SUMMARY OF FIELD WORK (JULY 22 TO AUGUST 2, 2019)

EO Baseline for Cumulative Effects Work Package 9: Regional Applications - Habitat

SUMMARY

This report summarizes the work that was completed by NRCan personnel and project partners at eleven study sites within Quebec and Labrador between July 22 and August 2, 2019. This work was conducted under Work Package 9 of the Earth Observation for Cumulative Effects Project, though the collected data may be useful for other work packages or projects.

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October 18, 2019

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Introduction

Between July 22 and August 2, 2019 a team of eight (8) NRCan employees conducted field work under Work Package 9 of the Earth Observation for Cumulative Effects Project. The specific objectives of this Work Package are to:

1. Develop lichen availability maps using field measurements, UAV survey, and satellite imagery for regions selected for cumulative effects assessments;
2. Quantify the footprints of human activities on caribou habitat using field survey and satellite remote sensing; and,
3. Develop methods and protocols applicable for other wildlife habitats, as well as NRCan's expertise for reviewing the assessment of cumulative effects on wildlife habitat.

The purpose of the 2019 field campaign was to collect field measurements and UAV survey data as described in objective 1. The trip included four dedicated driving days and eight days of data collection at sites located along the QC-389 and Trans-Labrador Highway (TLH) from Baie-Comeau, QC to Churchill Falls, Labrador (Figure 1).

Figures of each visited site are provided in Appendix A. Photographs documenting our field collection methods and site conditions are provided in Appendix B. A detailed description of our data collection methods is provided in Appendix C.

Figure 1: The location of our identified areas of interest are shown in yellow along the QC-389 and TLH highways.

Target Data

The following data was planned to be collected at each visited site during the 2019 field campaign:

- A land cover survey of 11 micro-plots (herein referred to as the Main LCMP);
- Three UAV flights that captured the 11 micro-plots;
  - hover over micro-plots,
  - 1cm resolution site survey,
  - 2cm resolution site survey.
- Close-range video surveys of each LCMP;
- High-precision GPS data of the UAV ground control points for post-processing;
- Five lichen biomass samples from the 11 micro-plots (randomly selected);
- Additional land cover surveys of micro-plots throughout the site (herein referred to as Additional LCMP);
- Leaf-area index survey;
- Land cover survey of the 30m^2 area surrounding the 11 micro-plots; and,
- Spectrometer data for various land cover classes.

Two of the NRCan team members had joined the trip to collect soil temperature data as part of a permafrost study. Additionally, the NRCan team was joined by two members of CFS and one member of the Government of Newfoundland and Labrador (GoNL) for one day (July 26, 2019). On this day the new team members collected tree cores and trained NRCan members in lichen species identification.

Therefore, additional data collected during the 2019 field campaign included:

- Opportunistic soil texture analysis (conducted in partnership with permafrost project);
- Lichen species identification within micro-plots (lead by CFS and GoNL personnel); and,
- Tree core collection (lead by CFS personnel).

Trip Pre-Planning

Prior to embarking on the trip, four Areas of Interest (AOIs; Areas A, B, C, and D) were identified along the route from Baie-Comeau, Québec to Churchill Falls, Labrador (Figure 1). We selected these areas based on the location of available high-resolution imagery (Worldview-2 and Worldview-3).

A total of 43 potential study sites and associated access routes were pre-selected within these AOIs from Landsat imagery (via Google Earth). Each potential study site was approximately 500m^2 in size to accommodate the maximum UAV survey range of 300m^2 and allow for flexibility in flight planning. A large number of sites were pre-selected to provide flexibility in the event that sites could not be accessed due to unforeseen issues or adverse weather conditions. Assuming we would be able to complete data collection at two sites each day, we identified high-priority sites for each AOI based on the number of days planned to be spent in each. We then prepared UAV flight plans for each of the identified high-priority sites.

Site pre-selection and priority assessment based on the following:

1. The likelihood of encountering terrestrial 'caribou' lichen must be high;
2. The site must be easily accessed from road (≤500m hike);
3. A safe parking and staging area must be available for each site;
4. Sites must be located within available high-resolution satellite imagery footprints;

5. Sites should include important features of interest:
    a. Disturbed sites with a range of ages and mechanisms (forest fires, clear cuts);
    b. A variety of ecological land classes (different lichen forest types);
    c. Sites within identified caribou herd ranges; and,
    d. A range of topographic conditions.

Based on project time constraints and site access conditions a total of eleven sites were visited by the NRCan team from July 24 to 31, 2019. This included two sites located in Québec, and nine within Labrador.

Summary of Collected Data

Consistently cloudy and occasionally rainy weather conditions prevented us from collecting all of the target data for each of our sites. We were only able to collect a few spectrometer measurements including; readings from two lichen species (*C. sterllaris*, and *C. stereocaulon*) while we were at site D6, and readings for the highway, shoulder, and nearby rocks while driving between sites on July 31, 2019. It is important to note that we made a number of modifications to our biomass sample collection methods while in the field, see M1 – M4, Appendix C for details.

Table E-1 below summarizes all data that were collected during the 2019 Québec-Labrador field campaign. Descriptions of the four AOIs and detailed results from individual sites are described in the following sections.

Table E-1 Trip Summary Table

Total Sites	12
Main LCMP	110
Additional LCMP	99
Land Cover Assessments (30m Resolution)	10
Lichen Biomass Assessments	65
Lichen Biomass Samples	54
Leaf Area Index Assessments	8
Soil Texture Analyses	6
UAV Flight – Hover above Micro-Plots	9
UAV Flight – 1cm Resolution Surveys	9.5
UAV Flight – 2cm Resolution Surveys	11
Close Range Micro-Plot Video Surveys	11
Sites with Tree Core Collection	2

Area A: Manic 5

This 405km^2 area is located south of the Manicouagan Reservoir, Québec, around the Manic 5 dam (Figure 2). In undisturbed portions Area A is comprised primarily of dense boreal forest (black spruce dominated) and open lichen woodlands, or forests with lichen. There are many waterbodies and watercourses throughout.

The Area is bisected by a paved portion of the Québec Route 389 highway, and twinning hydro power transmission line right of way (ROW). A large forest fire scar is visible in the south of Area A (burn date 2005[1]). Other observed anthropogenic disturbances within Area B include but may not be limited to:

1. Widespread clear cutting with an extensive network of gravel resource roads;
2. The hydro dam at Manic 5;
3. A rail line used for iron ore transportation;
4. Manicouagan airport;
5. A motel and fuel station; and,
6. Private cottages and associated gravel access roads.

Figure 1 (Appendix A) displays these and other features of interest within Area A.

Due to the location of Area A in relation to our overnight accommodations (Uapishka Research Station) and project time constraints, only one site (A6) was accessed and surveyed on July 24, 2019.

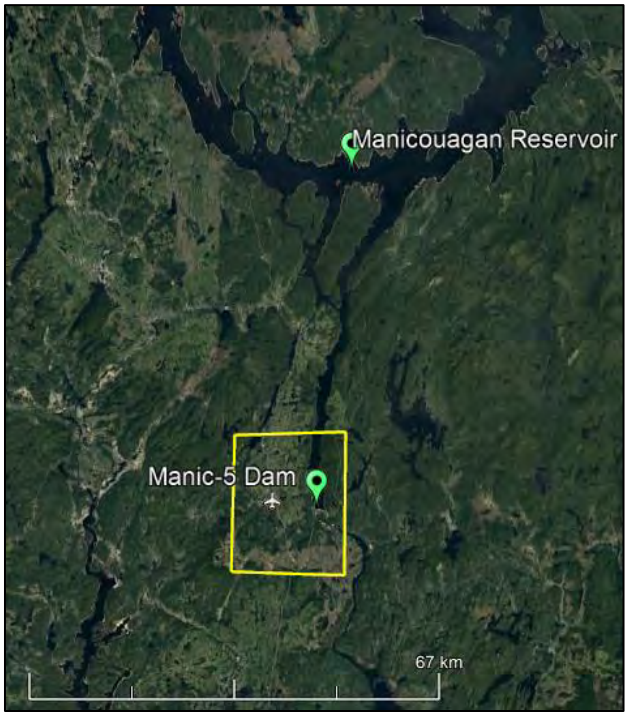


Figure 2: A screenshot from Google Earth showing the location of Area A (yellow) in relation to provincial hydro-electric features.

Site A6

The site is located approximately 7km southwest of the Manic 5 dam in an area that has been partially disturbed by clear cutting. We accessed the site using a gravel road (good condition) on July 24, 2019. Forested portions of the site were identified as a black spruce dominated forests with lichen, based on the ecological land classification (ELC) explained to us by Isabelle Schmelzer with the Government of Newfoundland and Labrador. We noted severe surface disturbances caused by the previous logging activities in the in the northeast portion of the site, and to the south beyond a small, untouched strip of forest. These disturbance features included deep vehicle ruts with exposed mineral soils/rocks, large amounts of coarse woody debris, and reduced vegetation cover. We do not know the exact date of tree harvesting at the site, however based on the degree of vegetation recovery (in particular Labrador Tea[2]) we estimate logging to have occurred more than 20 years before our survey. It would be beneficial to obtain forestry records to confirm the date.

Upon arrival, we selected an area to conduct the survey of 11 land cover micro-plots (LCMP). We based our selection on the high-resolution UAV flight plan extents, the presence of lichen ground cover, and the importance to collect data for different ecosystem types. In this case we were most interested in collecting data representing the forest with lichen conditions, therefore we set-up and performed the LCMP survey within the undisturbed portion of the site. We did conduct additional LCMP surveys throughout the disturbed areas, however these plots are not visible in the UAV flight photos.

Table A-1 summarizes the field work we completed at the site. Table A-2 provides an overall summary of the site, data, and key field observations. Figures 2 and 3 (Appendix A) show the site location with high-resolution satellite imagery and a digital elevation model with hill shade. Elevation data products derived from provincial LiDAR are publically available from the provincial government at 2m resolution[3] and were downloaded for our site.

Table A-1: Completed Field Work (Site A6)

Main LCMP	Yes
Additional LCMP	37 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	5 samples
Biomass Height and Sampling Method	H1, M1
Leaf Area Index	No
Soil Texture Analysis	3 points
UAV Flight – Hover above Micro-Plots	Yes-Mavic 10 (1.6mm)
UAV Flight – 1cm Resolution	Yes-Inspire
UAV Flight – 2cm Resolution	Yes-Inspire
Close Range Video Survey of Micro-Plots	Not nadir
Tree Cores (from CFS)	No

Table A-2: Site Summary (Site A6)

Site Center Point Coordinates	50°35.708' N, 68°47.360' W
Date of Field Survey	July 24, 2019
Identified Caribou Herd Range(s)	Manicouagan, Manouane, Québec*
Available High-Resolution Imagery	WV-2 (8-band) Date: 09/23/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce dominated forest with lichen
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	LDC
Site Land Cover Description (30m Resolution)	Undulating, <5% slope, SW aspect, 3-10m tall mature black spruce (90%) and jack pine (10%), 40-10% density
Site Soil Texture Description	Poorly graded, well-drained sands. - Surface to ~10cmbg: organic material (dead lichen mat and humic layers). - ~10 to ~12cmbg: very fine, grey silty sand (SM). - ~12 to ~20cmbg: coarse, brown, compact sand, some gravel and fines (SM). - >20cmbg: coarse, yellow, compact sand, some gravel (SM).
Average Lichen Cover (rounded to nearest 5%)	70%
Average Lichen Height	10.5 cm
Average Biomass	8.6 g/m^2

* Identified ranges pending update from Ministère des Forêts, de la Faune et des Parcs (Sabrina Plante)

Area B: Fire Lake

This 660km^2 area is divided into two sections (Figure 3). The Section A (294km^2) is located around the Fire Lake Iron Mine in Québec and is accessible via the QC-389 highway. Section B (366km^2) is located to the south and is inaccessible by car.

Both areas are comprised of dense boreal forest (black spruce dominated) with a greater proportion of open lichen woodlands and/or forests with lichen as compared to Area A. There are also significantly more water features (bodies and courses) than are present in Area A. Both sections of Area B have been heavily disturbed by forest fires (burn dates: 1974, 1976, 1997, and 2016[1]). Observed anthropogenic disturbances within Area B include but may not be limited to:

1. The QC-389 (unpaved);
2. The hydro power transmission line and ROW;
3. The iron mine and associated transportation network (roads, airstrip, and rail line); and,
4. Private cottages and associated gravel access roads.

Figure 4 (Appendix A) displays these and other features of interest within Area B.

Unfortunately we were unable to utilize secondary roads associated with the active iron ore mine, therefore we were limited to sites that could be safely access from the QC-389 highway. One site (B7) was accessed and surveyed within Area B on July 25, 2019.

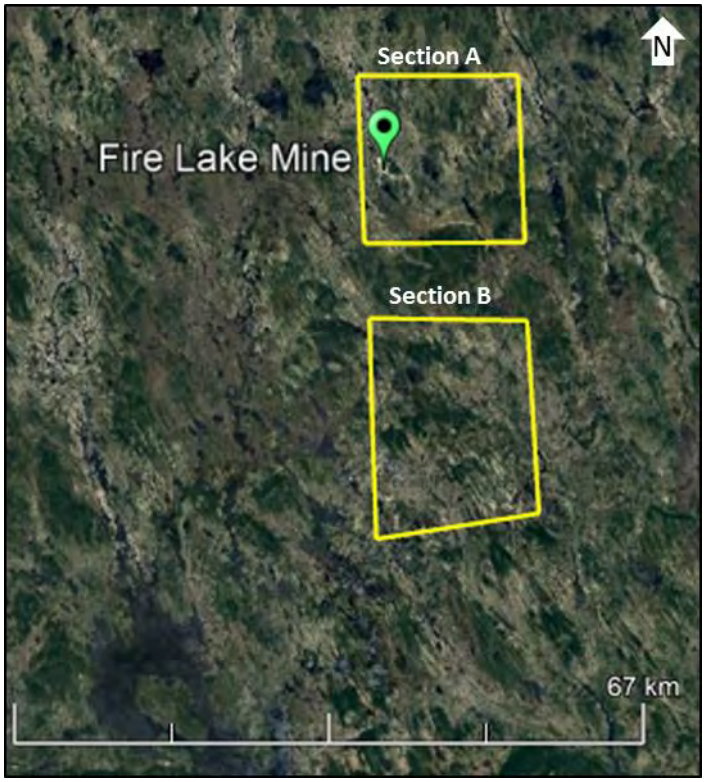


Figure 3: A screenshot from Google Earth showing the location of Area B (yellow) in relation to Fire Lake Iron Ore Mine.

Site B7

The site is located within Section A of Area B, approximately 50km southwest of Fermont, Québec. We accessed the site on July 25, 2019 by parking at a gravel pad associated with the rail line, and hiking south approximately 300m. We classified the site as a black spruce dominated forest with lichen and, as forest conditions were observed to be relatively uniform across the site, selected our LCMP survey area based solely upon the UAV flight plan extents. Additional LCMP surveys were conducted throughout the site, however these plots are not visible in the UAV photographs.

Table B-1 summarizes all field work that we completed at the site. Table B-2 provides an overall summary of the site, data, and key field observations. Figure 5 (Appendix A) displays the site location and high-resolution satellite imagery.

Table B-1: Completed Field Work (Site B7)

Main LCMP	Yes
Additional LCMP	13 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	5 samples
Biomass Sampling Method	H1, M2
Leaf Area Index	Yes
Soil Texture Analysis – *Rapid Assessment**	Yes
UAV Flight – Hover above Micro-Plots	Yes-Mavic 11 (3.6mm)
UAV Flight – 1cm Resolution	Yes-Mavic (2 flights)
UAV Flight – 2cm Resolution	Yes-Mavic
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

**Soils were assessed opportunistically to a maximum depth of 10cm in areas where fallen trees had made subsoil accessible to the observer.*

Table B-2: Site Summary (Site B7)

Site Center Point Coordinates	52°23.098' N, 67°22.348' W
Date of Field Survey	July 25, 2019
Identified Caribou Herd Range(s)	Québec*
Available High-Resolution Imagery	WV-2 (8-band) Date: 09/28/2016
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce dominated forest with lichen
Dominant Lichen Specie(s)	*C. stellaris*, *C. stygia*
Land Cover Assessment (30m Resolution)	LDC
Site Land Cover Description (30m Resolution)	Undulating/steeply sloped (10-30%), W aspect, 3-10m tall mature black spruce, 40-25% density
Site Soil Texture Description – *Rapid Assessment*	Surficial soils were observed to be similar to those of Site A-6 (SM). A full depth texture analysis was not completed.
Average Lichen Cover (rounded to nearest 5%)	65%
Average Lichen Height	6.1 cm
Average Lichen Biomass	4.1 g/m^2

* Identified ranges pending update from Ministère des Forêts, de la Faune et des Parcs (Sabrina Plante)

Area C: Labrador City

This 939km^2 area is divided into two sections; Section A is 267km^2 in size and Section B is 672km^2 in size (Figure 4). Both sections are located east of Labrador City, Labrador, and are accessible by the Trans Labrador Highway (TLH; previously QC-389).

Both areas are comprised of dense boreal forest (black spruce dominated) with a similar proportion of open lichen woodlands and/or forests with lichen as compared to Area B. There are also a significant number of water features (bodies and courses), similar to Area B. Section A, the section closer to Labrador City, has been recently disturbed by a very large forest fire (burn date 2013), as well as a smaller burn in 1992[1]. Section B has minimal disturbance by forest fire, with only small areas burned (2013, and 1990[1]). Observed anthropogenic disturbances within Area C include but may not be limited to:

1. The TLH (paved, 2-lane);
2. A hydro power transmission line and ROW;
3. The iron ore rail line and associated gravel roads/pads;
4. Ross Bay Junction airport; and,
5. Private cottages and associated gravel access roads.

Figure 6 (Appendix A) displays these and other features of interest within Area C.

Very few publically accessible secondary roads exist along this section of TLH, therefore our field work was limited to sites that could be safely accessed from the highway. Four sites (C1, C6, C7, and C8) were accessed and surveyed within Area C on July 26 and 27, 2019.

Figure 4: A screenshot from Google Earth showing the location of Area C (yellow) in relation to Labrador City, Labrador.

Unfortunately, high-resolution satellite imagery was not available for the entire ordered extent of Area C (yellow polygons in Figure 8 above). As a result we adjusted the location of pre-selected sites to ensure they fell within the available imagery extents (Figure 9).

Site C1

The site is located within Section A of Area C, approximately 15km east of Labrador City, Labrador. This site is entirely within the 2013 forest fire footprint[1]. We accessed the site on July 26, 2019 by parking at the wide gravel entrance to a private road and hiking approximately 150m to the southwest. Landsat imagery of the site in 2004 showed apparently abundant lichen cover in open areas between trees. Therefore, we classified the site as recently disturbed black spruce dominated forest with lichen. As all observed ground conditions were comparable, we selected our LCMP survey area based solely upon the UAV flight plan extents and ease of access. Additional LCMP surveys were conducted throughout the site, including some riparian areas that appeared to have been less disturbed by the forest fire. These plots are not visible in the UAV photographs.

Table C-1 summarizes all field work that we completed at the site. Table C-2 provides an overall summary of the site, data, and key field observations. Figure 7 (Appendix A) displays the site location and high-resolution satellite imagery.

Table C-1: Completed Field Work (Site C1)

Main LCMP	Yes
Additional LCMP	10 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	0 samples*
Biomass Sampling Method	H1, M4
Leaf Area Index	Yes
Soil Texture Analysis	Yes
UAV Flight – Hover above Micro-Plots	Yes-Mavic 11 (1.6mm)
UAV Flight – 1cm Resolution	Yes-Mavic
UAV Flight – 2cm Resolution	Yes-Mavic
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

*No lichen present at site due to recent fire disturbance

Table C-2: Site Summary (Site C1)

Site Center Point Coordinates	52°58.720' N, 66°41.985' W
Date of Field Survey	July 26, 2019
Identified Caribou Herd Range(s)	N/A – closest is Québec (8km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 07/11/2016
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Recently disturbed (burn) black spruce dominated forest with lichen
Dominant Lichen Specie(s)	N/A (no lichen)
Land Cover Assesssment (30m Resolution)	VLDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, 0% density, regrowth
Site Soil Texture Description	Surficial soils were assessed at one location. Poorly graded, moderate-to-well drained sands. - Surface to 10cmbg: burned organic material. - 10 to 15cmbg: very fine, light grey silty sand (SM). - >15cmbg: coarse, brown, compact sand, with gravel and some fines (SM).
Average Lichen Cover (rounded to nearest 5%)	N/A
Average Lichen Height	N/A
Average Lichen Biomass	N/A

Site C6

The site is located within Section B of Area C, approximately 35km east of Labrador City, Labrador. We accessed the site on July 27, 2019 by parking at a gravel pad associated with the rail line, and hiking across the TLH approximately 500m to the northwest. We classified the site as a high-density black spruce dominated forest with lichen. We selected our LCMP survey area based upon the UAV flight plan extents. Additional LCMP surveys were conducted throughout the site. While at this site the persistently cloudy conditions lightened enough for our team to collect a few spectrometer readings for *C. stellaris* and *C. stereocaulon*.

Table C-3 summarizes all field work that we completed at the site. Table C-4 provides an overall summary of the site, data, and key field observations. Figure 8 (Appendix A) displays the site location and high-resolution satellite imagery.

Table C-3: Completed Field Work (Site C6)

Main LCMP	Yes
Additional LCMP	16 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	5 samples
Biomass Sampling Method	H1, M2
Leaf Area Index	Yes
Soil Texture Analysis	Yes
UAV Flight – Hover above Micro-Plots	Yes-Mavic
UAV Flight – 1cm Resolution	Yes-Inspire
UAV Flight – 2cm Resolution	Yes-Inspire
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

Table C-4: Site Summary (Site C6)

Site Center Point Coordinates	53°03.947' N, 66°25.610' W
Date of Field Survey	July 27, 2019
Identified Caribou Herd Range(s)	N/A – closest is Québec (4.5km SW)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/12/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce dominated forest with lichen
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	HDC
Site Land Cover Description (30m Resolution)	Undulating, <5% slope, 3-10m tall mature black spruce, 60-40% density
Site Soil Texture Description	Surficial soils were assessed at one location. Poorly graded, moderate-to-well drained sands. - Surface to 10cmbg: organic material. - 10 to 15cmbg: very fine, light grey silty sand (SM). - >15cmbg: coarse, brown, compact sand, with gravel and some fines (SM).
Average Lichen Cover (rounded to nearest 5%)	65%
Average Lichen Height	8.4 cm
Average Lichen Biomass	7.7 g/m^2

Site C7

The site is located within Section B of Area C, approximately 30km east of Labrador City, Labrador. We accessed the site on July 26, 2019 by parking at a gravel pad associated with the rail line, and hiking approximately 450m to the southwest. The hike included one water crossing (flooded ditch, ~1ft depth) and bushwhacking through dense underbrush. We classified the site as a medium density black spruce dominated forest with some lichen. We selected our LCMP survey area based upon the UAV flight plan extents. Additional LCMP surveys were conducted throughout the site. Approximately half-way through the 1cm resolution UAV survey it began to rain. As a result we were unable to complete the survey, or conduct the 2cm resolution survey.

