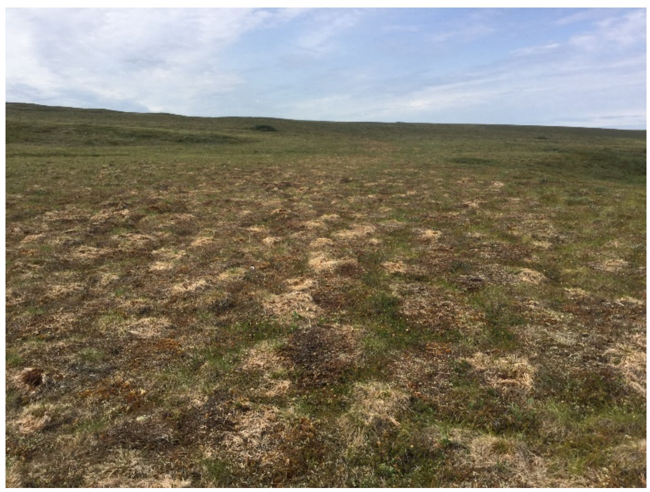

Photo 12. Very High Disturbance

APPENDIX C

2019 Species List

Table C-4: Species Observed During 2019 Field Surveys

SCIENTIFIC NAME	COMMON NAME
SHRUB	
Andromeda polifolia	bog rosemary
Arctostaphylos rubra	alpine bearberry
Betula nana	arctic dwarf birch
Cassiope tetragona	white mountain-heather
Dryas integrifolia	northern white mountain avens
Empetrum nigrum	crowberry
Kalmia procumbens	alpine azalea
Rhododendron lapponicum	Lapland rose-bay
Rhododendron tomentosum	northern Labrador tea
Salix arctica	arctic willow
Salix arctophila	northern willow
Salix planifolia	planeleaf willow
Salix reticulata	net-veined willow
salix species	willow species
Vaccinium uliginosum	bog bilberry
Vaccinium vitis-idaea	bog cranberry
FORB	
Astragalus alpinus	alpine milkvetch
bistorta sp.	bistort species
Bistorta vivapara	alpine bistort
Cardamine bellidifolia	alpine bitter-cress
Comarum palustre	marsh cinquefoil
Diphasiastrum alpinum	alpine club-moss
Equisetum arvense	common horsetail
Habenaria obtusata	northern bog orchid
Hedysarum boreale	northern sweetvetch
Huperzia selago	mountain club-moss
Lupinus arcticus	arctic lupine
Oxytropis arctica	arctic loxytrope
Oxytropis maydelliana	Maydell's oxytrope
Pedicularis labradorica	Labrador lousewort
Pedicularis lanata	woolly lousewort
Pedicularis lapponica	northern lousewort
Pedicularis sudetica	purple rattle
Pinguicula villosa	small butterwort
Pinguicula vulgaris	common butterwort

Table C-4: Species Observed During 2019 Field Surveys

SCIENTIFIC NAME	COMMON NAME
Polygonum vivparum	viviparous knotweed
Pyrola grandiflora	arctic wintergreen
Rubus chamaemorus	cloudberry
Saussurea angustifolia	narrowleaf saw-wort
Tofieldia coccinea	purple featherling
Tofieldia pusilla	dwarf false asphodel
GRAMINOID	
Carex aquatilis	water sedge
Carex aquatilis ssp. *stans*	water sedge
Carex aurea	golden sedge
Carex bigelowii	Bigelow's sedge
Carex capitata	capitate sedge
Carex leptalea	bristle-stalked sedge
Carex scirpoidea	bulrush sedge
carex species	sedge Species
Danthonia spicatta	poverty oatgrass
Eriophorum angustifolium	narrowleaf cotton-grass
Eriophorum brachyantherum	close-sheathed cotton grass
Eriophorum vaginatum	sheathed cotton grass
Festuca brachyphylla	shortleaf fescue
Hierochloe alpina	alpine sweet grass
Luzula species	woodrush species
BRYOPHYTE	
Abietinella abietina	wiry fern moss
Aulacomnium palustre	tufted moss
Aulacomnium turgidum	turgid moss
Brachythecium salebrosum	golden ragged moss
Bryum argenteum	silver-moss
dicranum species	moss species
homalthecium sp.	moss species
Pleurozium schreberi	Schreber's moss
polytrichum species	hair-cap moss species
Sphagnum fuscum	rusty peat moss
Sphagnum species	peat moss species
Tomentypnum nitens	golden moss
LICHEN	
Alectoria ochroleuca	green witch's hair lichen

Table C-4: Species Observed During 2019 Field Surveys

SCIENTIFIC NAME	COMMON NAME
Bryocaulon divergens	northern foxhai lichen
cetraria species	lichen species
Cladonia rangiferina	reindeer lichen
cladonia species	lichen species
Cladonia stellaris	star-tipped reindeer lichen
Cladonia stygia	reindeer lichen
Dactylina arctica	arctic finger lichen
Flavocetraria cucullata	curled snow lichen
Flavocetraria nivalis	crinkled snow lichen
Masonhalea richardsonii	tumbleweed lichen
Peltigera aphthosa	studded leather lichen
peltigera species	pelt lichen species
Stereocaulon paschale	common foam lichen
stereocaulon species	foam lichen
Thamnolia vermicularis	antler lichen