Table C-5 summarizes all field work that we completed at the site. Table C-6 provides an overall summary of the site, data, and key field observations. Figure 9 (Appendix A) displays the site location and high-resolution satellite imagery.

Table C-5: Completed Field Work (Site C7)

Main LCMP	Yes
Additional LCMP	12 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	4 samples
Biomass Sampling Method	H1, M4
Leaf Area Index	No
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	Yes-Mavic
UAV Flight – 1cm Resolution	Yes-Mavic*
UAV Flight – 2cm Resolution	No
Close Range Video of Micro-Plots	Yes
Tree Cores (from CFS)	No

*Issues with cloud points. Needs to be worked on manually or try adding more frames.

Table C-6: Site Summary (Site C7)

Site Center Point Coordinates	53°03.830' N, 66°27.987' W
Date of Field Survey	July 27, 2019
Identified Caribou Herd Range(s)	N/A – closest is Québec (3.5km S)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/12/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce dominated forest with some lichen
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	MDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, 3-10m tall mature black spruce, 60-40% density
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	15%
Average Lichen Height	4.6 cm
Average Lichen Biomass	0.5 g/m^2

Site C8

The site is located within Section B of Area C, approximately 50km east of Labrador City, Labrador. We accessed the site on July 27, 2019 by parking at a gravel pad associated with the rail line, and hiking across the rail line approximately 250m to the west. We classified the site as an ericaceous lichen woodland. The site had extremely high lichen ground cover (>90%) and was estimated to be in a successional climax state for lichen woodlands. We selected our LCMP survey area based upon the UAV flight plan extents. One additional LCMP surveys was conducted.

Table C-7 summarizes all field work that we completed at the site. Table C-8 provides an overall summary of the site, data, and key field observations. Figure 10 (Appendix A) displays the site location and high-resolution satellite imagery.

Table C-7: Completed Field Work (Site C8)

Main LCMP	Yes
Additional LCMP	1 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	5 samples
Biomass Sampling Method	H1, M2
Leaf Area Index	Yes
Soil Texture Analysis	Yes
UAV Flight – Hover above Micro-Plots	Yes 11(?mm)
UAV Flight – 1cm Resolution	Yes
UAV Flight – 2cm Resolution	Yes
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

Table C-8: Site Summary (Site C8)

Site Center Point Coordinates	53°04.031' N, 66°12.408' W
Date of Field Survey	July 27, 2019
Identified Caribou Herd Range(s)	N/A – closest are Québec (13.5km SW) and Lac Joseph (11km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 07/16/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Ericaceous lichen woodland
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	MDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, >10m tall mature black spruce, 40-25% density
Site Soil Texture Description	Surficial soils were assessed at one location. Poorly graded, well drained sands. - Surface to 5cmbg: organic material. - 5 to 10cmbg: fine, grey sand (SP). - >10cmbg: very coarse, brown, compact sand, with gravel >2mm (SP).
Average Lichen Cover (rounded to nearest 5%)	90%
Average Lichen Height	7.3 cm
Average Lichen Biomass	6.8 g/m^2

Area D: Churchill Falls

This 669km^2 area is divided into two sections; Section A is 272km^2 in size and Section B is 397km^2 in size (Figure 5). Both sections are located west of Churchill Falls, Labrador. Section A includes the Ossokmanuan Reservoir/TLH crossing point and is accessible by the TLH. Section B is located approximately 15km north of Section A and is accessible by Esker Road, which meets TLH at point 53°38.291'N, 64°35.285'W.

Both areas are comparable to Area C, being comprised of dense boreal forest (black spruce dominated), open lichen woodlands and/or forests with lichen. This area appears to have more wetlands and wet areas than the others. Two relatively small areas within Section A were disturbed by forest fires (burn dates 1989 and 1991[1]). A slightly larger portion of Section B was disturbed by forest fires (burn dates 1989 and 1990[1]). Other observed anthropogenic disturbances within Area D include but may not be limited to:

1. The TLH (paved, 2-lane);
2. The hydro power transmission line and ROW; and,
3. Private cottages and associated gravel access roads.

Figure 11 (Appendix A) displays these and other features of interest within Area D.

Four sites (D2, D3, D9a, and D9b) were accessed and surveyed within Area D on July 28, 29, and 31, 2019.

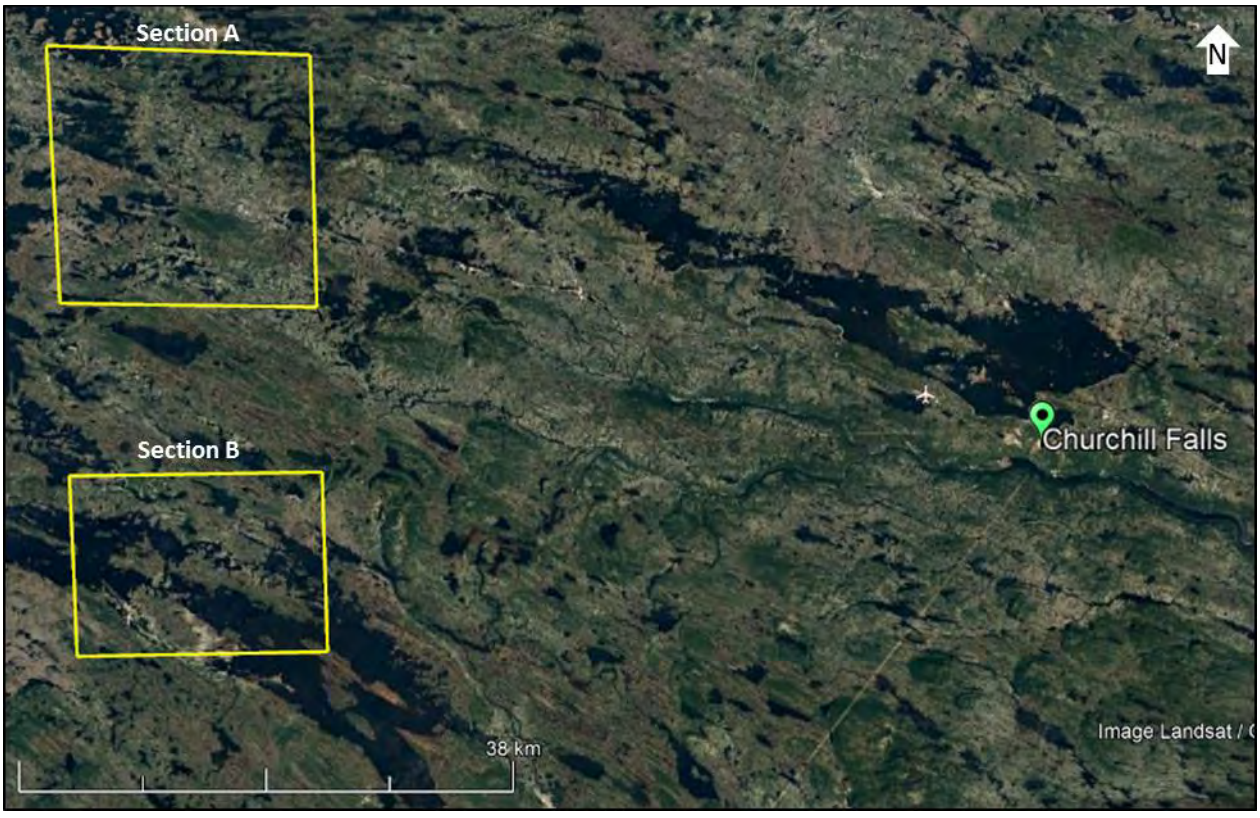


Figure 5: A screenshot from Google Earth showing the location of Area D (yellow) in relation to Churchill Falls, Labrador.

Site D2

The site is located within Section A of Area D, approximately 75km west of Churchill Falls, Labrador. We access the site on July 31, 2019 by parking on the side of the TLH and hiking approximately 300m northeast

through a previously burned area (burn date 1989[1]). We classified the site as a very-high density black spruce and balsam fir forest. We selected our LCMP survey area based upon the UAV flight plan extents. Due to the extremely dense canopy cover and tree heights >30m, it was not possible to conduct the low-altitude UAV flights. Therefore we only completed one UAV survey, collecting data at 2cm ground resolution.

Table D-1 summarizes all field work that we completed at the site. Table D-2 provides an overall summary of the site, data, and key field observations. Figure 12 (Appendix A) displays the site location and high-resolution satellite imagery.

Table D-1: Completed Field Work (Site D2)

Main LCMP	Yes
Additional LCMP	No
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	2 samples
Biomass Sampling Method	H2, M3
Leaf Area Index	Yes
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	No
UAV Flight – 1cm Resolution	No
UAV Flight – 2cm Resolution	Yes-Mavic
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

Table D-2: Site Summary (Site D2)

Site Center Point Coordinates	53°24.195' N, 65°04.385' W
Date of Field Survey	July 31, 2019
Identified Caribou Herd Range(s)	N/A – closest is Lac Joseph (4.5km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/06/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce and balsam fir forest with little to no lichen
Dominant Lichen Specie(s)	*C. stygia*
Land Cover Assessment (30m Resolution)	HDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, SW aspect, >10m tall mature black spruce and balsam fir, >60% density
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	5%
Average Lichen Height*	3.95 cm
Average Lichen Biomass*	0.2 g/m^2

*results are based on two samples

Site D3

The site is located within Section A of Area D, approximately 60km west of Churchill Falls, Labrador. We access the site on July 28, 2019 by parking on the side of the TLH and hiking approximately 500m southwest through a previously burned area (burn date 1991[1]), across a dry riverbed and up a steep slope. We classified the site as a medium density black spruce forest with some lichen. Some of the trees in the undisturbed portion of the site were observed to be very tall (>30m). We selected our LCMP survey area within an undisturbed portion of the site, and conducted some additional MP surveys within the disturbed portion.

Table D-3 summarizes all field work that we completed at the site. Table D-4 provides an overall summary of the site, data, and key field observations. Figure 13 (Appendix A) displays the site location and high-resolution satellite imagery.

Table D-3: Completed Field Work (Site D3)

Main LCMP	Yes
Additional LCMP	4 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	4 samples
Biomass Sampling Method	H1, M4
Leaf Area Index	Yes
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	Yes-Mavic
UAV Flight – 1cm Resolution	Yes-Mavic
UAV Flight – 2cm Resolution	Yes-Mavic
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

Table D-4: Site Summary (Site D3)

Site Center Point Coordinates	53°28.737' N, 64°51.555' W
Date of Field Survey	July 28, 2019
Identified Caribou Herd Range(s)	N/A – closest is Lac Joseph (4.5km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/06/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Black spruce forest with very little lichen
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	MDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, >10m tall mature black spruce, 60-40% density
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	20%
Average Lichen Height	4.0 cm
Average Lichen Biomass	0.6 g/m^2

Site D9

This site is located within Section B of Area D, approximately 65km northwest of Churchill Falls, Labrador. The site was partially burned by a forest fire in 1990[1], the scar of which divides the site nearly in half.

On July 29, 2019 our team was joined by two members of CFS (André Aresenault and Katherine Flores) as well as one member of the Government of Newfoundland and Labrador (Isabelle Schmelzer). To maximize efficiency we decided to conduct two surveys at the site D9, one within the undisturbed forest (D9a) and a second within an area that had been burned by forest fire in 1990[1] (D9b). We accessed both sites on July 29, 2019 by parking at a gravel pad adjacent to Esker Road and hiking approximately 150m north (D9a) and 270m northeast (D9b).

The results of this work are summarized for each site separately in the following sections.

Site D9a

We classified the site as a medium density black spruce forest with lichen, and discovered a caribou skull at the site. This confirms the area has been used by caribou in the past. As ground conditions were comparable throughout the Site, we selected our LCMP survey area based on the UAV flight plan.

Table D-7 summarizes all field work that we completed at the site. Table D-8 provides an overall summary of the site, data, and key field observations. Figure 14 (Appendix A) displays the site location and high-resolution satellite imagery.

Table D-7: Completed Field Work (Site D9a)

Main LCMP	Yes
Additional LCMP	5 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	5 samples
Biomass Sampling Method	H1, H2, M4
Leaf Area Index	Yes
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	Yes-Mavic 11 (1mm)
UAV Flight – 1cm Resolution	Yes-Inspire
UAV Flight – 2cm Resolution	Yes-Inspire
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	Yes – 7 total

Table D-8: Site Summary (Site D9a)

Site Center Point Coordinates	53°41.089' N, 64°53.138' W
Date of Field Survey	July 29, 2019
Identified Caribou Herd Range(s)	N/A – closest is Lac Joseph (4.5km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/06/2017
Average Stand Age (from cores)	125 years
Maximum Stand Age (from cores)	125 years
Lichen Site Description	Black spruce forest with lichen
Dominant Lichen Specie(s)	*C. stellaris*
Land Cover Assessment (30m Resolution)	MDC
Site Land Cover Description (30m Resolution)	Flat, <5% slope, >10m tall mature black spruce, 40-25% density
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	55%
Average Lichen Height	9.0 cm
Average Lichen Biomass	5.5 g/m^2

Site D9b

We classified the site as a recovering burn and selected our LCMP survey area based on the UAV flight plan. Table D-9 summarizes all field work that we completed at the site. Table D-10 provides an overall summary of the site, data, and key field observations. Figure 14 (Appendix A) displays the site location and high-resolution satellite imagery.

Table D-9: Completed Field Work (Site D9b)

Main LCMP	Yes
Additional LCMP	No
Land Cover Assessment (30m Resolution)	No
Lichen Biomass Sample Collection	7 samples
Biomass Sampling Method	H2, M4
Leaf Area Index	No
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	Yes-Mavic
UAV Flight – 1cm Resolution	Yes-Mavic
UAV Flight – 2cm Resolution	Yes-Inspire*
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	No

*Same flight as D9a, so it doesn't have micro plots in it

Table D-10: Site Summary (Site D9b)

Site Center Point Coordinates	53°41.151' N, 64°52.959' W
Date of Field Survey	July 29, 2019
Identified Caribou Herd Range(s)	N/A – closest is Lac Joseph (4.5km SE)
Available High-Resolution Imagery	WV-2 (8-band) Date: 06/06/2017
Average Stand Age (from cores)	N/A
Maximum Stand Age (from cores)	N/A
Lichen Site Description	Recovering burn site (1990)
Dominant Lichen Specie(s)	*C. uncialis, C. gracillus, pixie cups, crustose lichen*
Land Cover Assessment (30m Resolution)	N/A
Site Land Cover Description (30m Resolution)	N/A
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	45%
Average Lichen Height	2.9 cm
Average Lichen Biomass	1.0 g/m^2

Area D: Churchill Falls – Additional Sites

Based on recommendations to our team by Isabelle Schmelzer with the Government of Newfoundland and Labrador, two additional sites (D15 and D16) were selected and added to Area D (Figure 6). These sites were chosen based on the results of the provincial ecological land classification (ELC)[4] that was shared with us by Isabelle, in combination with her extensive knowledge of caribou behaviour within the region.

Both sites are located approximately 90km east of Churchill Falls and were easily accessed on July 30, 2019 by a secondary gravel road (fair condition). These are the only two sites we visited where evidence of caribou grazing was observed. Unfortunately, we do not yet have high-resolution satellite imagery for these areas, however we are planning to task the satellite for data acquisition.

Figure 6: A screenshot from Google Earth showing the location of additional Area D sites (yellow) in relation to Churchill Falls, Labrador.

Site D15

This site was mostly comprised of areas classified in the ELC[4] as Lichen Woodland, Lichen-Shrub Woodland, or Forest-Some Lichen (Figure 15). The site had extremely high lichen ground cover (>90%) and was estimated to be in a state of successional climax for lichen woodlands. There was clear evidence of caribou grazing activity. Based on lichen species within the caribou grazing craters we determined that the site has been regularly foraged by caribou over the past five years. We selected our LCMP survey area based upon the UAV flight plan extents. Six additional LCMP surveys were conducted.

Table D-11 summarizes all field work that we completed at the site. Table D-12 provides an overall summary of the site, data, and key field observations. Figure 16 (Appendix A) displays the site location and low-resolution satellite imagery (high-resolution unavailable).

Table D-10: Completed Field Work (Site D15)

Main LCMP	Yes
Additional LCMP	6 total
Land Cover Assessment (30m Resolution)	Yes
Lichen Biomass Sample Collection	11 samples
Biomass Sampling Method	H2, M3
Leaf Area Index	Yes
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	Yes-Mavic
UAV Flight – 1cm Resolution	Yes-Mavic
UAV Flight – 2cm Resolution	Yes-Mavic
Close Range Video Survey of Micro-Plots	Yes
Tree Cores (from CFS)	Yes – 8 total

Table D-11: Site Summary (Site D15)

Site Center Point Coordinates	53°18.285' N, 62°41.867' W
Date of Field Survey	July 30, 2019
Identified Caribou Herd Range(s)	Red Wine Mountain
Available High-Resolution Imagery	N/A – must task satellite for acquisition
Average Stand Age (from cores)	165 years
Maximum Stand Age (from cores)	168 years
Lichen Site Description	Ericaceous lichen woodland
Dominant Lichen Specie(s)	*C. stellaris* In grazing craters: *C. uncialis, C. gracillus, pixie cups,* other
Land Cover Assessment (30m Resolution)	MDC
Site Land Cover Description (30m Resolution)	Flat to undulating, <5% slope, 3-10m tall mature black spruce, 25-10% density
Site Soil Texture Description	N/A
Average Lichen Cover (rounded to nearest 5%)	81%
Average Lichen Height	7.3 cm
Average Lichen Biomass	5.7 g/m^2

Site D16

Approximately half of this site was comprised of areas classified in the ELC[4] as Lichen Woodland, Lichen-Shrub Woodland, or Forest-Some Lichen (Figure 15). Due to project time constraints, and the similarity of this site's ground conditions to D15, only the 1cm and 2cm UAV surveys were conducted. Figure 17 (Appendix A) displays the site location and freely available satellite imagery (high-resolution unavailable). Table D-12 summarizes the work that was completed at this site.

Table D-12: Completed Field Work (Site D16)

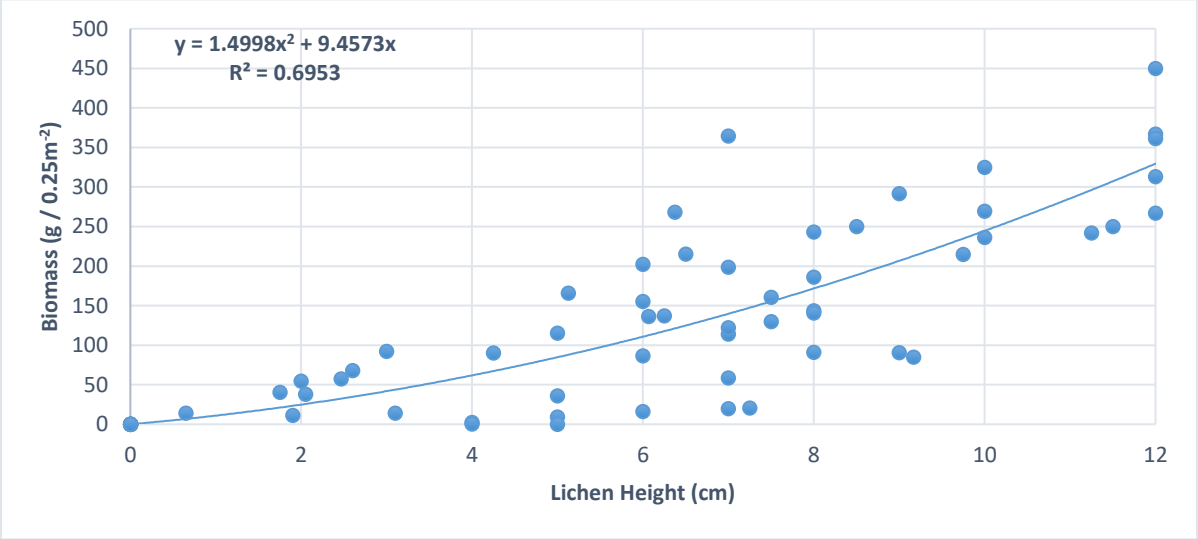
Main LCMP	No
Additional LCMP	0
Land Cover Assessment (30m Resolution)	No
Lichen Biomass Sample Collection	0
Leaf Area Index	No
Soil Texture Analysis	No
UAV Flight – Hover above Micro-Plots	No
UAV Flight – 1cm Resolution	Yes-Inspire
UAV Flight – 2cm Resolution	Yes-Inspire
Close Range Video Survey of Micro-Plots	No
Tree Cores (from CFS)	No

Preliminary Results: Micro-Plot Measurements and Biomass

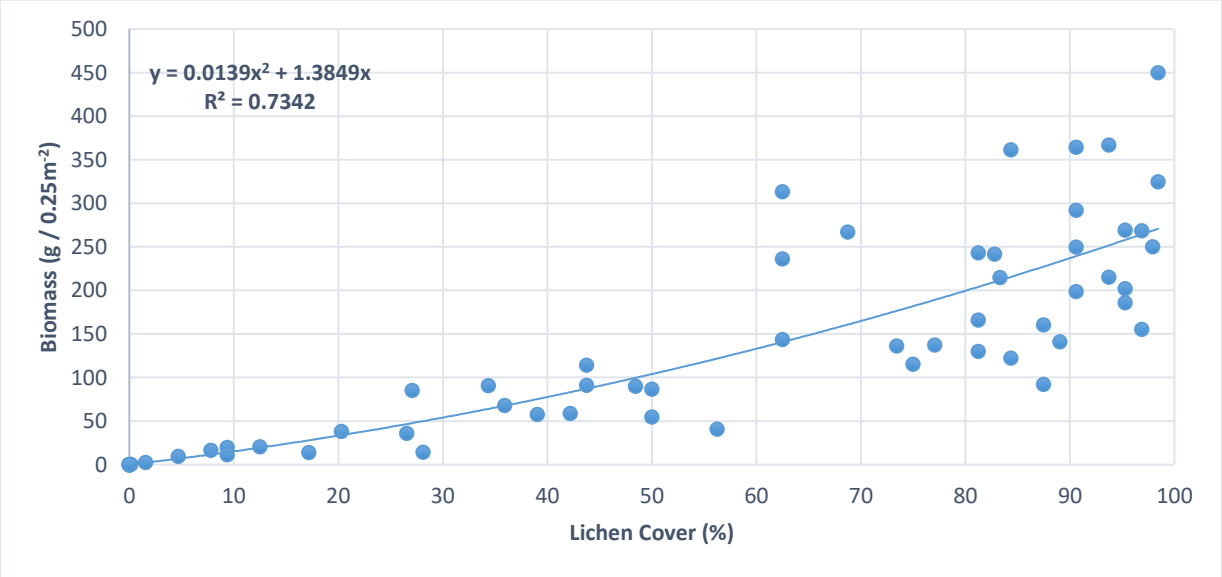
A total of sixty-five (65) micro-plots were randomly selected for biomass sample collection. Eleven (11) of these had no lichen and therefore had biomass values of zero (0). This resulted in a total of fifty-four (54) biomass samples collected during the 2019 field campaign. After returning from the field trip we cleaned the samples of non-lichen debris, oven-dried, and weighed them. We used these weights to calculate biomass for each of the sampled areas.

We plotted the calculated lichen biomass values against three other lichen metrics measured for each plot: lichen height, lichen cover, and lichen volume (Plots 1-3). The results of these comparisons indicate that lichen biomass can be reasonably predicted if lichen height ($R^2 = 0.6953$) or lichen cover ($R^2 = 0.7342$) are known. Unsurprisingly, there is a strong relationship between lichen volume and biomass ($R^2 = 0.8676$).

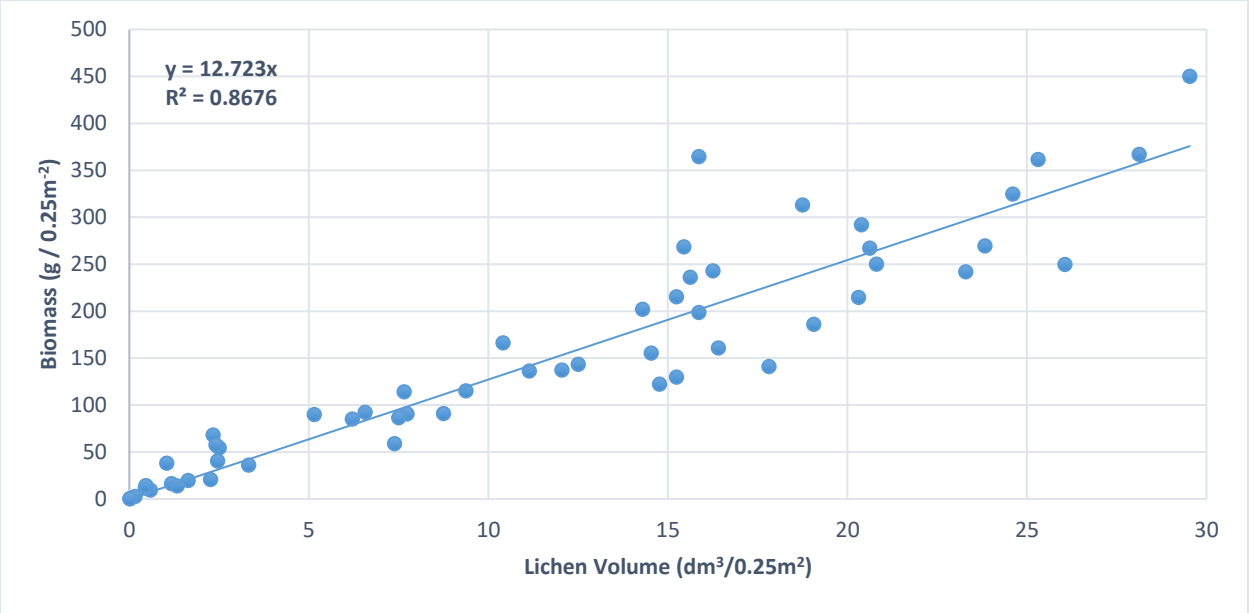
Plot 1: Lichen Biomass ($gm^{-2}/0.25m^2$) vs. Lichen Height (cm)



Plot 2: Lichen Biomass (gm^{-2}) vs. Lichen Cover (%)

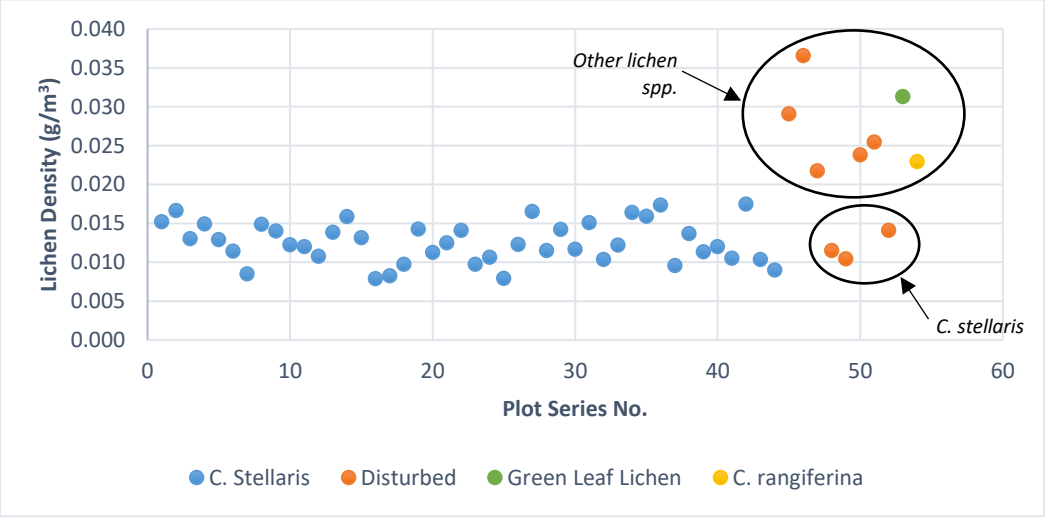


Plot 3: Lichen Biomass (g/0.25m^2) vs. Lichen Volume (dm^3/0.25m^2)



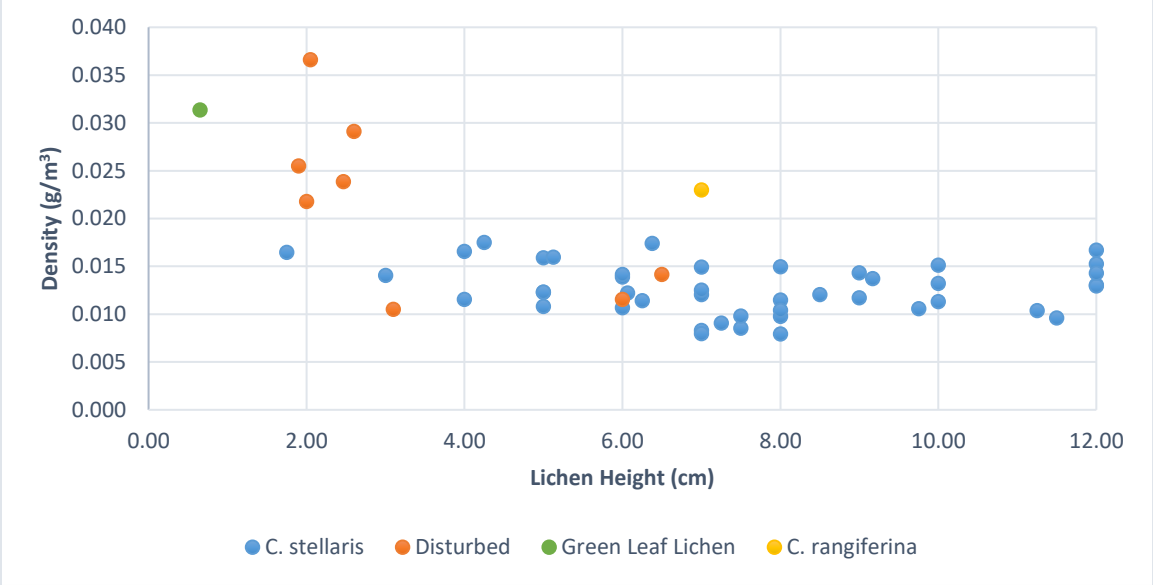
It is important to note that the vast majority of our samples were collected from undisturbed sites where *C. stellaris* was dominant. Only ten (10) samples were collected from sites with significantly different conditions. Eight (8) of the fifty-four (54) biomass samples were collected from disturbed sites (D9b – fire site, and D15 – grazed plot). One (1) biomass sample was comprised of a different lichen species: *C. rangiferina* (site A6), and one (1) biomass sample was comprised of a green leaf lichen (unknown spp.). We highlighted these samples within the biomass comparisons (Plots 1-3) but did not observe significant differences in the derived relationships. This is not overly surprising considering the sample size was very small. However, when we plotted the density of all samples we noted that differences appear to exist between lichen species, but not necessarily between disturbance conditions (Plot 4).

Plot 4: Lichen Density (gm^{-3}) of each Micro-Plot

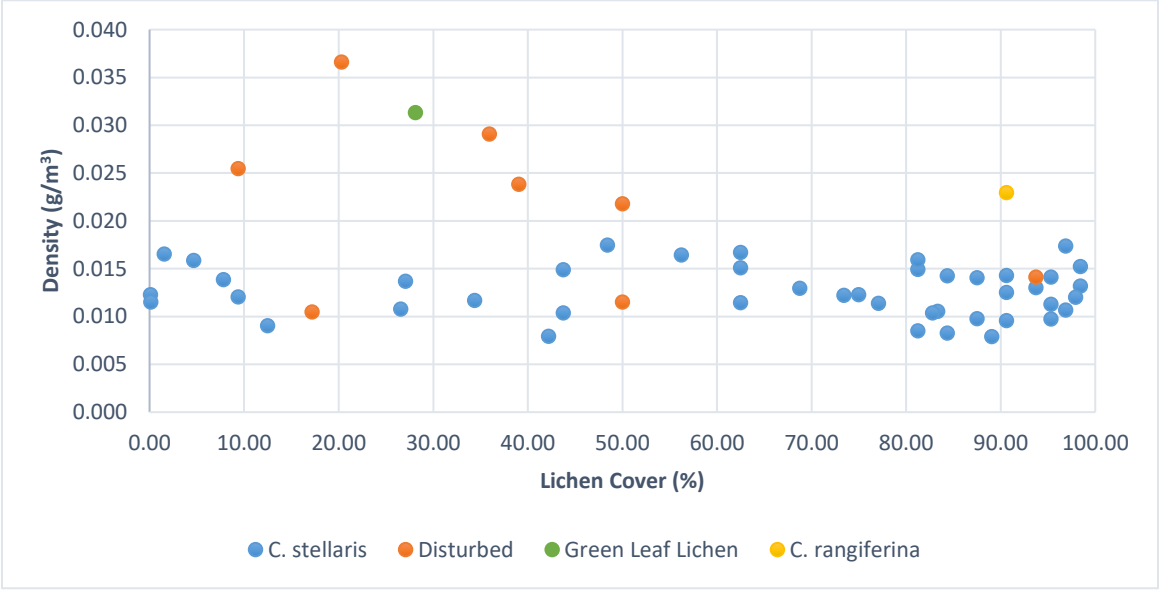


Similarly, differences exist between lichen species when plotting lichen density against height (Plot 5) and cover (Plot 6). From the plots we can see that the density of *C. stellaris* remains constant regardless of height or cover while the other species, especially the early colonizers and leaf lichen, tend to be shorter with very high densities. A lower percent cover is also associated with these conditions. This is not surprising as most plots containing different species were located in disturbed areas and the green leaf lichen was located in a dense forest with little to no observed lichen cover. Had we plotted all observations without distinguishing different lichen species we may have misinterpreted these results.

Plot 5: Lichen Density (gm^{-3}) vs. Lichen Height (cm)

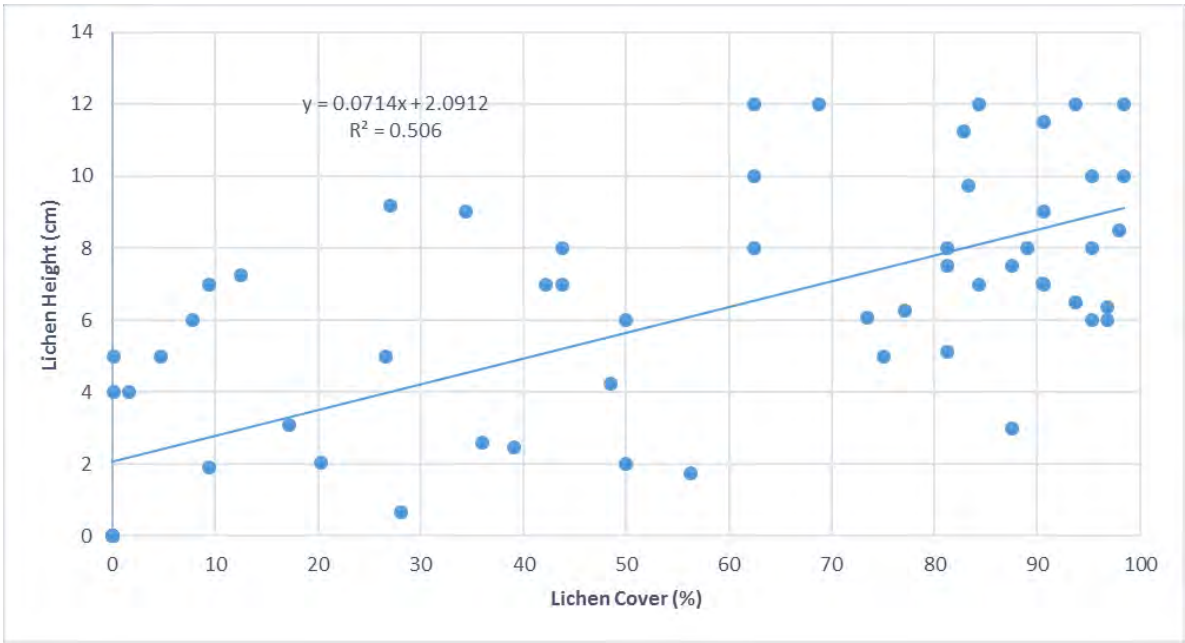


Plot 6: Lichen Density (gm^{-3}) vs. Lichen Cover (%)



As a final comparison we plotted lichen height (cm) against lichen cover (%) (Plot 7). From this plot we derived a linear relationship between the two variables, however the relationship (R^2 = 0.506) is not as strong as those derived in the biomass plots (R^2 > 0.7).

Plot 7: Lichen Height (cm) vs. Lichen Cover (%)



References

1. Natural Resources Canada. (2018). *National Fire Database – Agency Provided Fire Perimeters* [Data file]. Retrieved from: https://cwfis.cfs.nrcan.gc.ca/datamart/metadata/nfdbpoly

2. Gucker, C.L. (2006). Ledum groenlandicum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Retrieved from: https://www.fs.fed.us/database/feis/plants/shrub/ledgro/all.html

3. Ministère des Forêts, de la Faune et des Parcs. (2017). *Produits derives LiDAR* [Data file]. Retrieved from: ftp://transfert.mffp.gouv.qc.ca/Public/Diffusion/DonneeGratuite/Foret/IMAGERIE/Produits_derives_LiDAR/

4. Government of Newfoundland and Labrador. (2013). *Ecological Land Classification* [Data file]. Access provided by Isabelle Schmelzer, June 28, 2019.

Appendix A: Figures

Figure 1.
Area A (Manic 5) Location, Imagery Extents, and Forest Fire Footprints

Kilometers
0 0.75 1.5 3 4.5 6

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- QC-389
- Forest Fire Scar (2003)
- Ordered WV-2 Extents

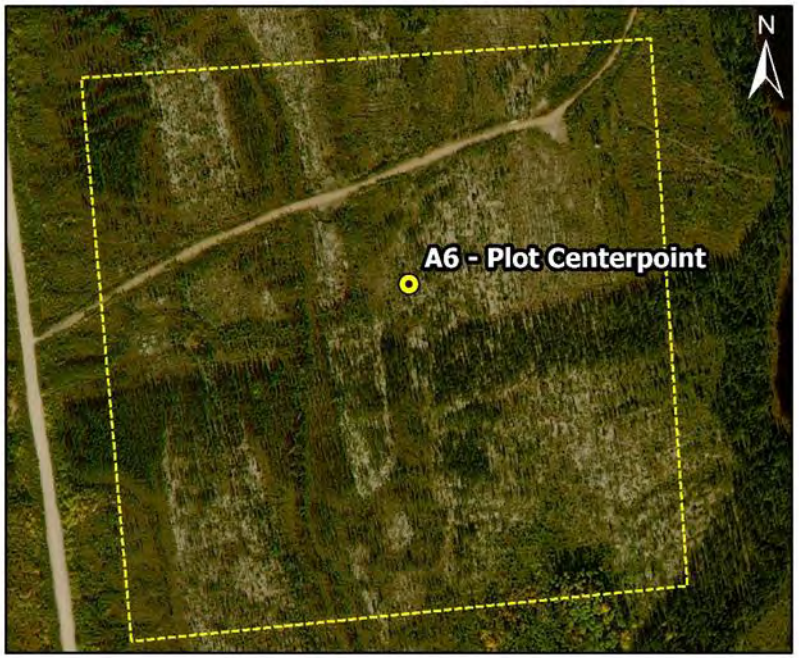
Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

Figure 2.
Area A (Manic 5): Site A6 Location in Relation to Nearby Features of Interest

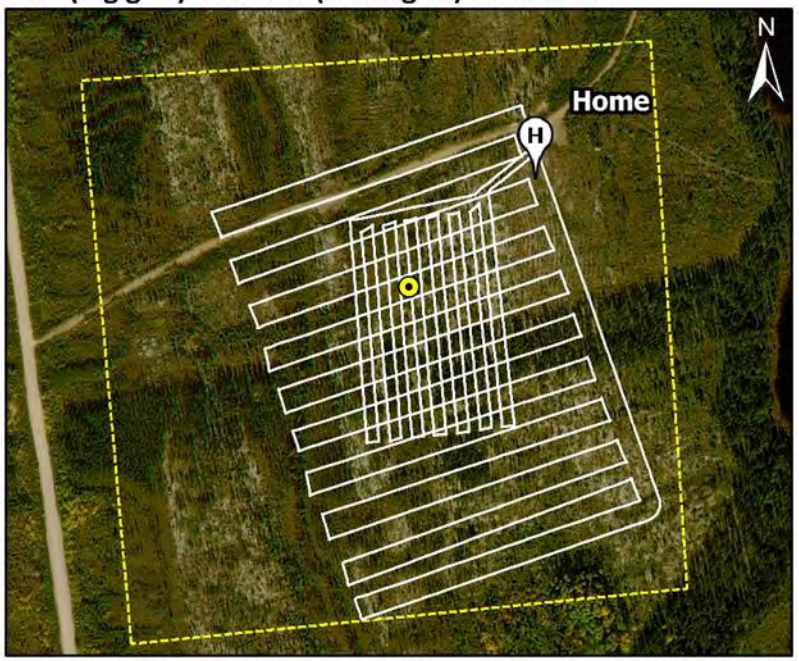
Kilometers
0 0.45 0.9 1.8 2.7 3.6

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point

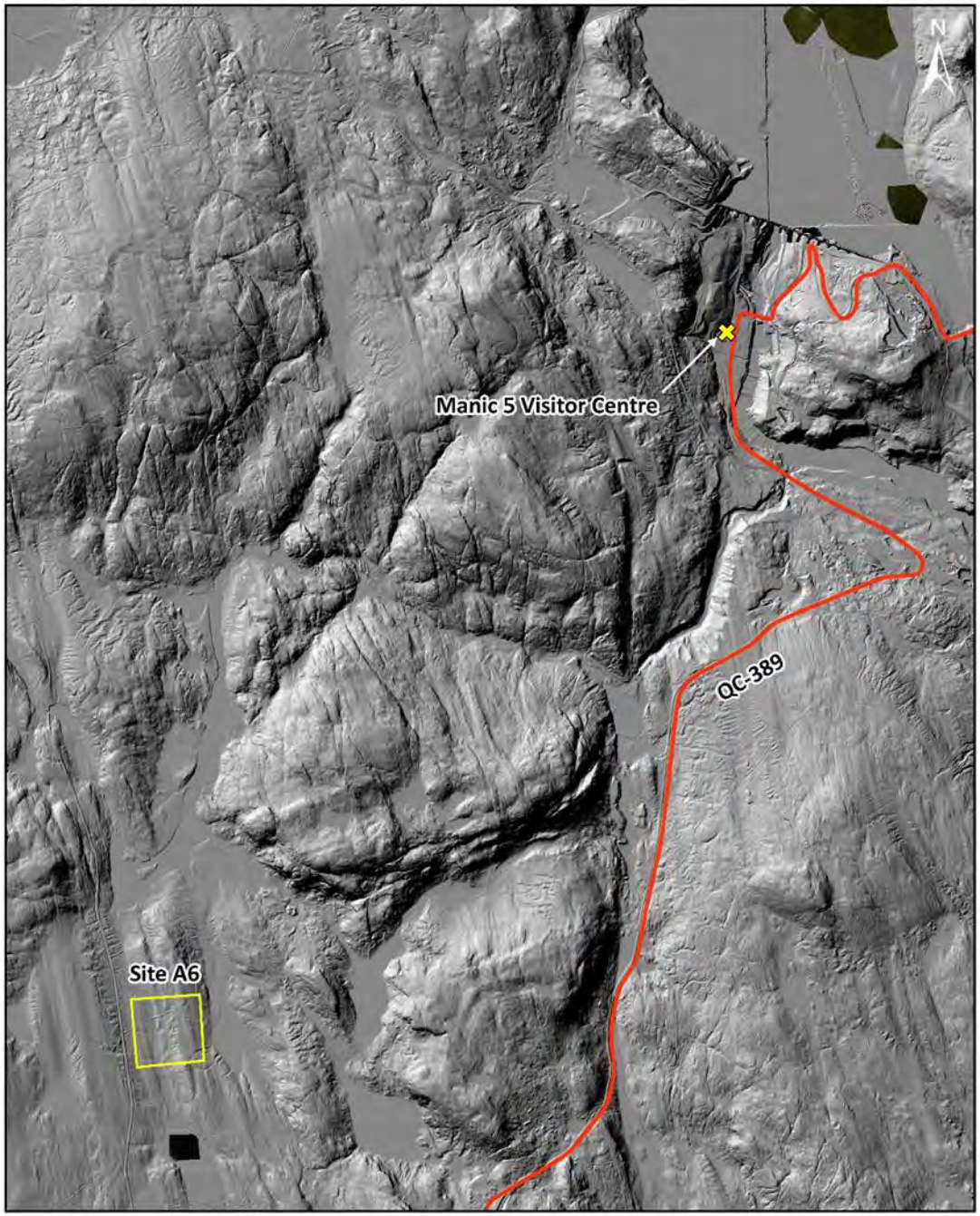


2. UAV Flight Plans:
2cm (big grid) and 1cm (small grid) Resolution



Meters
0 65 130 260 390 520

Figure 3. Digital Elevation Model with Hillshade[1]
Area A (Manic 5): Site A6 Location in Relation to Nearby Features of Interest

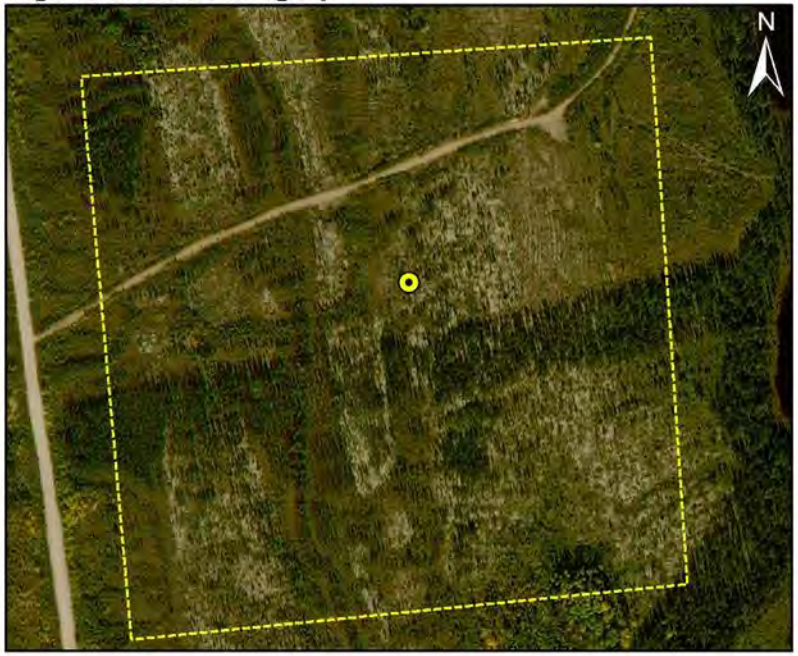


Kilometers
0 0.45 0.9 1.8 2.7 3.6

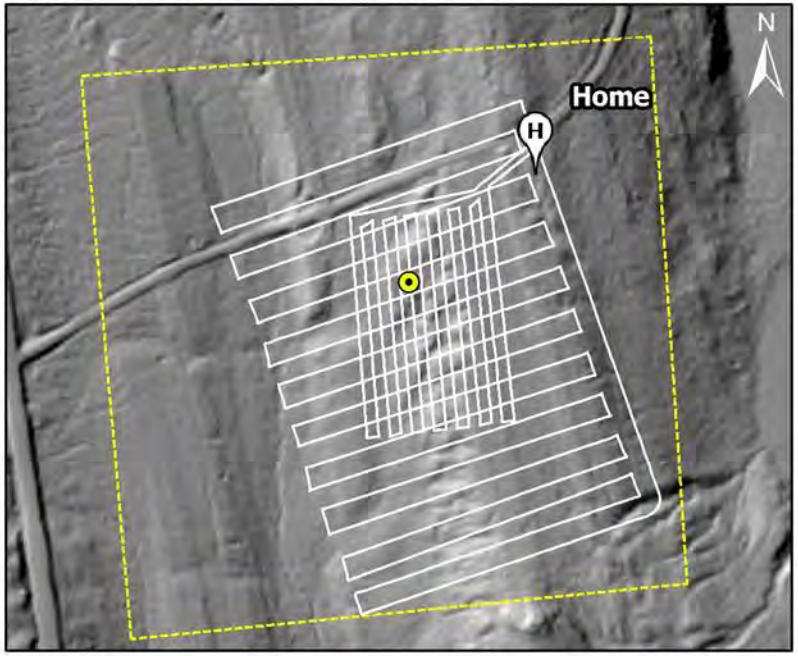
1. Provincial LiDAR product (2m resolution) downloaded from ftp://transfert.mffp.gouv.qc.ca/Public/Diffusion/DonneeGratuite/Foret/IMAGERIE/Produits_derives_LiDAR/

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point (yellow)
High-Resolution Imagery



2. Site Overview and Field Survey Center Point (yellow)
Digital Elevation Model with Hillshade[1]



Meters
0 65 130 260 390 520

Figure 4.
Area B (Fire Lake) Location, Imagery Extents, and Forest Fire Footprints

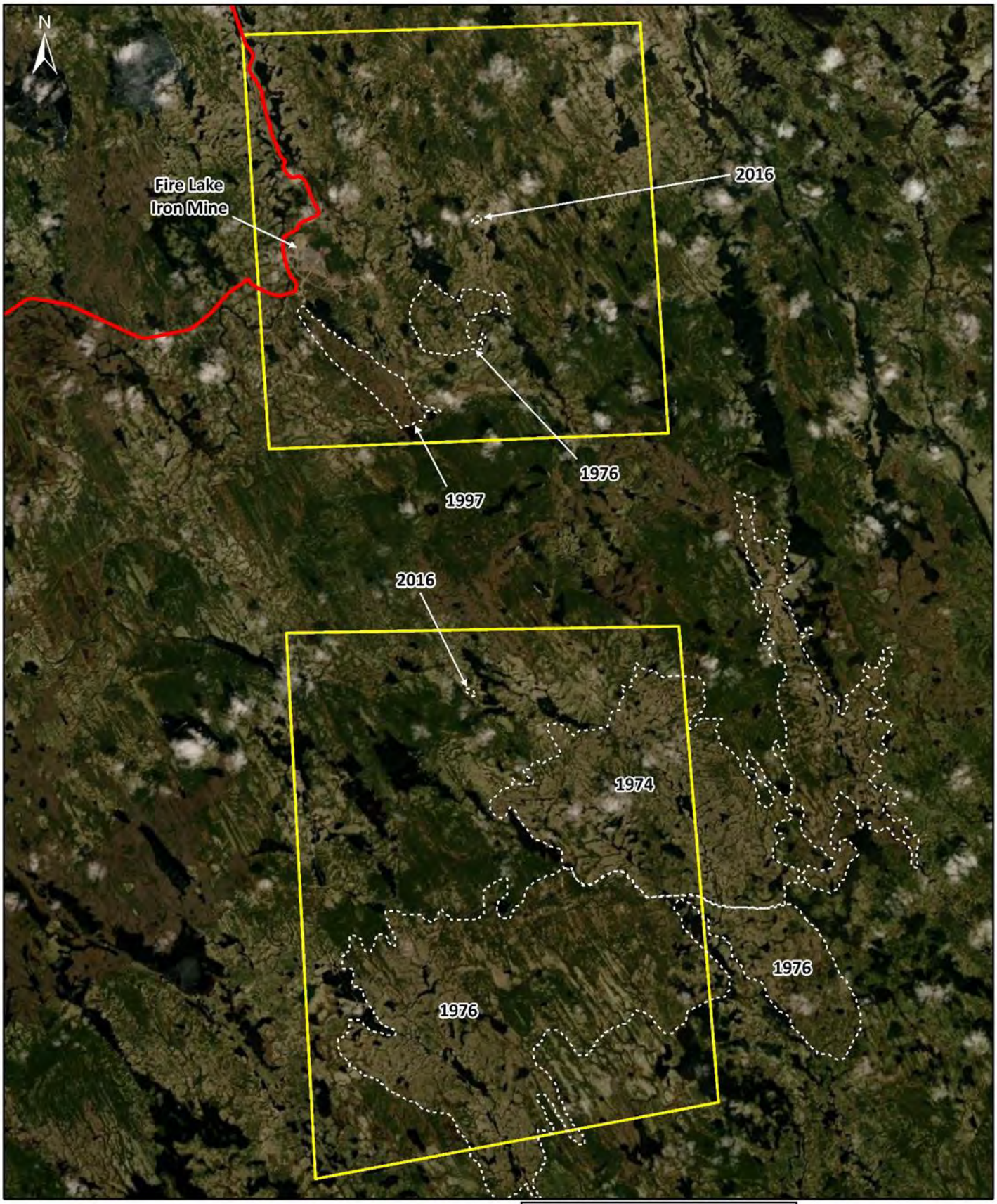
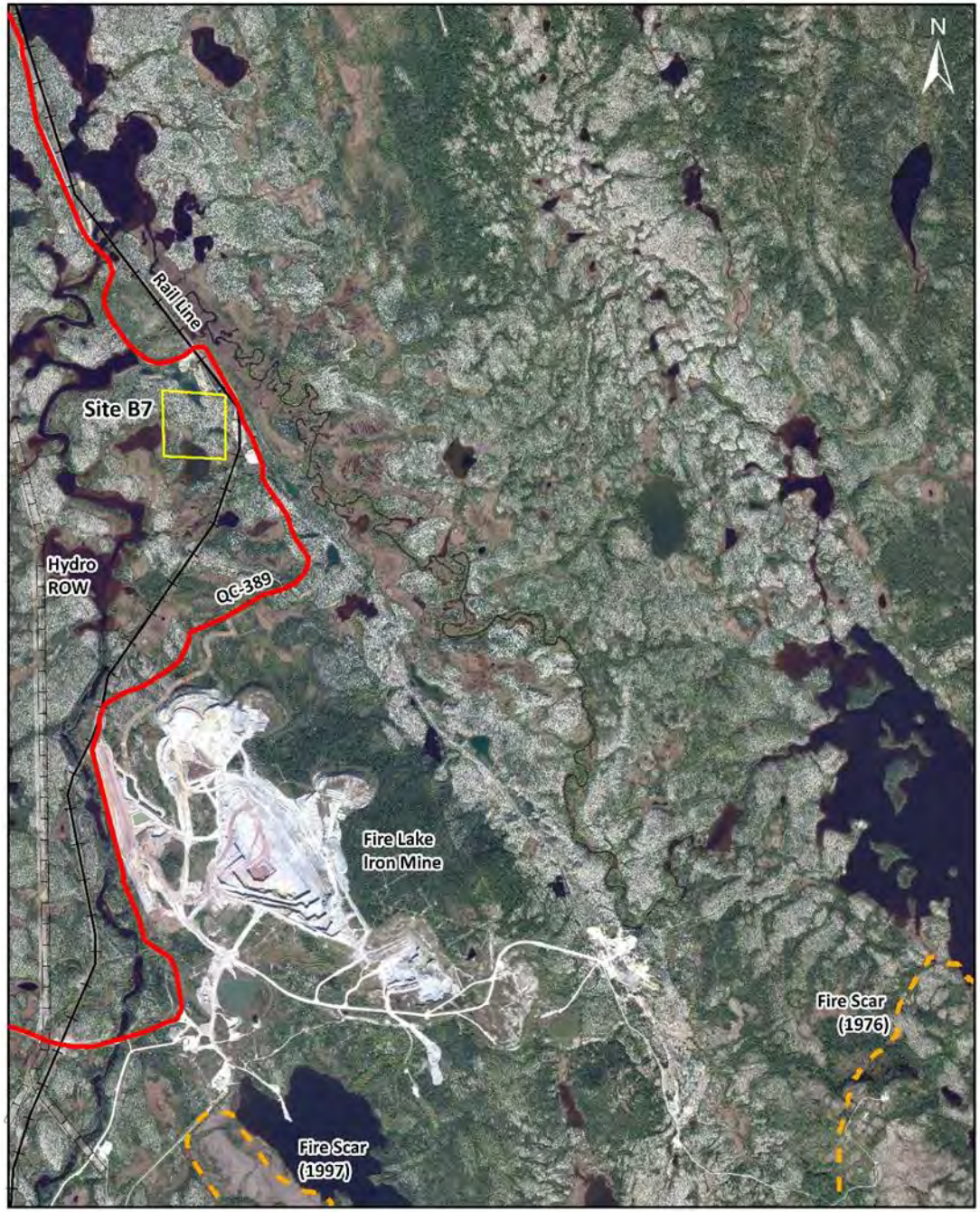


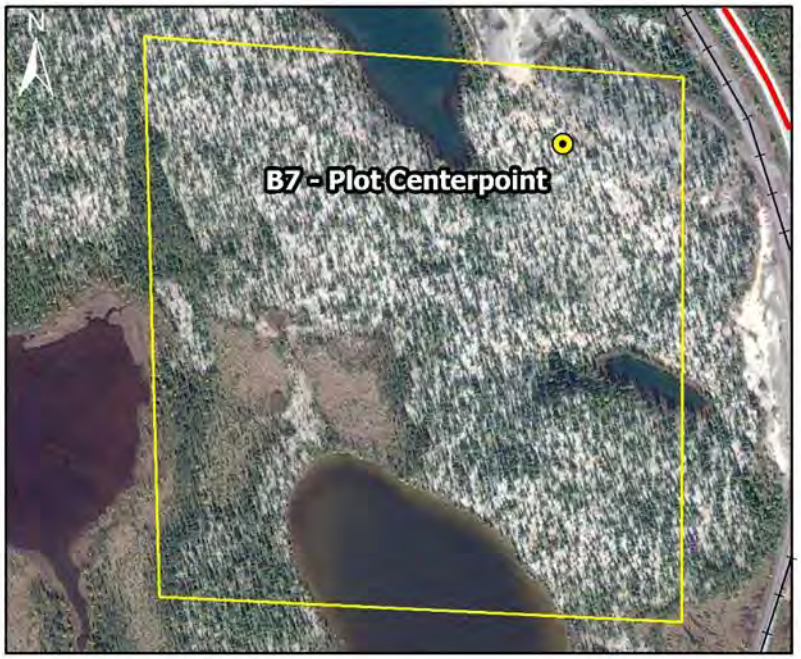
Figure 5.
Area B (Fire Lake): Site B7 Location in Relation to Nearby Features of Interest



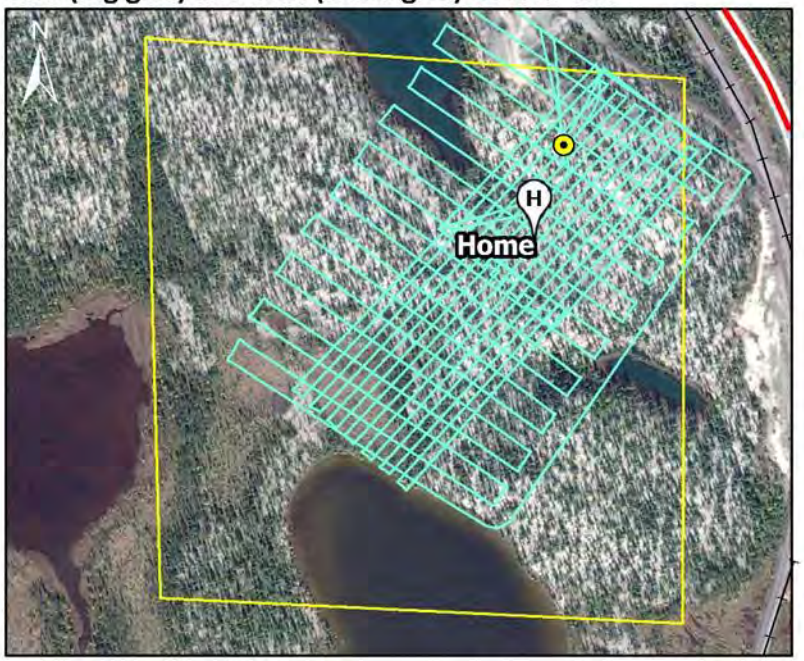
0 0.45 0.9 1.8 2.7 3.6 Kilometers

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plans:
2cm (big grid) and 1cm (small grid) Resolution



0 62.5 125 250 375 500 Meters

Figure 6.
Area C (Labrador City) Location, Imagery Extents, and Forest Fire Footprints

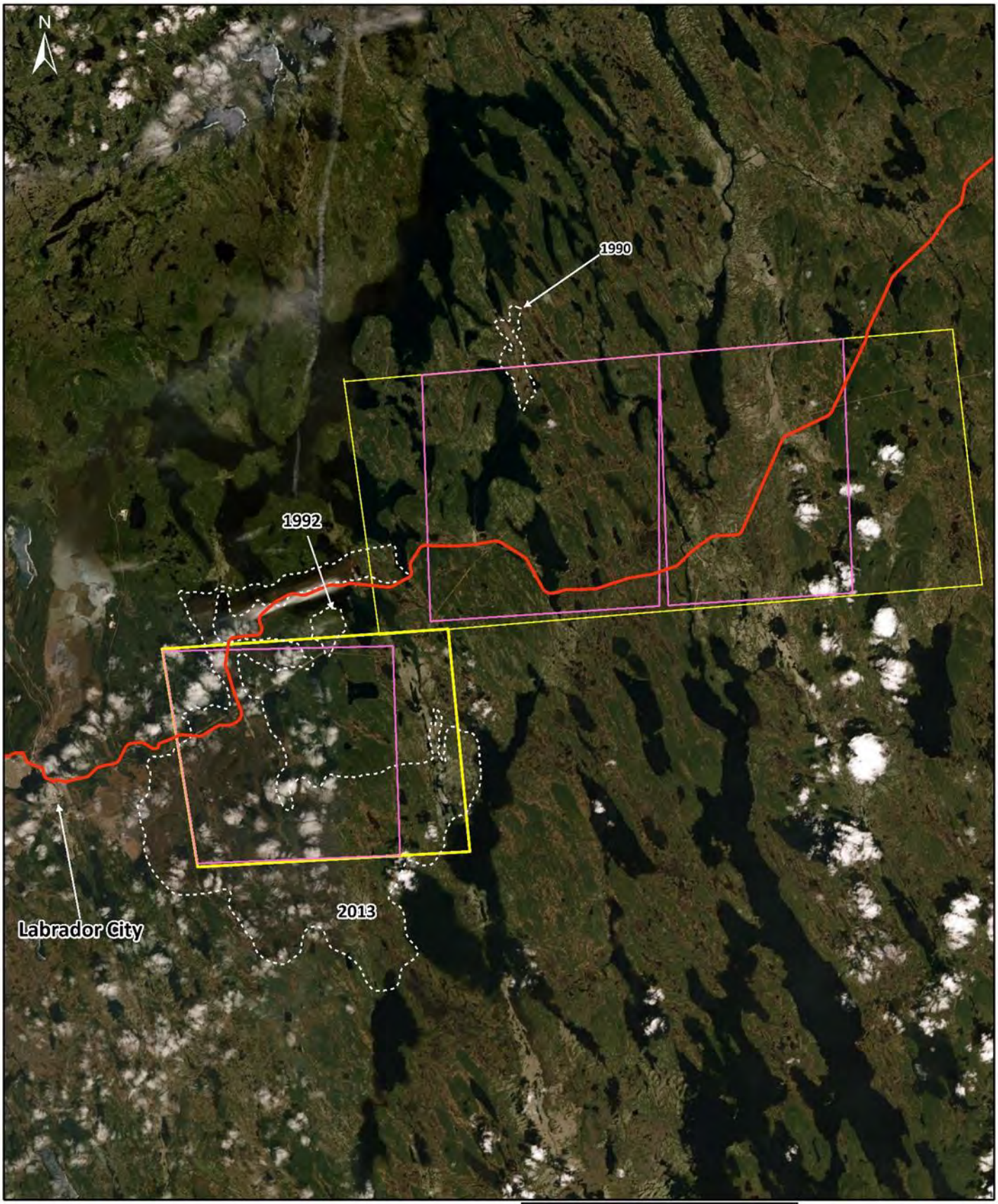
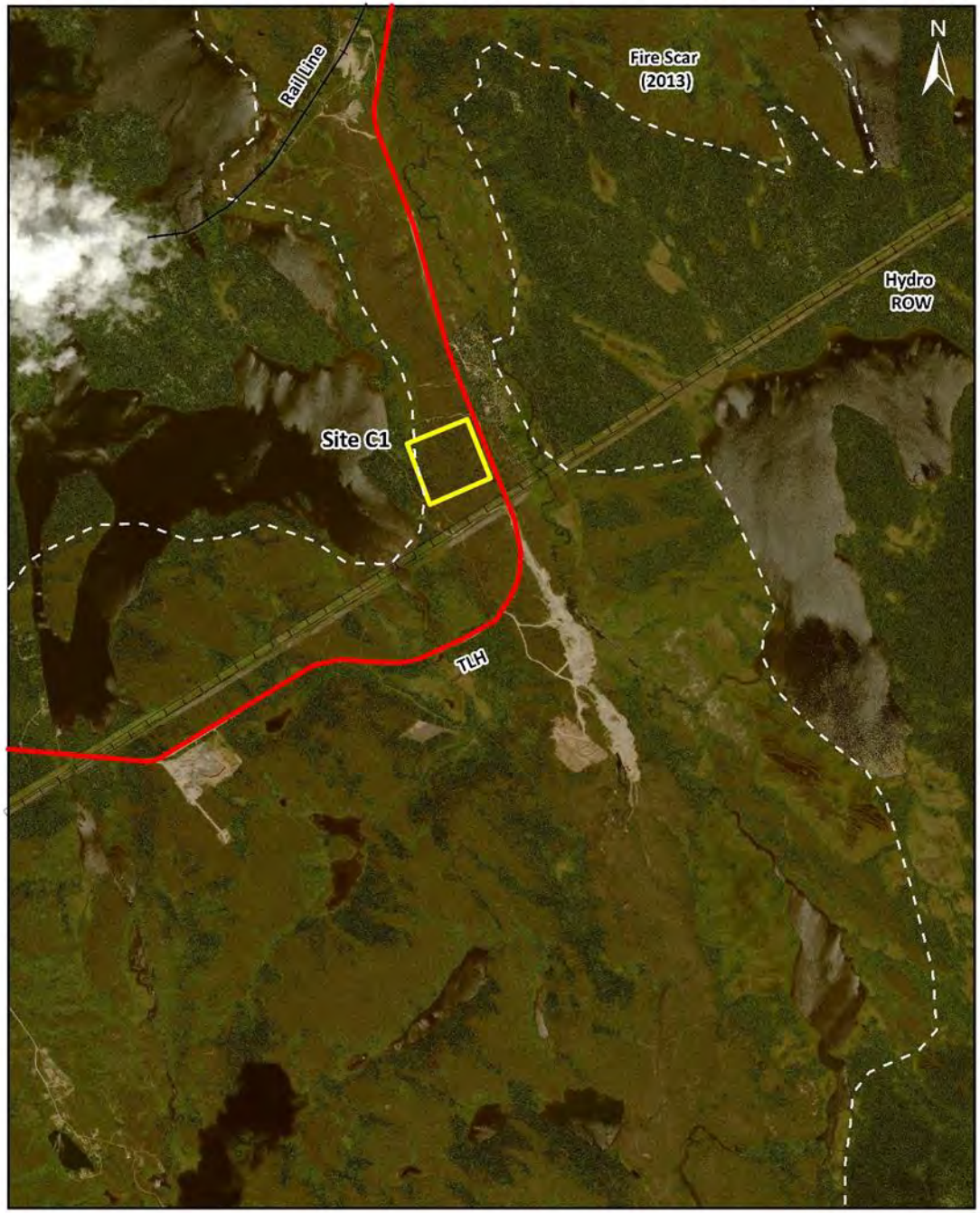
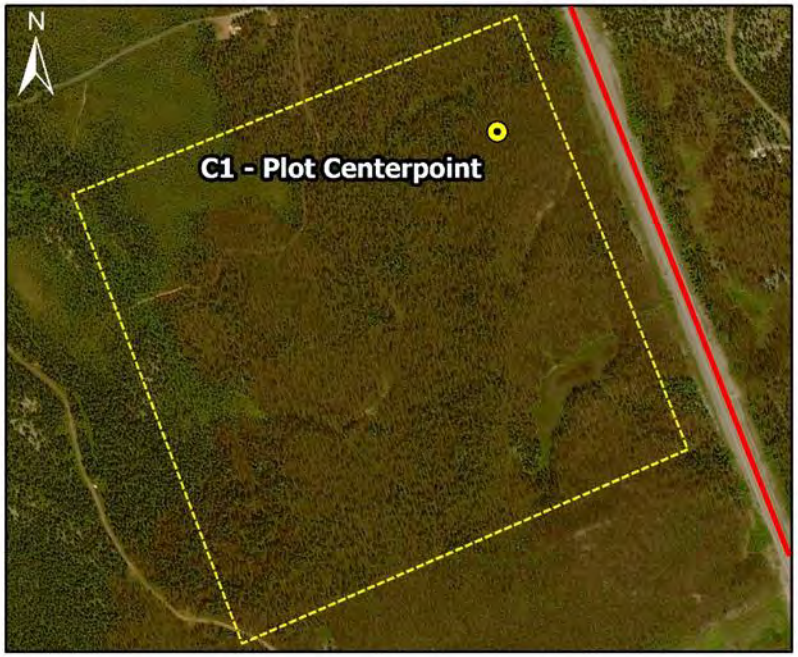


Figure 7.
Area C (Labrador City): Site C1 Location in Relation to Nearby Features of Interest



Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plans:
2cm (big grid) and 1cm (small grid) Resolution

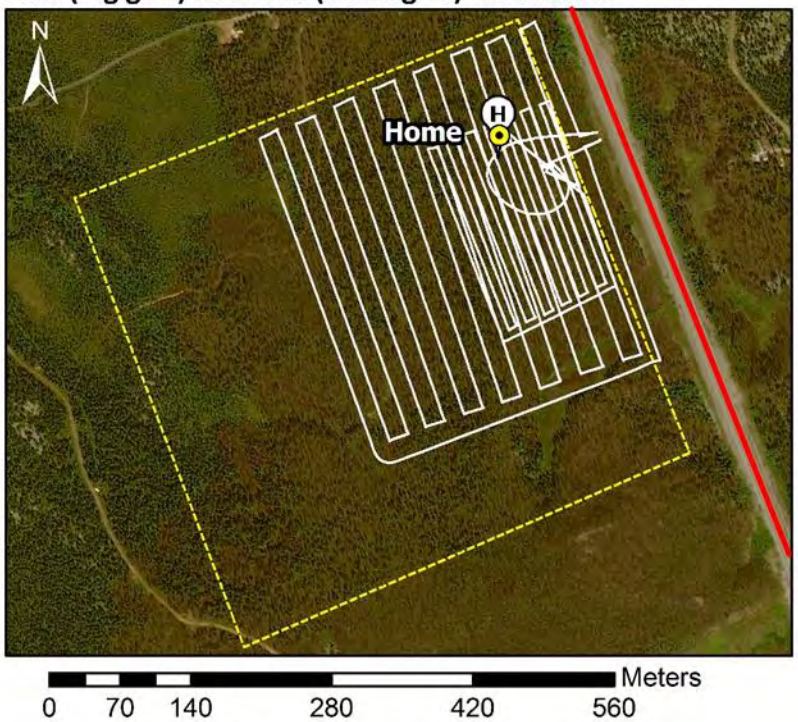


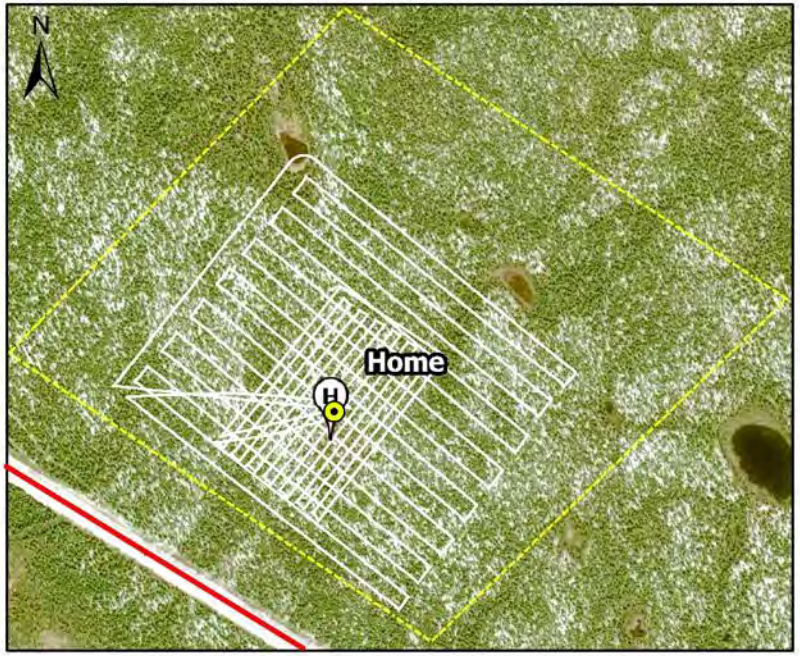
Figure 8.
Area C (Labrador City): Site C6 Location in Relation to Nearby Features of Interest

Kilometers
0 0.25 0.5 1 1.5 2

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point (yellow)

2. UAV Flight Plans:
2cm (big grid) and 1cm (small grid) Resolution



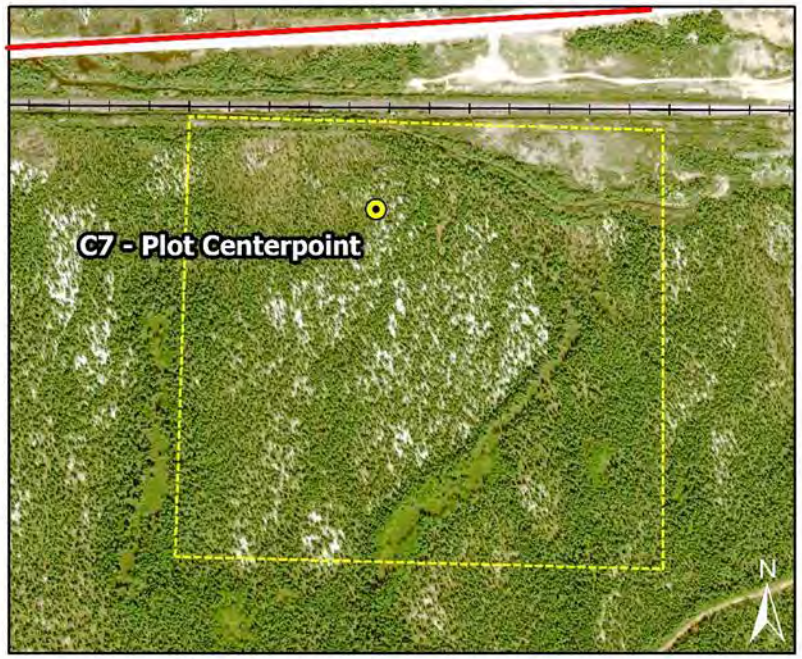
Meters
0 70 140 280 420 560

Figure 9.
Area C (Labrador City): Site C7 Location in Relation to Nearby Features of Interest

Kilometers
0 0.25 0.5 1 1.5 2

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

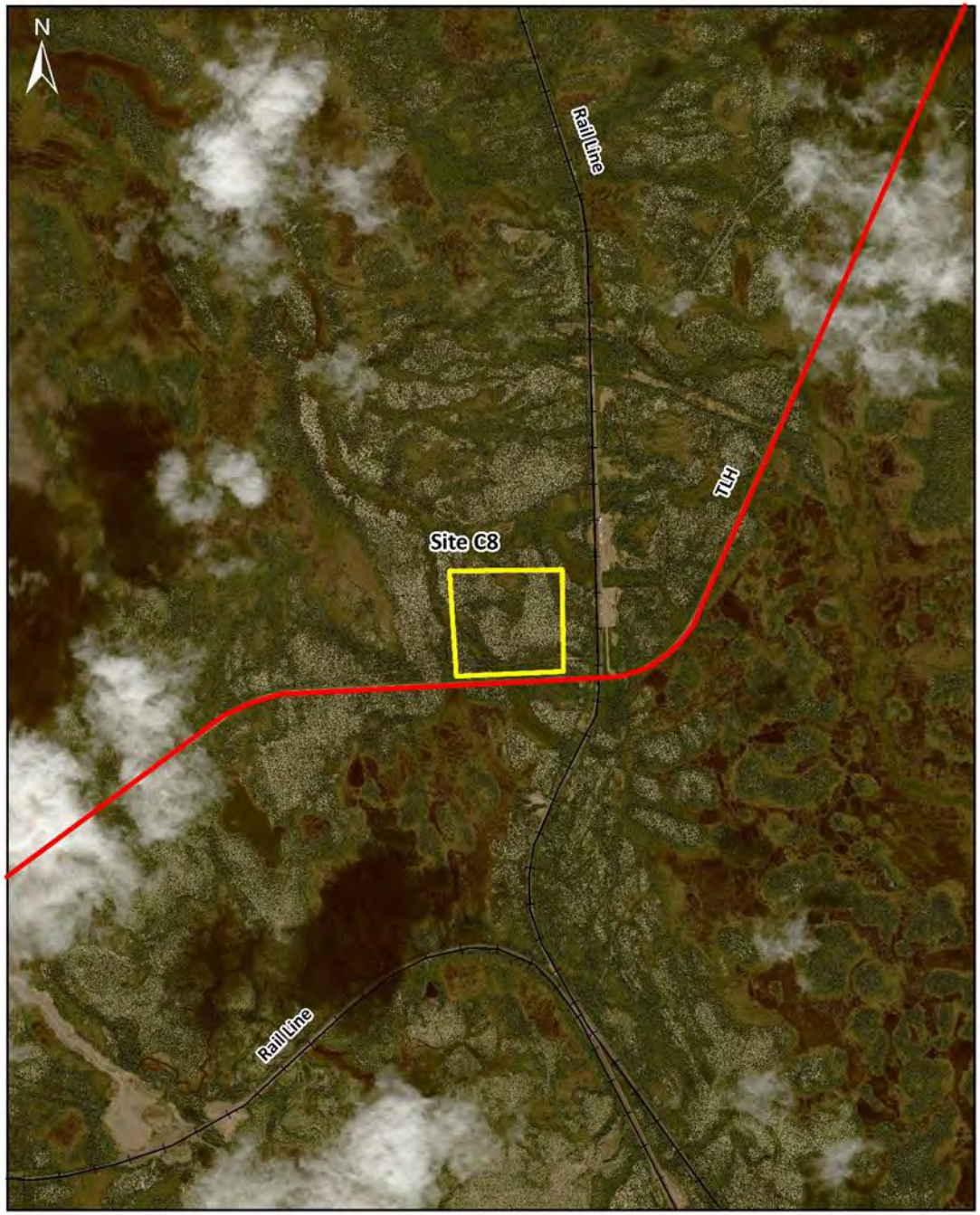
1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plan:
Partial Completion of 1cm Resolution Survey

Meters
0 70 140 280 420 560

Figure 10.
Area C (Labrador City): Site C8 Location in Relation to Nearby Features of Interest



Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview and Field Survey Center Point (yellow)

2. UAV Flight Plan:
2cm (big grid) and 1cm (small grid) Resolution

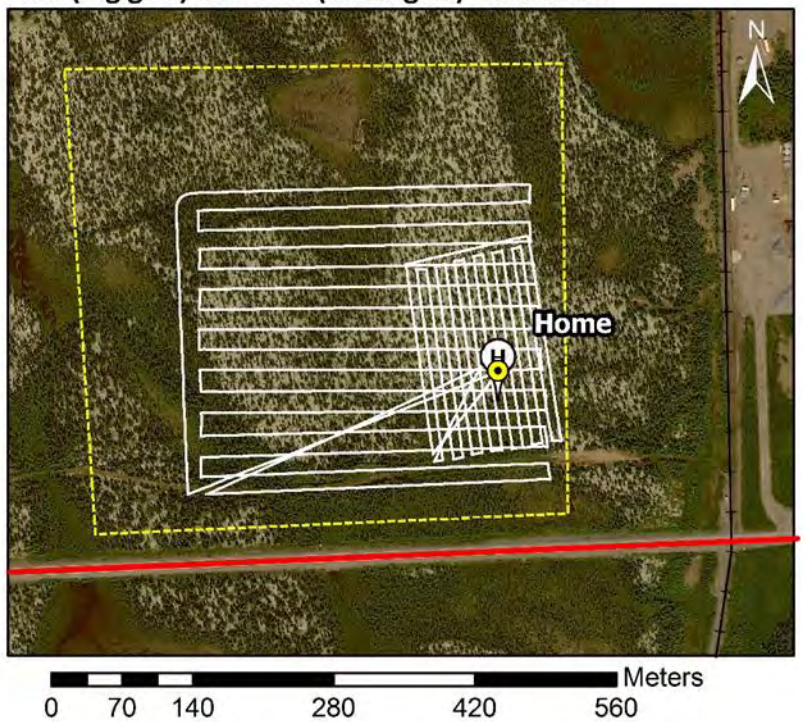
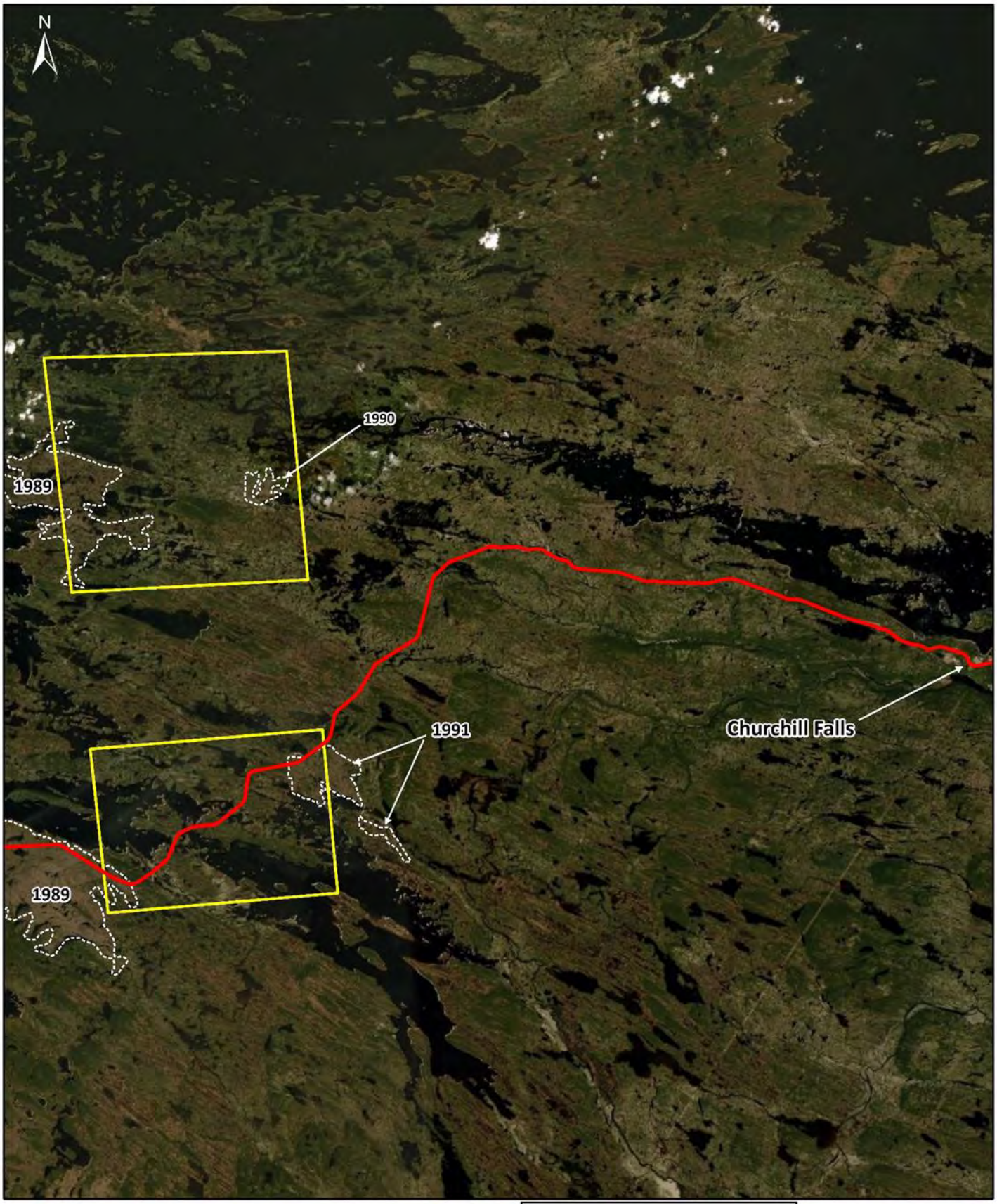


Figure 11.
Area C (Labrador City) Location, Imagery Extents, and Forest Fire Footprints



0 4 8 16 24 32 Kilometers

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

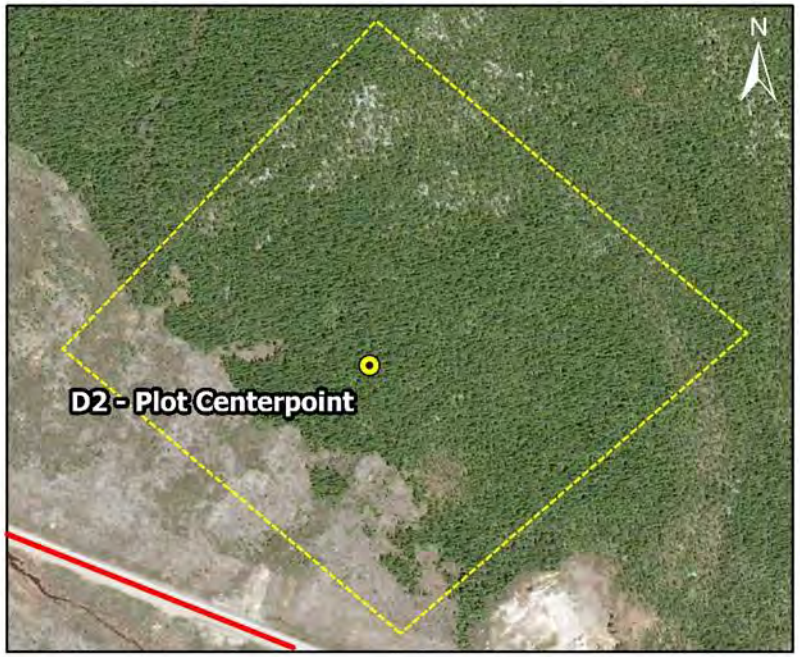
- TLH
- Forest Fire Scars
- Ordered WV-2 Extents

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

Figure 12.
Area D (Churchill Falls): Site D2 Location in Relation to Nearby Features of Interest

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

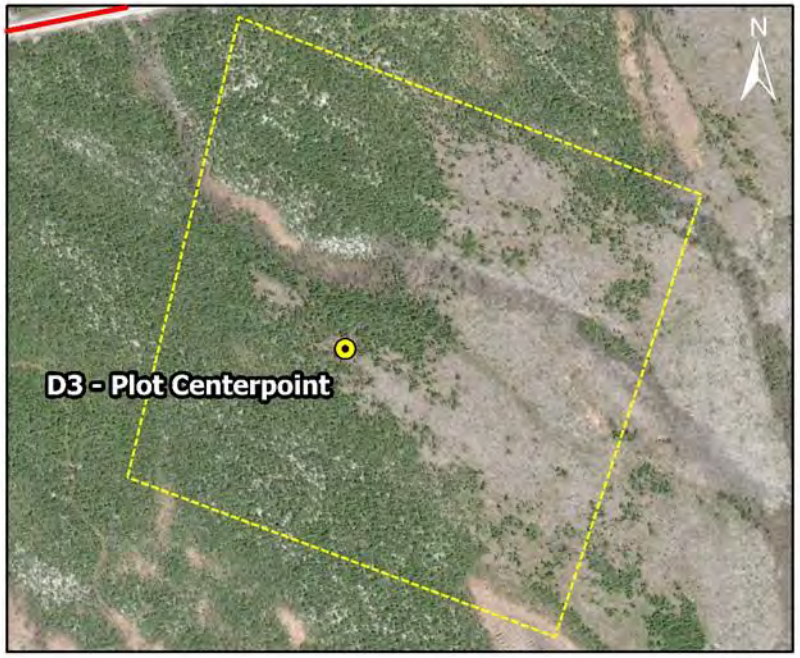
1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plan: 2cm Resolution Survey

Figure 13.
Area D (Churchill Falls): Site D3 Location in Relation to Nearby Features of Interest

1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plan:
2cm (big grid) and 1cm (small grid) Resolution

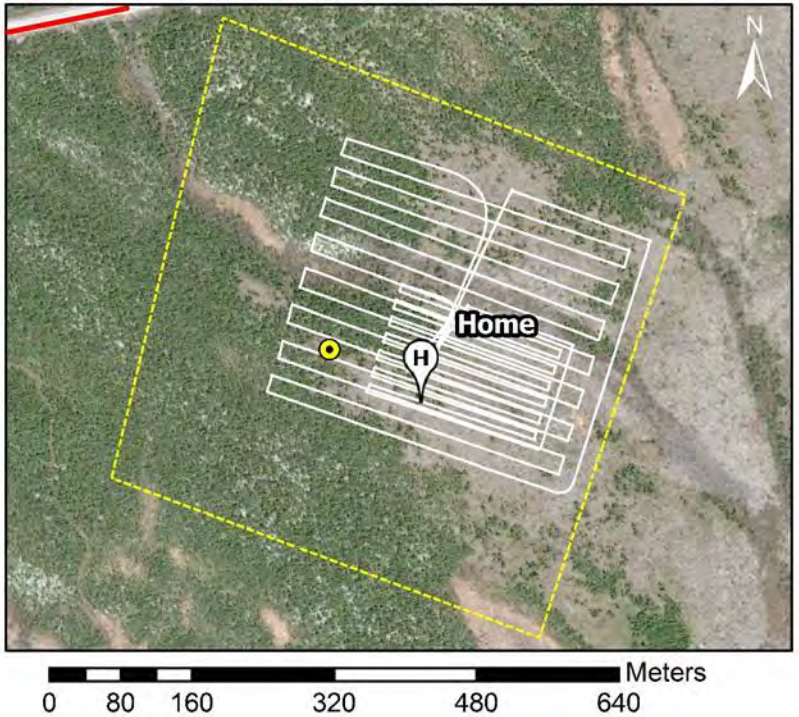
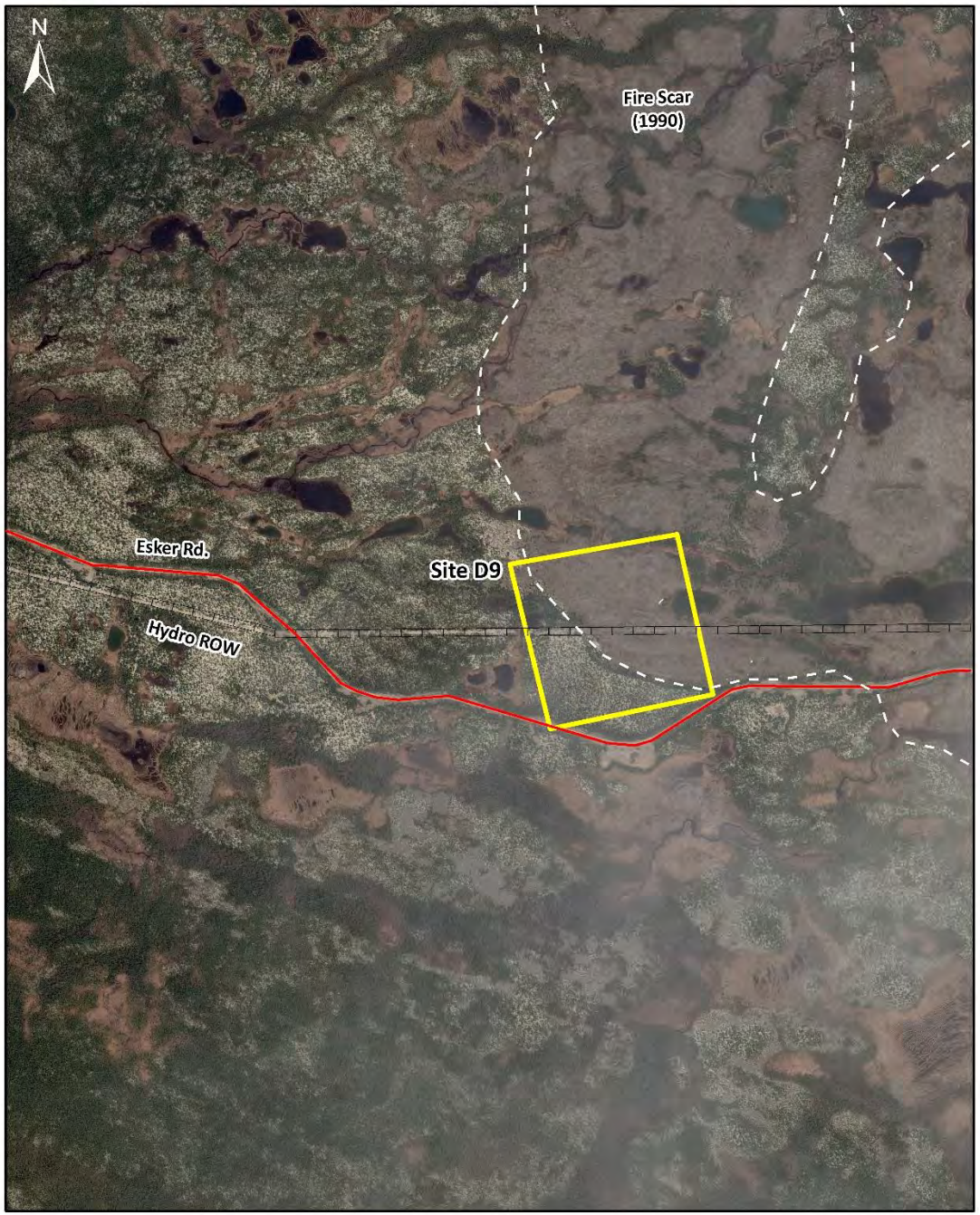
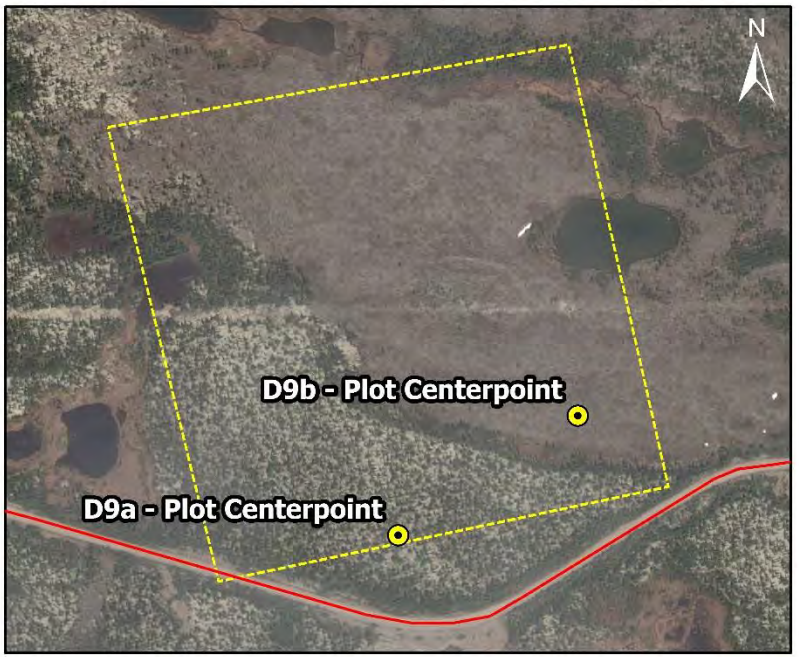


Figure 14.
Area D (Churchill Falls): Site D9(a,b) Location in Relation to Nearby Features of Interest



1. Site Overview and Field Survey Center Points (yellow)



2. UAV Flight Plan:
2cm (big grid) and 1cm (small grid) Resolution

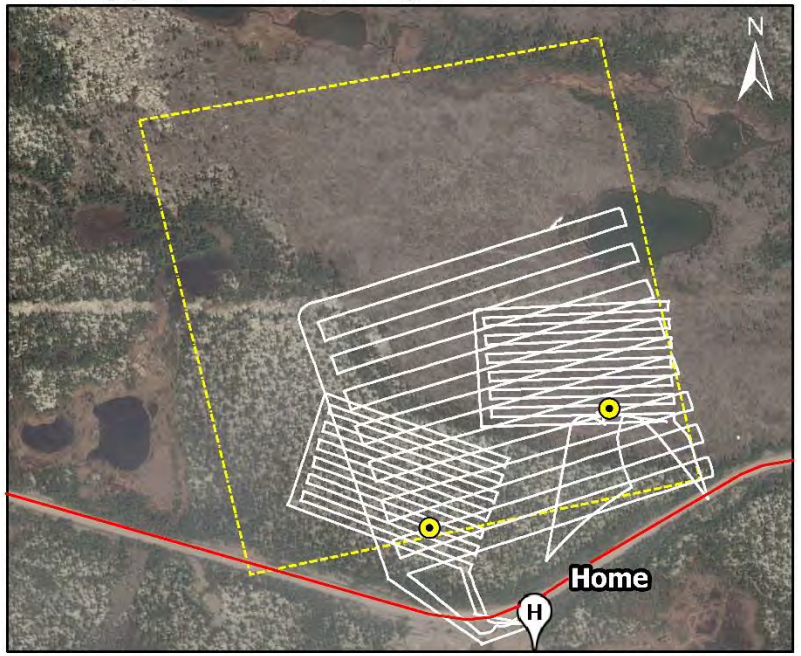


Figure 15.
Sites D15 and D16 with Ecological Land Classification

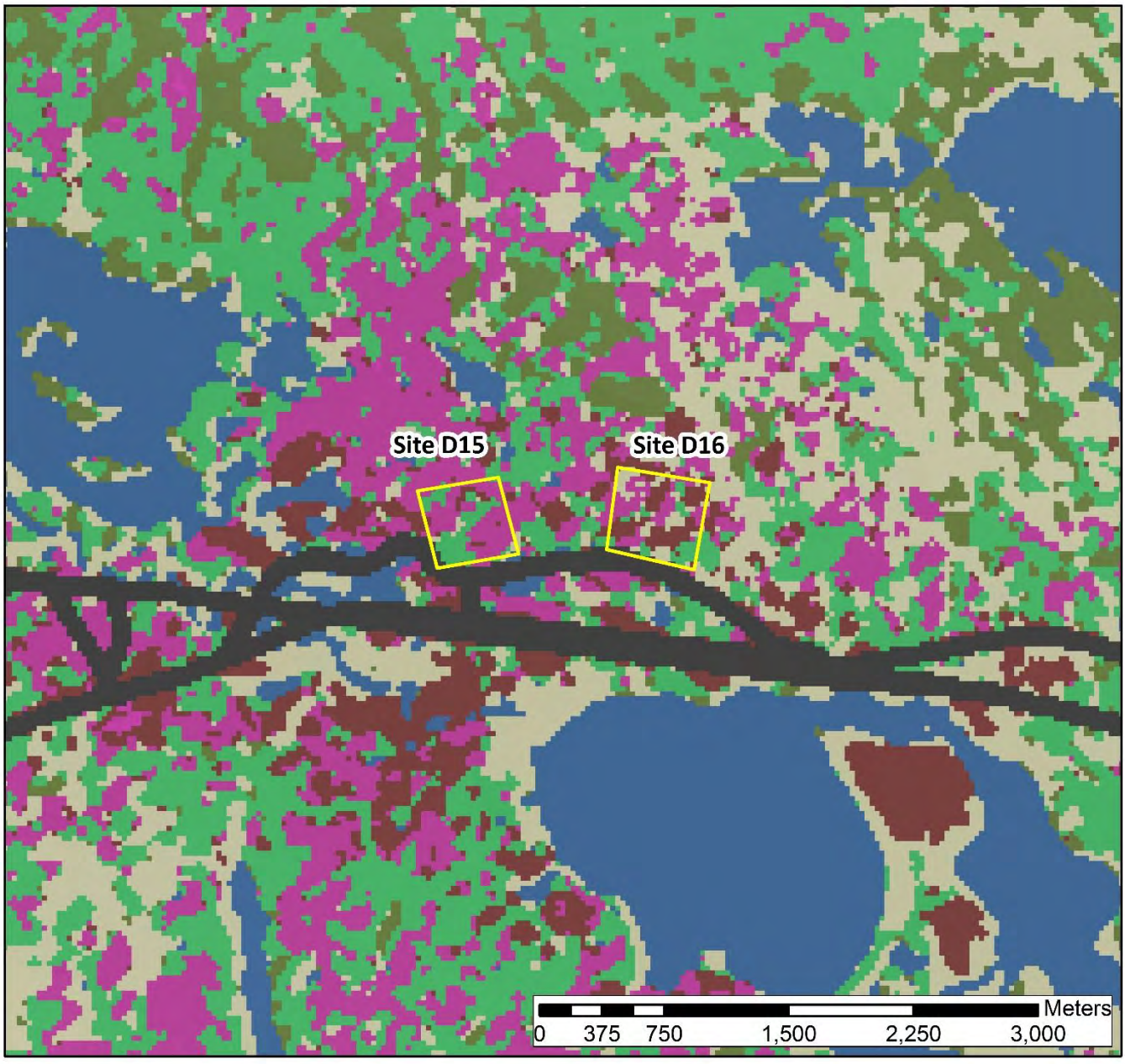
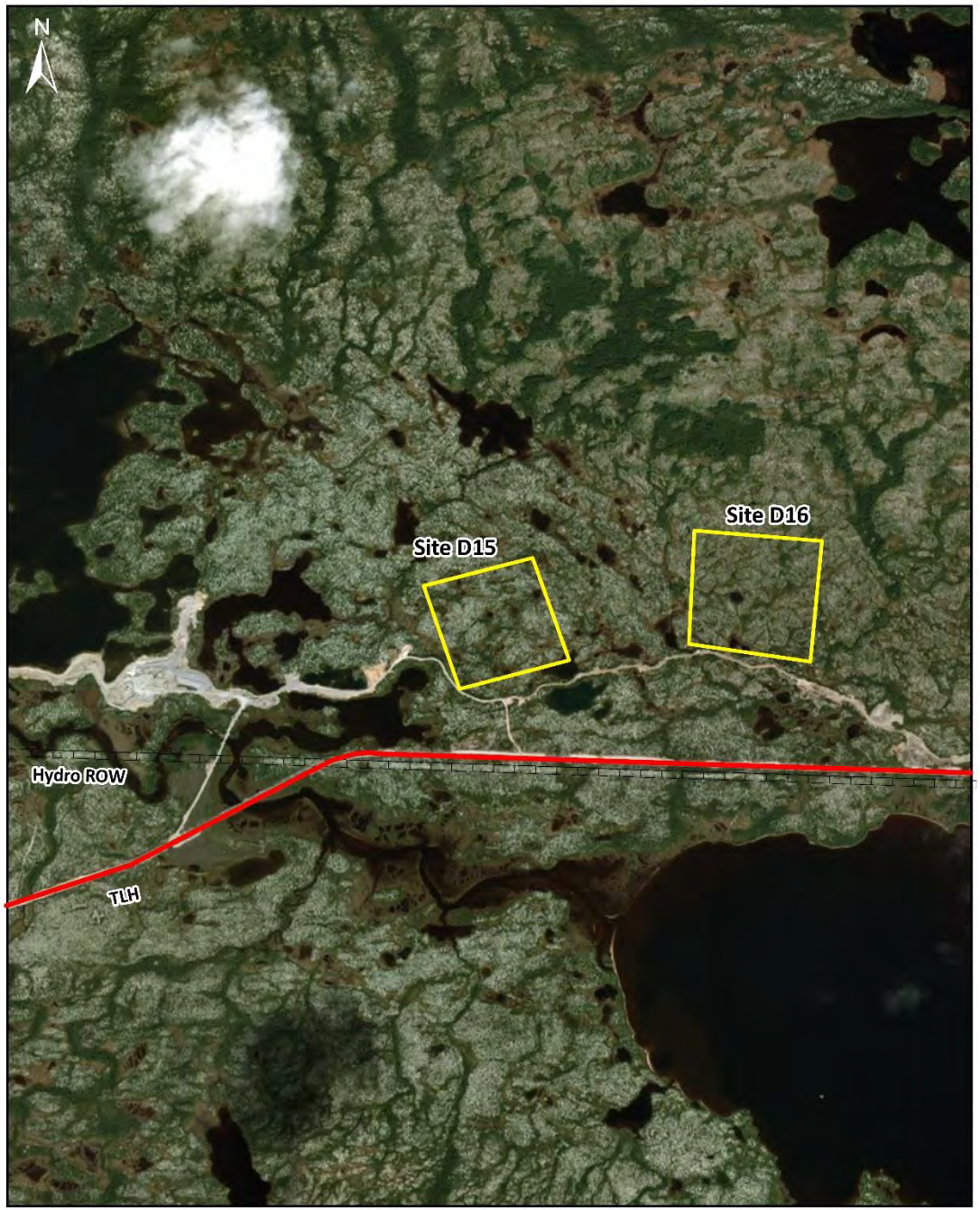


Figure 16.
Area D (Churchill Falls): Site D15 Location in Relation to Nearby Features of Interest

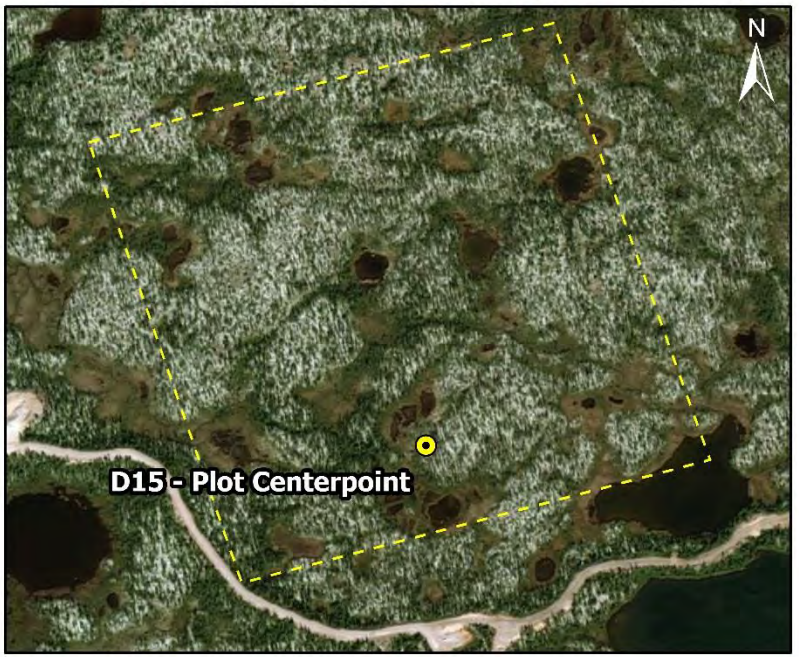


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Kilometers
0 0.25 0.5 1 1.5 2

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

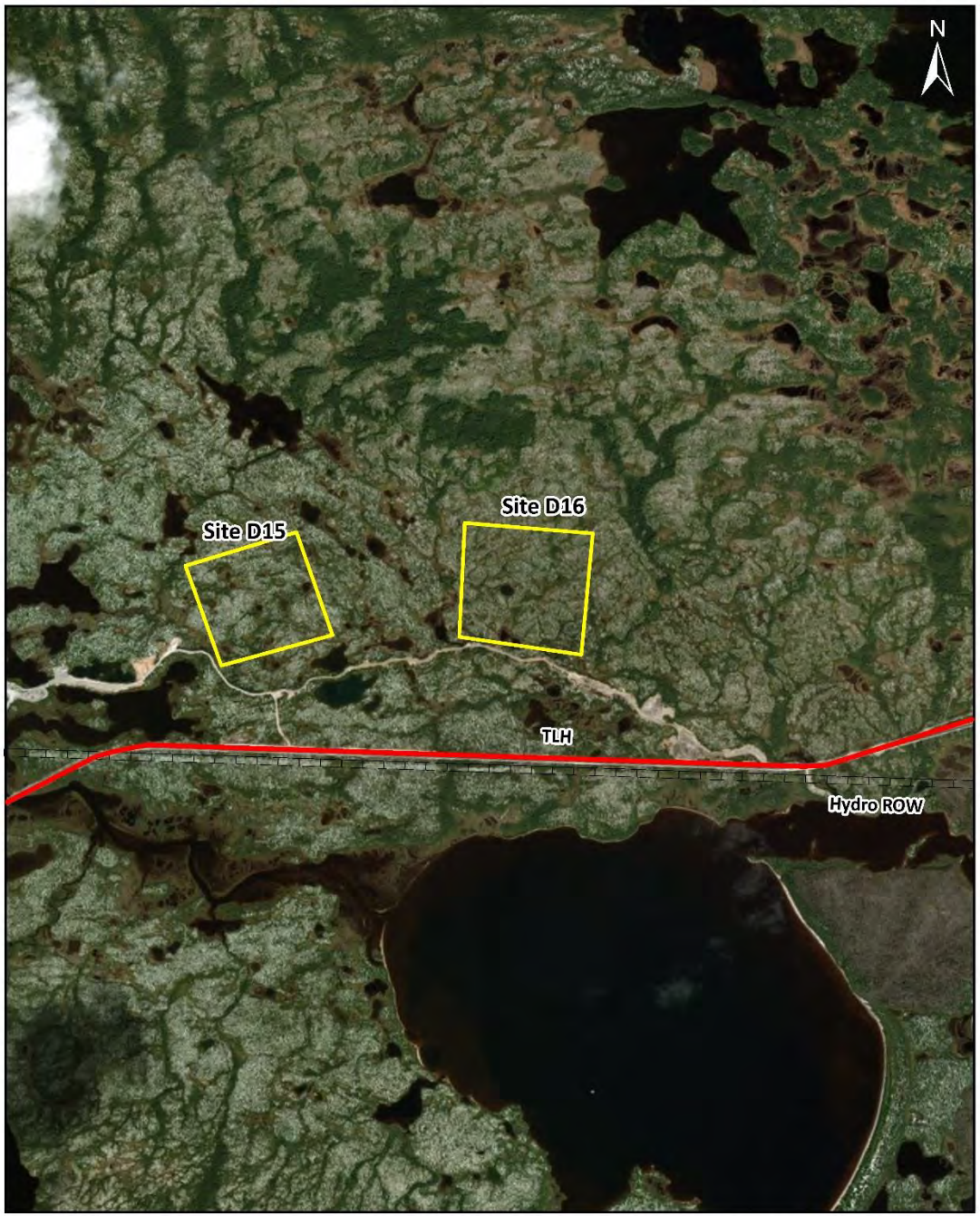
1. Site Overview and Field Survey Center Point (yellow)



2. UAV Flight Plan:
2cm (big grid) and 1cm (small grid) Resolution

Meters
0 75 150 300 450 600

Figure 17.
Area D (Churchill Falls): Site D16 Location in Relation to Nearby Features of Interest

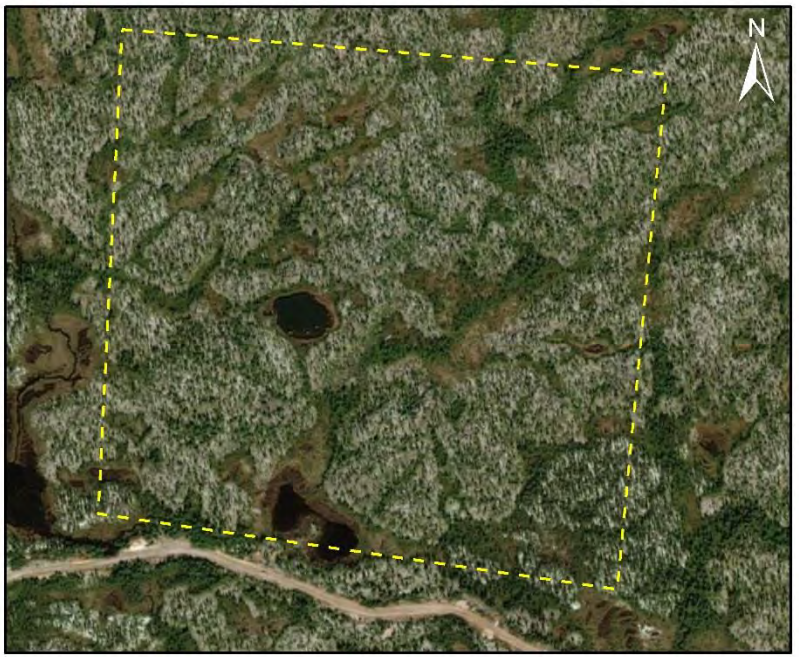


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

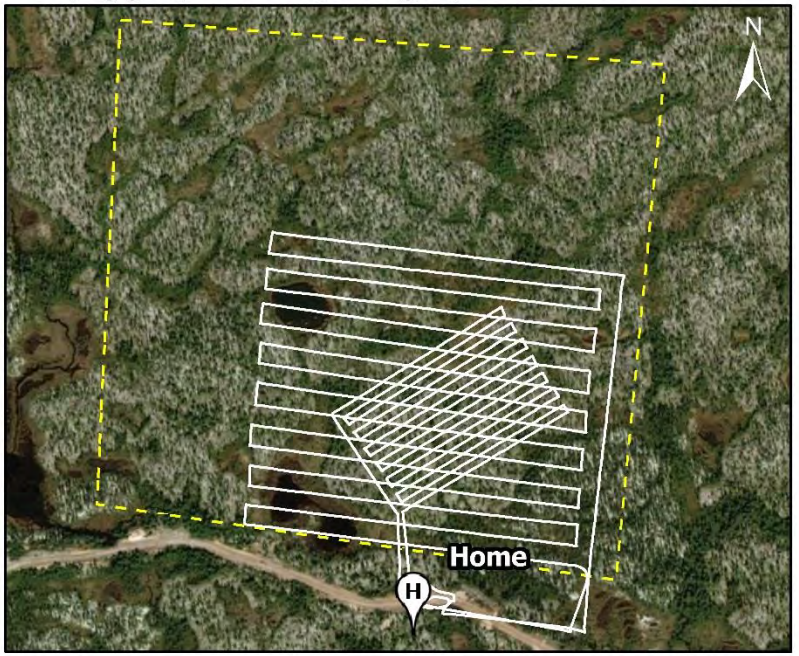
Kilometers
0 0.25 0.5 1 1.5 2

Coordinate System: NAD 1983 UTM Zone 19N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -69.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

1. Site Overview



2. UAV Flight Plan:
2cm (big grid) and 1cm (small grid) Resolution



Meters
0 75 150 300 450 600

Appendix B: Photo Log

Photograph 1: A UAV ground control point (foreground) and LCMP survey layout at Site B7.

Photograph 2: A spectrometer reading of C. stellaris is collected during full sun conditions near Site C6.

Photograph 3: LCMP are sub-sampled using a plastic tube (A6). Samples are collected from areas with ~100% lichen cover (M1).

Photograph 4: Lichen height measurements (D9a) are measured at multiple points within each sampled area and averaged (H2).

Photograph 5: Biomass is collected from a LCMP at Site D9a by collecting all lichen within the micro-plot.

Photograph 6: A LCMP at Site D9a where all lichen within the micro-plot was collected for biomass.

Photograph 7: Biomass samples are collected at Site D15 via sub-sampler from the center of each LCMP.

Photograph 8: A tree core is collected at Site D15 by project partners.

Photograph 9: The Ae horizon at Site A6 (classified as SM under USCS).

Photograph 10: The Bm horizon at Site A6 (classified as SM under USCS).

Photograph 11: Instability of steep slopes and underlying sandy soils causes slumping at Site B7.

Photograph 12: A view of the recently burned Site C1 (burn date 2013). No lichen was noted at the site.

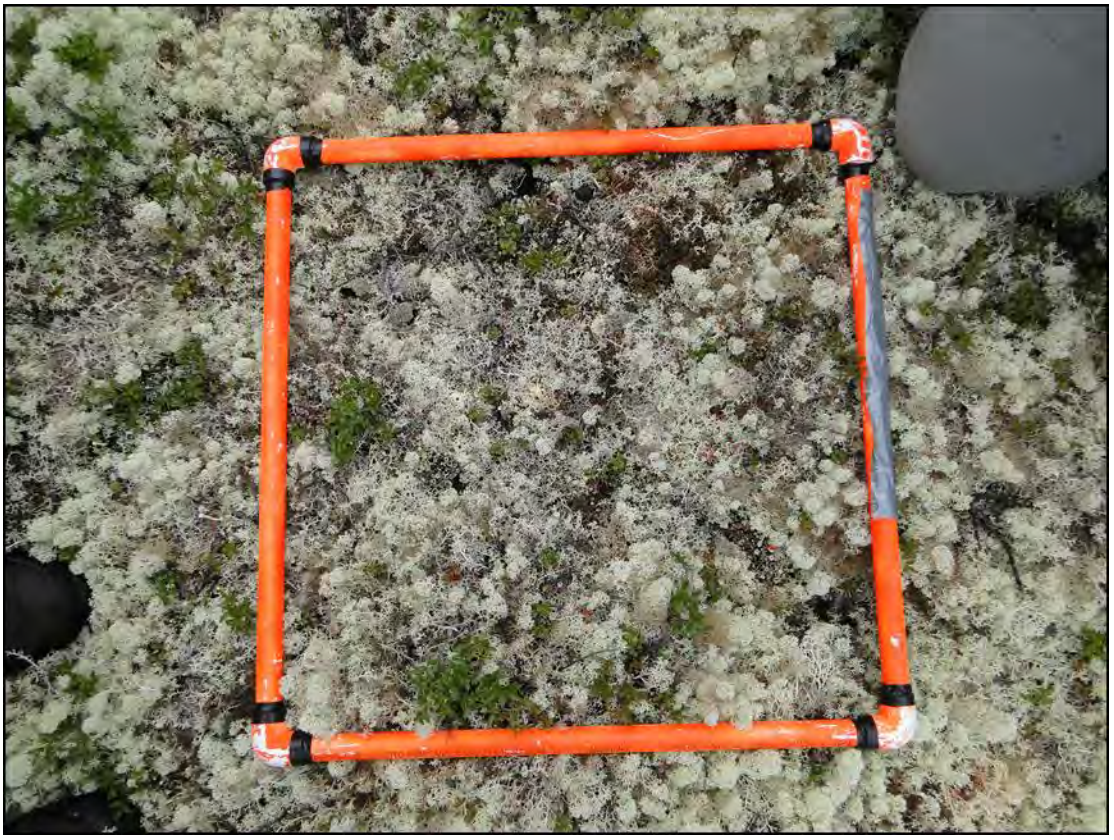
Photograph 13: Looking towards Site D3 from the adjacent burned area (1990). More lichen cover was noted here than in D3 (undisturbed).

Photograph 14: An example of shorter lichen heights in an area southeast of Site D3 (burned 1990).

Photograph 15: Site D9b (burned 1990) shows recovering lichen communities and greater lichen diversity similar to the burned area near Site D3.

Photograph 16: The burned area southwest of D2 (burn date 1989) shows high lichen diversity and moderate cover.

Photograph 17: Recently grazed caribou craters near Site D15 are clearly visible as greyer, lichen-free areas in the lichen mat.



Photograph 18: A close-up of a plot that was grazed a few years ago (D15). A higher diversity of lichen species is noted in grazing craters.

Photograph 19: A thick, very dry C. stellaris lichen mat located between vehicle ruts in the disturbed section of Site A6 (clear cut).

Photograph 20: Horizontal vehicle ruts are clearly visible at Site A6 as deep (>10cm) troughs with bare mineral soil.

Photograph 21: A second layer of lichen is noted below a brown moss layer at Site C7.

Photograph 22: Site C8 is in a state of climax for lichen woodlands.

Photograph 23: Very high canopy closure at Site D2 results in significantly lower lichen ground cover.

Appendix C: Data Collection Methods

Land Cover Micro-Plot (LCMP) Assessments

J. Lovitt & I. Schmelzer

A total of eleven micro-plots were distributed at each site within the UAV flight survey extents, approximating the protocol provided to us by Isabelle Schmelzer, Gov NL (diagram below). The plots were laid out before UAV flights, and placement was adjusted to avoid locations under trees or other dense canopy cover to ensure they were visible in the imagery. Plots were labeled P1 – P11 as shown below.

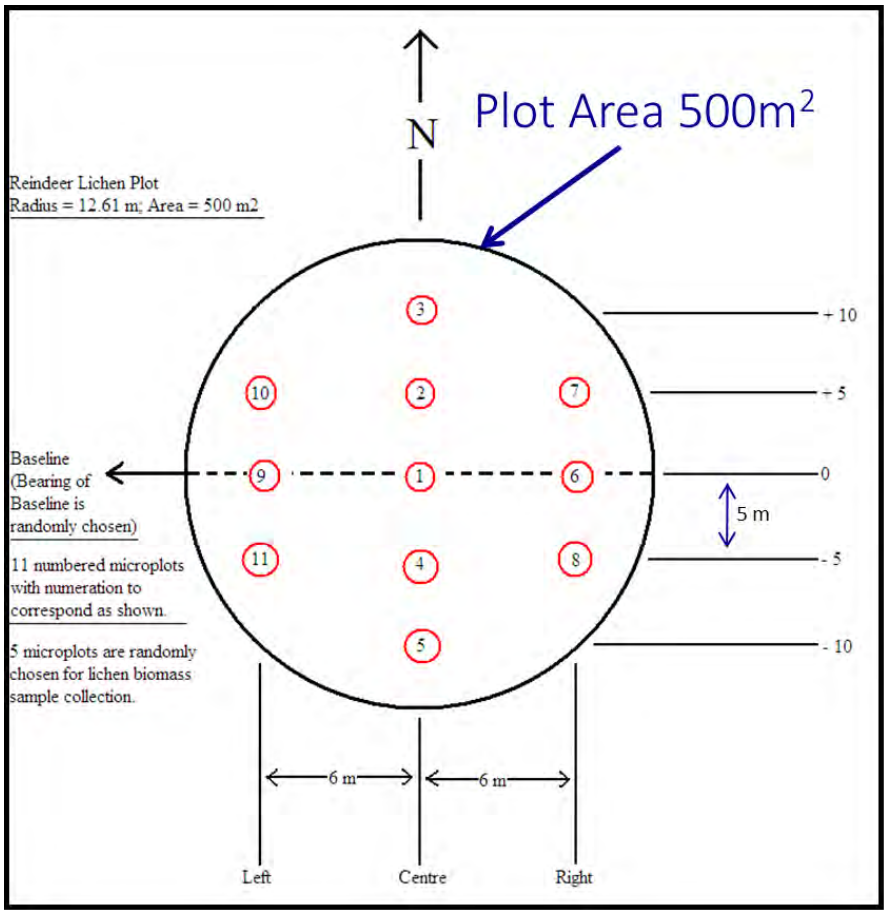


Figure 1: LCMP Plot Distribution Design[1]

Micro-plots were 50cm x 50cm and made of PVC tubing that had been spray painted neon orange to increase visibility within the UAV survey. Ocular land cover was assessed to the nearest 5% by identifying major plant groups and species when possible. Photographs were collected manually at each micro-plot in the order: down, north, east, south, west, up. Coordinates were collected via handheld GPS for the center point of the first plot (P1). After returning from the field the lichen cover (%) of each LCMP was more accurately quantified by applying point-frame technique (100 points over the biomass sampling area) to the down-looking digital photo of the biomass sampling area.

Additional LCMP assessments were completed along transects or over areas of interest throughout the site. Handheld GPS points were collected for the additional plots, but they are not visible in the UAV imagery.

[1]Schmelzer, I. (2013). A Multi-Attribute Approach to Mapping Boreal Woodland Caribou Habitat in Labrador [PowerPoint slide]. Retrieved from Isabelle Schmelzer, Government of Newfoundland and Labrador.

Biomass

W. Chen & J. Lovitt

Biomass Sample Collection

Five of the eleven LCMPs were randomly selected for biomass sampling at each site. We tested several methods of biomass sample collection (see table 1 below). We used sub-samplers of varying diameters to collect "representative" biomass samples from LCMPs when lichen cover (%) was near 100% (M1 and M2). In cases where lichen cover (%) was heterogeneous but low, we opted to collect all lichen within the LCMP (M4). It was difficult to determine how to properly sample from LCMPs where lichen cover (%) was moderate and heterogeneous, as finding a "representative" sample (M1 & M2) under these conditions was challenging, but collecting all lichen within the LCMP (M4) was too time consuming. As a result we decided to sub-sample the LCMP at the center of the 50cm x 50cm frame (M3).

Table 1. Biomass Sampling Methods

Biomass Sampling Method	Description	Site(s)
M1	Sub-samples were collected from an area of the LCMP with 100% lichen cover using an open ended plastic tube (**diameter 11.8cm**)	A6
M2	Sub-samples were collected from an area of the LCMP with 100% lichen cover using an open ended plastic tube (**diameter 9.0cm**)	B7, C6, C8
M3	Sub-samples were collected from the center of the LCMP using an open ended plastic tube (**diameter 12.8cm**)	D2, D15
M4	All lichen within the LCMP plot was collected	C1, C7, D3, D9a, D9b

Only the living portion of lichen was collected (i.e., the portion of lichen that was not slimy or rotten). Non-lichen debris (eg. Sticks or other plants) were roughly removed from the sample before placing in dedicated paper bags that had been clearly labeled with the date, site and plot number.

Lichen Height Measurements

Lichen height measurements were collected from the LCMPs selected for biomass sampling using two methods:

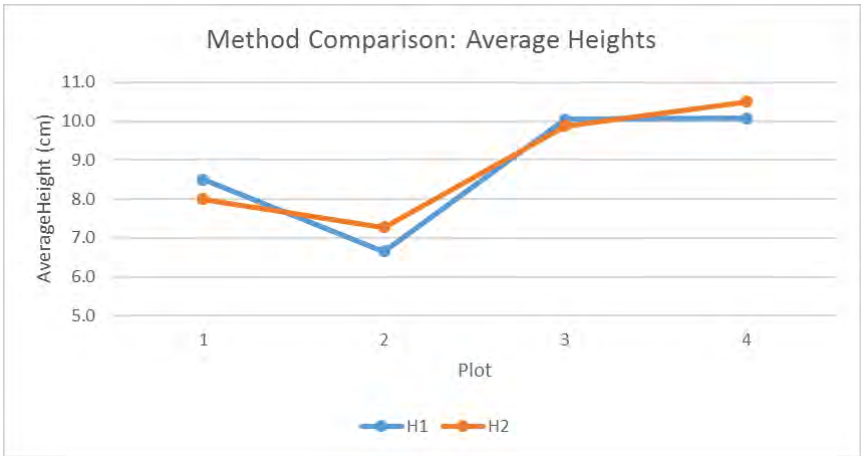
H1: Measuring height from a selected lichen sample during collection; and,

H2: Measuring the height of lichen in-situ prior to collection at four locations and averaging.

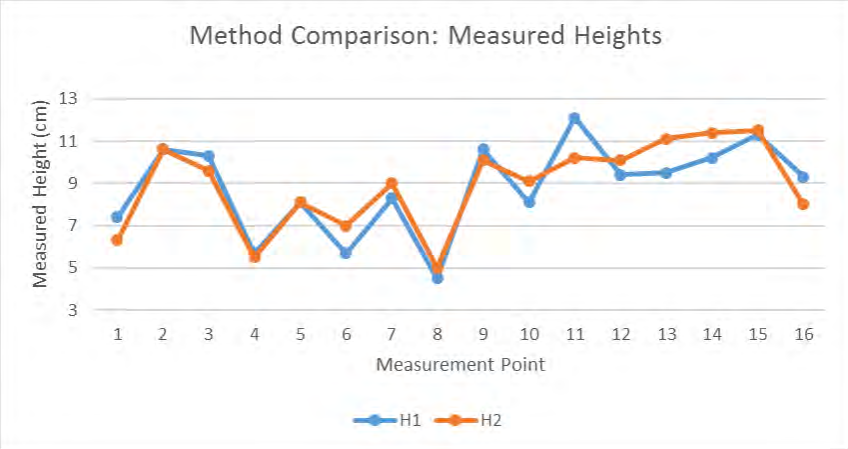
The height measurement method H1 (sites: A6, C1, C6, C7, C8, D3, and D9a) was used until our team was joined by project partners (CFS and Gov NL) on July 29, 2019. Based on discussions with our project partners we modified our measurement methods to H2 (sites: D2, D9a, D9b, and D15). A comparison of

the two methods was completed at site D9a. Results of the comparison showed that differences in recorded heights were not significant between the two methods (see graphs).

Plot 1. Comparison of Height Measurement Methods M1 & M2 – Average Heights



Plot 2. Comparison of Height Measurement Methods M1 & M2 – All Heights



We measured lichen height by matching the ruler zero mark with the point at which the lichen is considered to be dead. This point was determined by noting where the lichen became slimy to touch. In method H1 the lichen height was measured after the lichen had been harvested from the LCMP, but before it was placed in the collection bag. In method H2 this measurement was made in-situ by separating the lichen to the side of ruler to allow the assessor to find the correct starting point, and then gently pulling the lichen back to the original position for measurement. We recommend using a sturdy, metal ruler that clearly ends at zero, not one where the ruler material continues beyond zero, to avoid incorrect in-situ measurements. The condition of no lichen cover at a LCMP had already been captured in the LCMP assessment (described in previous section), and therefore lichen height measurements were not collected in areas without lichen (i.e., lichen heights of 0 were not reported).

Biomass Sample Processing

In the Laboratory, we further cleaned lichen samples of non-lichen debris and oven-dried each sample at 70^{o}C for 48 to 72 hours. Once the samples were dry we weighed them and recorded the stabilized weight.

Soils

W. Chen & J. Lovitt

pH Sampling

While collecting lichen biomass samples we also measured and recorded the depth of the underlying soil organic layer. We then collected a sample of the organic layer located immediately below the lichen and bagged each sample in a clearly labelled (site #, plot #, date) plastic Ziploc bag for pH measurement. In the laboratory, we measured soil pH using a soil pH meter (HACH H135 Advanced Compact WaterPR by Cole-Parmer Canada, http://www.hach.com). The soil pH analysis followed these steps:

1. A batch of 8 to 10 beakers (300 ml) was washed using distilled water.
2. Approximately 10-20 g of a soil sample from a site was added to a beaker.
3. Distilled water was added to the beaker to fully cover the soil sample.
4. The solution was shaken and well mixed.
5. A digital photo of the solution was taken, together with a site label.
6. The pH meter calibrated with standard solutions at pH = 4, 7, and 10.
7. The pH meter was then washed with distilled water after calibration and shaken dry.
8. The soil solution was transferred to a 50 ml beaker, and the pH meter was submerged into it and allowed to stabilize (usually within 1 minute). The pH value for the site was then recorded.

Field Texture Analysis

Soil texture was assessed using the Unified Soil Classification System (USCS). In order to properly determine soil texture a sieve analysis is required. As this analysis was not completed at any sites, the soil textures described in this report should be considered an approximation based on tactile assessment. All sites where soil texture was assessed were found to have coarse sandy soils mixed with gravel and some fines. Below is an example of USCS classification divisions for coarse-grained soils:

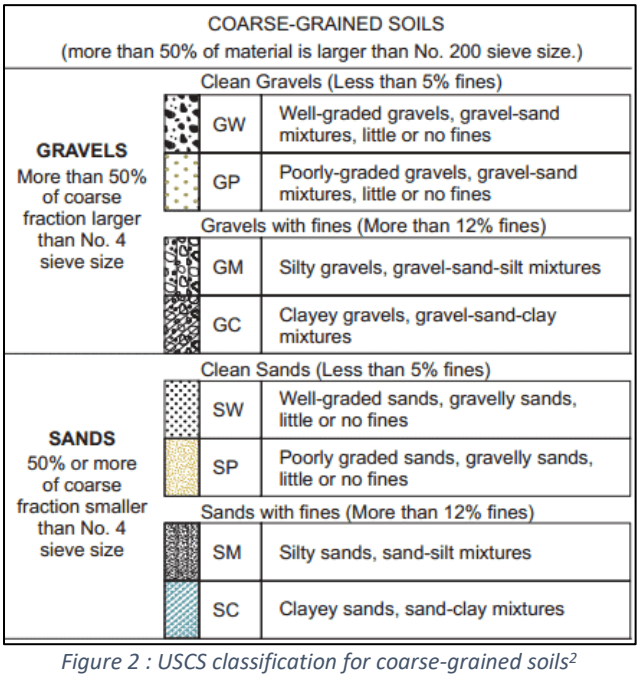


Figure 2 : USCS classification for coarse-grained soils[2]

[2]Mishra, G. (2019). Unified Soil Classification System (USCS) [Online Content]. Retrieved from https://theconstructor.org/geotechnical/unified-soil-classification-system-uscs/7297/.

Unmanned Aerial Vehicle (UAV) Surveys

S. LeBlanc

For the Manic-Labrador field campaign, we brought three UAVs:

- **DJI Inspire 1 UAV with Sentera Double 4K NDRE camera** - 5 bands at 12megapixel (Red, Green, Bleu, Red Edge and Near Infrared).
- **DJI Mavic Pro 2 with onboard RGB camera** (20 megapixel photographs and 8-9 megapixels video frames) and attached Sentera NDRE camera (1.2 megapixels)
- **DJI Phantom 3 Pro with on board RGB camera** (12 megapixels photographs and 8-9 megapixels video frames) as a backup.

For each pre-selected site, two UAV missions were pre-planned using the Litchi hub (https://flylitchi.com/hub). Missions were first planned to be used with the Inspire 1 UAV. However, the same missions were either pre-planned, or modified (altitude and speed only) in the field, for the Mavic Pro 2.

One mission was to cover 10 ha with a 2cm ground resolution, and the second to cover 3ha with 1cm ground resolution. Both missions covered the plot/micro plots. The Inspire was to be flown at 35m AGL (and 17km/h) and 70m AGL (and 30 km/h) for 1cm and 2 cm resolution, respectively. The Sentera camera on the Inspire 1 was used in a mode that starts the camera as soon as it is warmed up. Although there is a diode that can be used to check the status of the camera, it is not easy to see it well under the UAV. We connected the iPad to the camera Wi-Fi connection to verify that it was activated before sending the UAV on its autonomous mission. This is the safest way we found to use this camera. The camera was also set to take one photograph every second with most other parameters set at defaults. Since there is no live view for this camera on the Inspire 1, we set the camera speed and aperture to automatic mode.

For the Mavic Pro 2, the flights settings were 25m AGL at 12km/h and 60m AGL at 24km/h to get 1cm and 2 cm resolution, respectively. The Sentera camera on the Mavic was set to start as soon as the UAV goes above 10m AGL. This means that no NIR photographs were taken in the micro-plots flights at low altitude.

The choice of the UAV to be used was based on site proximity to were we parked our vehicle and the wind speed. The wind was not a factor in our field work, so the Mavic 2 Pro was used for most of the missions. Its low weight and long battery life compared to the Inspire 1 more than compensated for its lower ground resolution due to different field of view, RGB video mode and NDRE camera. Although the photographs are usually much better quality than the video frames on the Mavic 2 Pro, we had issues in pre-field tests and the photographs were not always taken automatically. This also brought another problem on cloudy days: the lower altitude required by the Mavic Pro 2 to get the same ground resolution as the Inspire 1 system made it prone to more movement blur in the imagery.

At the site, a launch location was chosen based on openness and best visibility of the UAV at all time on its mission. For lift-off, the Inspire was positioned on the ground or its travel box when vegetation was too high. The Mavic Pro 2 was usually hand launched and landed.

A third flight, in manual mode, was done a low altitude (2-5m), to acquire very high resolution imagery of the micro-plots. These flights are also used to produce points cloud in the order of 0.3-0.5cm. Micro-plots were also sampled with a handheld camera (Panasonic Lumix ZS60) in 4K video for a similar purpose. Note

that for Lumix ZS60, no GPS information can be attached to the frames. If needed, geoinformation from the UAV flights will be used to geo-reference point clouds from the Lumix ZS60 camera.

All flight logs are saved in the cloud in our free airdata.com account. This allow a quick recovery of data flight information that can be sued to identify sites, missions, and UAV used in case field notes are lost. The original flight log from Litchi is available on the tablet or smartphone used, but also available directly on Airdata. This file, in CSV format, is used to match video frames to geo-information (x,y,z).

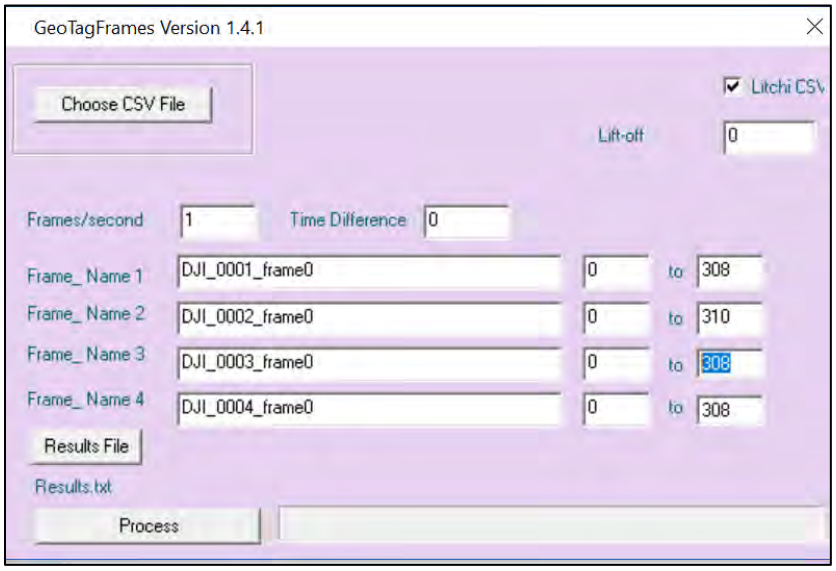


Figure 3: A screenshot of GeoTagFrames 1.4.1 used to geotag extracted video frames using the Litchi CSV file

An in-house software, named GeoTagFrames 1.4.1 is used to extract the x-y-z info needed as geotags to the frames extracted (Figure 3). This is done for all flights using video instead of photos. For the Sentera cameras, the Geotags were saved in the JPGs. We generally extract 1 frames per seconds to get decent results with ix4DMapper 4.3.33. With Pix4D, we create point clouds (RGB+NIR) and orthomosaics (RGB, NIR, and elevation).

A first run for all UAV data is underway, without GCPs, to assess the data quality. Other products to be produced from this data include canopy/crown closure, tree heights, and lichen area

High Precision GPS Surveys

C. Prevóst

For most UAV surveys, the onboard GPS provides reliable imagery positioning. In some cases it may be valuable, or necessary, to improve the accuracy of on-board positions with external information. We acquire this information by dispersing ground control points (GCPs) across the site in areas where they are visible in the UAV survey, and recording their center points with a high-precision GPS (Figure 1).

Figure 1: The GPS receiver antenna is shown acquiring the center point coordinates of a GCP.

The precision of positioning increases with time of observation (hours) on a point. Therefore, the longer the receiver antenna remains static on a point, the better the point's 3D positioning will be. This being said we often do not have the luxury of extended observation time in the field. In such cases, we use a method called GPS differential phase processing to generate high quality results with observation times that are minutes in length. This method relies upon a second station with a well known position to acquire GPS data simultaneously with the field GPS receiver.

This method is divided into two phases. In the first phase, the user establishes the precise position of a single reference point through static, long observation time (the base station; Figure 2). In the second phase, the user places a second receiver (the rover) over a GCP to acquire the center point position data simultaneously. The process allows us to establish a 3D vector between the base and rover, and uses this information in combination with the known position of the base station to calculate the position of the GCP. For example, in Labrador, we installed a temporary base station close to each site before hiking in to begin data collection. This receiver collected data for the duration of time we spent conducting field work (~4 hours/site) and was always the final piece of equipment to be packed up at each site to maximize its observation time.

Figure 7: A temporary base station is established near a site to collect data for the phase differential processing method

The Canadian Active Control Station (CACS) located in Schefferville acquires GPS data on a continuous basis, and therefore its position is very well known. We can use the data for this station, acquired simultaneously with both the temporary base station and the roving receiver to guarantee that the position of our GCPs will be of the highest quality.

Figure 8: The Schefferville Canadian Active Control Station acquires GPS data on a continuous basis. The data can be used in phase differential processing.

Tree Cores

A. Arsenault

Four sites were investigated for tree age. These included D9 and D15 near Churchill Falls which were part of the remote sensing project and two additional sites were sampled, one near Goose Bay (TLH1), and one near the cabin at the Esker road cabin. A total of 42 trees were sampled in the field.

Core Collection

Tree diameter was measured at breast height and ages were estimated by obtaining tree core samples at the base of dominant trees (approximately 5-10 per site). Tree cores were extracted from live trees at approximately 30 cm above the ground using an increment borer. Trees were cored one or more times until the pith was obtained. Cores were stored in plastic straws and labelled and brought back to the Atlantic Forest Ecology lab.

Core Processing

All tree cores were mounted on wood mounts, secured with carpenters glue and masking tape, and left to dry at air temperature. Once the cores were dried, the masking tape was removed and the surface of each core surface was sanded by using successively finer sand paper until details of tree ring structure were clearly visible. Calendar years were assigned to each ring placing a dot for each decade, 2 dots at 50 years and 3 dots for centuries. Tree age was estimated as the number of rings counted between the bark and pith and precision noted as how far away the end of the core was from the pith.

Precision of core refers to the amount of tree rings captured by the core. A core which included the pith was recorded as a '1', a core which was within approximately 5 years of the pith was a '2', a core which was greater than 5 years away from the pith, but included at least half of all the rings, was a '3', and a core which included less than half of the rings, was a '4'. Only trees with high precision (levels 1 and 2) within five years of the pith were kept for tree age estimation. This resulted in 30 trees ranging between 55 to 177 years.

Table 2. Mean Tree Diameter at Breast Height (dbh) and Age for Four Labrador Sites

Sites	DBH cm (SE)	Age years (SE)
D9 N=7	13.43 (1.2)	94.7 (8.0)
D15 N=8	12.6 (0.5)	153 (5.8)
Cabin N=5	16.7 (0.8)	154.4 (8.8)
TLH1 N=9	16.1 (1.8)	89.9 (5.1)

Tree ring width will be measured with WinDendro™ software. We will perform several attempts to cross-date all tree cores. Cores that fail this cross-dating process will not be included in tree growth analyses.

Leaf Area Index (LAI) and Land Cover ($30m^2$)

Our team was provided with workflows for LAI and land cover ($30m^2$) data collection. This data was collected opportunistically in support of a different work package. The instructions provided to our team by F. Canisius are included in the following pages.

CCRS DHP LAI Field Notes V1.8

Campaign: Region: Date:

T1 Waypoint ID: PLOT Name:
N E

T2 Waypoint ID:
N E

T1_7 Waypoint ID:
N E

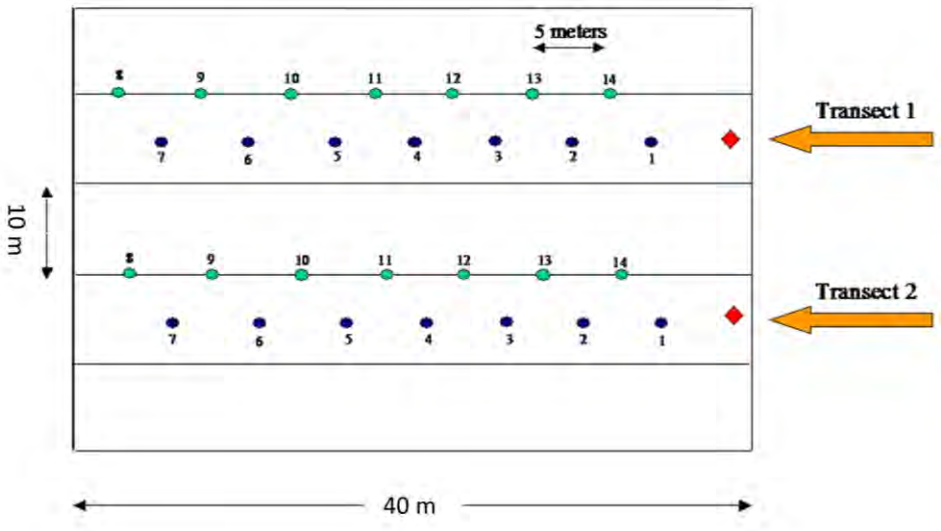
T2_7 Waypoint ID:
N E

Elevation/Slope/Aspect:

Overstory:
Understory:
Surface:
Soils:
Sky:
Site Notes:

Transect	Camera/Lens	Operator	Chip	Photos
A				
B				

Notes:



Camera Setup for NIKON D7000

http://download.nikonimglib.com/archive2/j0v3l00Dv39x01U97ft13W9kOV17/D7000_EU(En)06.pdf

Camera should be set up as follows

1. Charge 2 Nikon EN-EL15 batteries (P21).

2. Load 1 EN-EL 15 battery in camera and close the lid (P24).

3. Press the button on camera face and attach 10.5mm Nikon FISHEYE lens (p34). Make sure the lens is locked in place.

4. Load SD Nano memory card (>= 64 GB) in Slot 1 (P29).

5. Turn on camera and check charge (P35).

6. Time zone and date (Setup Menu)

The following settings must be adjusted using left, write, up and down arrows and select using ok button
- Time Zone
- Local time and date
- Date format = Y/M/D
- Daylight savings time – OFF

7. Set exposure mode to ‘P’ on the top left dial (P68).

8. Set to manual focus by moving the focus mode selector on front bottom right to ‘M’ (P99).

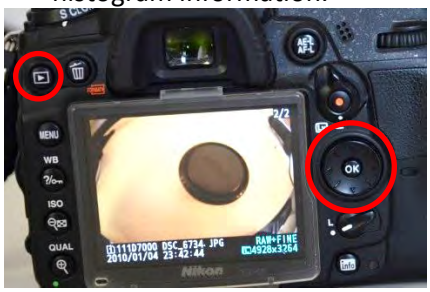
9. If camera is used for ‘down’ images focus at 50cm otherwise focus at infinity.

10. Set metering to ‘matrix’. To adjust, press metering button (circled below) and rotate the primary wheel until matrix metering symbol is displayed on LCD screen (same square symbol as on button) (P105).

11. Check contents of memory card using playback function on camera (P204).

    - Use the Left and Right arrow keys on the Multi-Selector to select the desired image.

- Press the Up and Down arrow keys on the Multi-Selector to bring up the “Overview” histogram information.



12. Back up disk if it contains images by using a card reader or by plugging camera into USB port of computer (P180).

13. Format memory card (Setup Menu – Format Memory Card (P236).

14. If using a NIKON GPS connect it to the flash attachment and plug it in to the camera GPS port. Turn on the camera and check that the “GPS” icon is flashing on the status display (P281).

15. Under shooting menu:

a. Image Quality – NEF (RAW) + JPEG Fine

b. Image Size – Large 4928x3264

c. JPEG Compression – Optimal quality

d. NEF (RAW) recording – lossless compressed ON; 14 bit

e. White Balance - AUTO Normal

f. Active D Lighting - OFF

g. Long Exp. NR - ON

h. HIGH ISO NR - High

i. ISO Sensitivity – Auto ISO Sensitivity - ON

16. Connect camera to monopod.

18. Remove lens cap.

19. Take a test picture and check in playback mode. Delete if OK.

20. Turn camera off.

21. Put on lens cap.

Camera Setup for NIKON D300

(https://downloadcenter.nikonimglib.com/en/products/11/D300.html)

Camera should be set up as follows

1. Load 8 AA batteries.

2. Press the button on camera face and attach 10.5mm Nikon FISHEYE lens (p34). Make sure the lens is locked in place.

3. Use the knob to open the cover Load memory card (P39).

4. Turn on camera and check charge (P44).

5. World Time (Setup Menu)

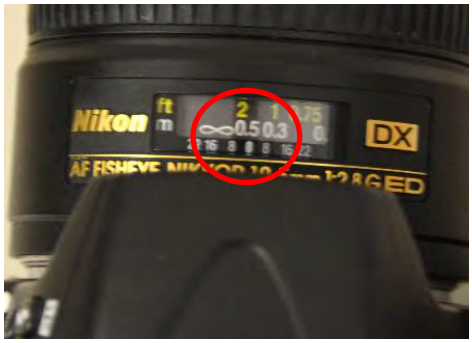
The following settings must be adjusted using left, write, up and down arrows and select using ok button

- Time Zone
- Local time and date
- Date format = Y/M/D
- Daylight savings time – OFF

6. Set exposure mode to ‘P’ by pressing the ‘MODE’ button on top right and rotating main command dial until the status display indicates a ‘P’ in the top right corner (P48).

7. Set to manual focus by moving the focus mode selector on front bottom right to ‘M’.

8. If camera is used for ‘down’ images focus at 50cm otherwise focus at infinity.



9. Set metering to ‘matrix’ by selector on back left near viewfinder (P49).

10. Check contents of memory card using playback function on camera (P204).

- Use the Left and Right arrow keys on the Multi-Selector to select the desired image.
- Press the Up and Down arrow keys on the Multi-Selector to bring up the “Overview” histogram information.

11. Back up disk if it contains images by using a card reader or by plugging camera into USB port of computer (P226).

12. Format disk (Setup Menu – Format Memory Card , P312).

13. If using a NIKON GPS connect it to the flash attachment and plug it in to the camera GPS port. Turn on the camera and check that the “GPS” icon is flashing on the status display (P201).

14. Under shooting menu:

a. Image Quality – NEF (RAW) + JPEG basic

b. Image Size – L 4288x2848

c. JPEG Compression – default (Size Priority)

d. NEF Raw Encoding – lossless compressed ON; 14 bit

e. White Balance - AUTO

f. Active D Lighting - OFF

g. Long Exp. NR - ON

h. HIGH ISO NR - OFF

i. ISO Sensitivity - ON

15. Connect camera to monopod.

16. Remove lens cap.

17. Take a test picture and check in playback mode. Delete if OK.

18. Turn camera off.

19. Put on lens cap.

Camera Setup for NIKON D850

(http://downloadcenter.nikonimglib.com/en/products/359/D850.html)

Camera should be set up as follows

1. Charge 2 batteries (P14) – you can use the EN-EL15a or EN-EL15 (as a backup).

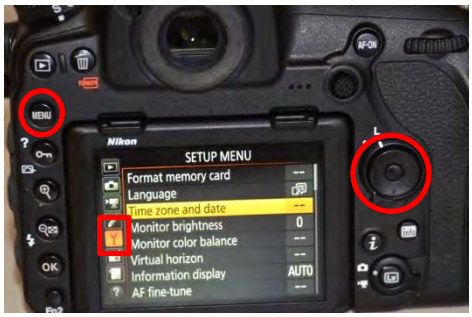
2. Load battery EN-EL15a and close the lid(P16).

3. Press button on camera face and attach the Nikkor 8-15mm FISHEYE lens (p19). Make sure lens is locked in place

4. Load SD Nano memory card (>=64GB) in Slot 1 (P16).

5. Turn on camera and check charge (P21).

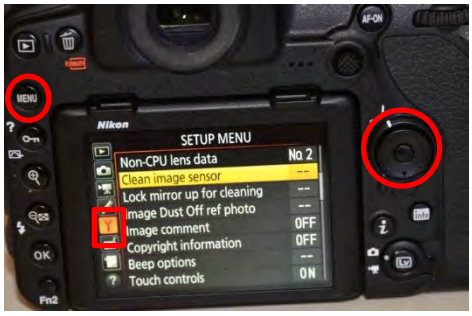
6. Time zone and date (Setup Menu)



The following settings must be adjusted using left, write, up and down arrows and select using ok button

- Time Zone
- Local time and date
- Date format = Y/M/D
- Daylight savings time – OFF

7. Clean the image sensor (p. 312). Holding the camera base down, select clean image sensor in the setup menu, then highlight Clean now and press ok.



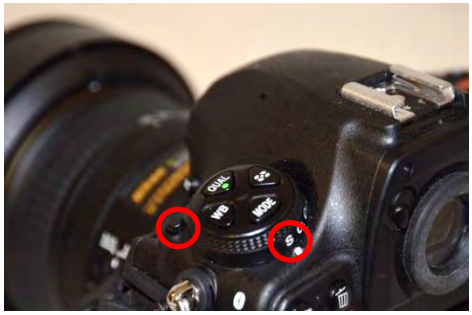
8. Set exposure mode to ‘P’ by pressing ‘MODE’ on the top left dial and rotating the main command dial (rotate the primary wheel until P symbol is displayed) (P126).

9. Turn off the flash if need be by pressing the flash button on the back left and rotating the main command dial (rotate the primary wheel until flash off symbol is displayed) (P193)

10. Set to manual focus by moving the focus mode selector on front bottom right to

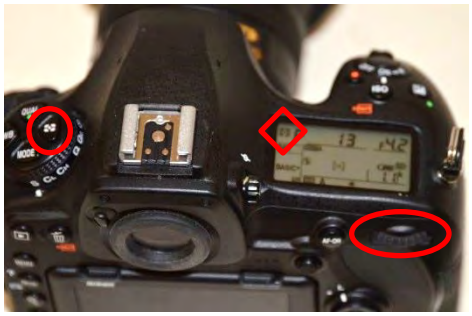
'M' (P11) and on the side of the fisheye lens.

11. Set to single frame release model by pressing the button (located next to top left dial) and rotating the top left dial to 'S' (P112).



12. If camera is used for 'down' images focus halfway between 0.25 and infinity otherwise focus at infinity.

13. Set metering to 'matrix' by pressing metering button on the top left dial and rotating the main command dial (the primary wheel) until matrix metering symbol is displayed on LCD screen (same square symbol as on button) (P124).



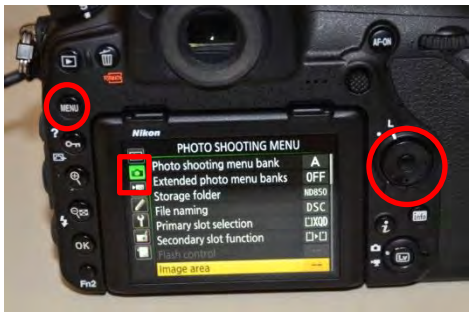
14. Check contents of memory card using playback function on camera (P223). Use the Left and Right arrow keys on the Multi-Selector to select the desired image.

15. Back up disk if it contains images by using a card reader or by plugging camera into USB port of computer.

16. Format memory card (Setup Menu – Format Memory Card – SD slot (P271).

17. If using a NIKON GPS connect it to the flash attachment and plug it in to the camera GPS port. Turn on the camera and check that the “GPS” icon is flashing on the status display (P221).

18. Under shooting menu:



a. Image Area – FX (p83)

b. Image Quality – NEF (RAW) + JPEG FINE

c. Image Size –

- Jpeg/Tiff small

- Raw L Large

d. NEF Raw recording – lossless compressed ON; 14 bit

e. White Balance - AUTO

f. Active D Lighting - OFF

g. Long Exp. NR - ON

h. HIGH ISO NR - Normal

i. ISO Sensitivity – Auto ISO Sensitivity - ON

19. Set the lens zoom to 15mm (ring closest to glass) and focus to infinity.

20. Connect camera to monopod.

20. Remove lens cap.

21. Take a test picture and check in playback mode. Delete if OK.

22. Turn camera off.

23. Put on lens cap.

Land Cover Field Note

No: Date: Photos: Observer:

Latitude/Northing: Longitude/Easting: Landmark:

Topography: Flat Undulating Mountainous

Slope: <5 5-10 10-30 >30 Aspect: N NE E SE S SW W NW

TREE STRATA

Conifers: %
BlackSpruce WhiteSpruce JackPine WhitePine

Broadleaf: %
Maple Oak Birch Aspen Beech

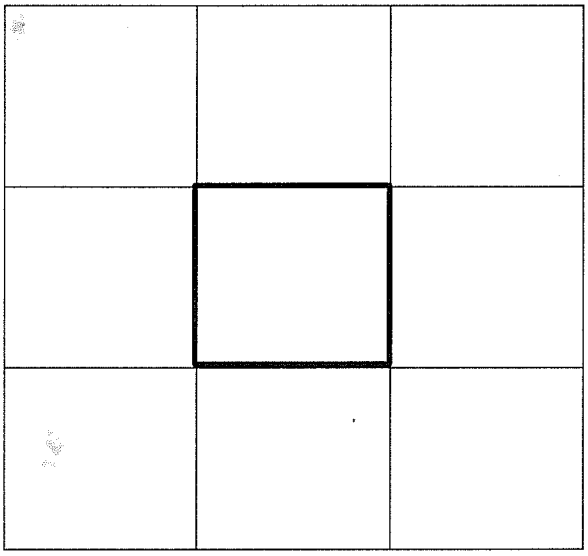
Density: >60 60-40 40-25 25-10 <10
Height (m): <3 3-10 >10
Stage: Regrowth Young Matured
Origen: Burn Cut
Disturbances: Yes No

SHRUB AND GRASS STRATA

High shrub: %
Low shrub: %
No shrub Grass land

OPENLAND/BACKGROUND

Grass:	%	Mosses:	%
Herbaceous:	%	Rock:	%
Fen:	%	Litter:	%
Water:	%	Lichen:	%
Sphagnum:	%	Other:	%



Land cover of nine 30m pixels

Photographs
1) GPS
2) Down
3) North
4) East
5) South
6) West
7) Up
8) Zoomed photos
9) Field note

NOTES:

Land cover legend

Conifers:	HDC	– High Density
	HDYC	– High Density Young
	MDC	– Medium Density
	LDC	– Low Density
	VLDC	– Very Low Density
Broadleaf:	HDB	– High Density
	LDB	– Low Density
Mixed:	MC	– Mixed Conifers
	MB	– Mixed Broadleaf
	MO	– Mixed Orchard
Shrub:	HDS	– High Density
	LDS	– Low Density
	OG	– Open Grassland
Cropland:	HB	– High Biomass
	MB	– Medium Biomass
	LB	– Low Biomass
Wetland:	BW	– Bog
	MW	– Marsh
	SW	– Swamp
Open:	OL	– Barren Land
	OB	– Burnt Land
	OW	– Water
	OS	– Snow/Ice
	ONV	– Northern Vegetation
	RO	– Rock
Built:	I	– Infrastructure
	B	– Buildings
	M	– Mines
Others:	–	

Land cover information (Educational purpose only)

Conifers

Black Spruce

Black Spruce is a slow-growing, small upright evergreen coniferous tree (rarely a shrub), having a straight trunk with little taper, a scruffy habit, and a narrow, pointed crown of short, compact, drooping branches with upturned tips.


White Spruce

The white spruce is a large coniferous evergreen tree which grows normally to 15 to 30 m tall. The bark is thin and scaly, flaking off in small circular plates 5 to 10 cm (2 to 4 in) across. The crown is narrow – conic in young trees, becoming cylindric in older trees.


Jack Pine

It grow ranges from 9–22 m in height. Some jack pines are shrub-sized, due to poor growing conditions. They do not usually grow perfectly straight, resulting in an irregular shape. The leaves are in fascicles of two, needle-like and twisted.


Red Pine

It usually ranges from 20–35 m in height and 1 m in trunk diameter. The crown is conical, becoming a narrow rounded dome with age. The bark is thick and gray-brown at the base of the tree, but thin, flaky and bright orange-red in the upper crown. Some red color may be seen in the fissures of the bark. The species is self pruning; there tend not to be dead branches on the trees, and older trees may have very long lengths of branchless trunk below the canopy. The leaves are in fascicles of two.


White pine

This species produces the largest trees. White pine is the native pine with bundles of five needles (red pine and jack pine needles come in bundles of two). The needles have a blueish tinge to them and feel quite soft. White pine can grow to 30m tall and over 1.2m in diameter. The tops of older specimens often break off, giving them a flat-topped appearance.


Broadleaf

Maple

Most maples are trees growing to a height of 10–45 m). Others are shrubs less than 10 meters tall with a number of small trunks originating at ground level. Most are shade-tolerant when young and are often riparian, understory, or pioneer species rather than overstory trees.


Oak

Oaks have spirally arranged leaves, with lobate margins in many species; some have serrated leaves or entire leaves with smooth margins. Many deciduous species are marcescent, not dropping dead leaves until spring.

Birch

Birch species are generally small to medium-sized trees or shrubs, mostly of northern temperate and boreal climates. The simple leaves are alternate, singly or doubly serrate, feather-veined, petiolate and stipulate. The bark of all birches is characteristically marked with long, horizontal lenticels.

Aspen

Aspens typically grow in environments that are otherwise dominated by coniferous tree species, and which are often lacking other large deciduous tree species. The bark is photosynthetic, meaning that growth is still possible after the leaves have been dropped. The bark also contains lenticels that serve as pores for gas exchange (similar to the stomata on leaves).


Beech

Beech grows on a wide range of soil types, acidic or basic, provided they are not waterlogged. The tree canopy casts dense shade, and carpets the ground thickly with leaf litter.


Moss

Sheet moss

Fern

Sphagnum

Lichen