McLeod Lake Moose Habitat Enhancement Project

Prepared by: Brandon Geldart, RFT and Britney Grunerud, RPF
Monitoring Protocol developed by Vanessa Uschenko, RPBIO
Prepared with financial support from the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, and McLeod Lake Indian Band.
Date: May 21, 2025

Statement of Need

Moose population declines in various locations in the interior of British Columbia have caused significant local and provincial concern. Moose are an iconic wildlife species and an important food source for many residents and First Nations. Moose population declines have been associated with extensively disturbed landscapes following salvage logging of mountain pine beetle damaged lodgepole pine stands (Kuzyk and Heard 2014, Boucher et al. 2022). While early seral forests and roadside areas are associated with high moose forage availability, these same sites have been correlated to moose declines (Beyer et al. 2013, Francis et al. 2020, Boucher et al. 2022). The cumulative effect of timber harvesting and installation of dense road networks appears to have impacted habitat features necessary for moose survival. Wolf predation is the primary cause of cow moose mortality (Mumma and Gillingham 2019, Sittler 2020, Birch and McNay 2021, Anderson et al. 2023). Wolves typically prefer areas of low road density and wolf caused moose kills are most often occur away from these features (Mumma and Gillingham 2019). Despite this, in some landscapes where linear features and openings are seemingly inescapable higher occurrences of wolf caused moose kills have been correlated to these features (Mackenzie et al. 2012, Boucher et al. 2022). Human harvest and apparent starvation are the next most frequent causes of cow moose mortality and a are strongly correlated with recent occupancy of new cutblocks and areas with high road density (Mumma and Gillingham 2019).

Moose rely on wetlands, ponds and early seral forests for foraging and late seral forests for thermal cover, predator avoidance, and snow interception (Belovsky et al. 1973). They require winter range (Bunnel et al. 2004) having forested areas that provide thermal cover during low temperatures and for snow interception to reduce energy expenditure in late winter (Schwab 1985). Seasonal thermal cover is particularly important during spring and summer high temperatures (Street et al. 2015). As plantations age they are likely to exclude moose forage species over time due to reforestation practices that promote dense conifer stands to optimize timber values (Leblond et al. 2015). Given mounting pressures on local moose populations it is important to review the relationship between harvesting and silviculture practices and moose habitat viability. Mcleod Lake Indian Band (MLIB) has supported this multi-year project to address the issue of food sovereignty in their territory.

In addition to being important to First Nations, hunters and recreationists; moose are categorized as a focal species under FWCP's Peace Region Cross Ecosystem and Uplands Action Plan. The goals and objectives of this project coincide with Cross-Ecosystem Actions 5,6,7 and 10; and with Upland Actions 2,6,9,10,11,12,13, and 14.

Background

In 2023 SERNbc was approached to coordinate project delivery for McLeod Lake's moose enhancement proposal in hopes of creating a replicable process. Experts and interest groups were solicited for input into the proposed project and a Round Table of First Nation, biology, forestry, and research expertise was created. SERNbc had field crews assess all of the original enhancement polygons proposed by Madrone in MLIB's original project proposal. Most of these areas fell within new openings created by clear-cut logging. The roundtable decided that efforts in these areas had limited benefit to moose and the potential restoration efforts would neglect to address the core reasons for ungulate population decline. The loss of primary forest and habitat conversion were major discernable factors linked to biodiversity loss in British Columbia. It was determined that the most direct method for habitat restoration was to recruit habitat through the conversion of conifer plantations via variable spaced thinning and reduction of linear features. This method would break up uniformity and could economically utilize a portion of the wood fiber to offset restoration costs in an effort to create a cost conducive replicable method for moose habitat enhancement.

Project History

2023-2024:

In Year 1 SERNbc and MLIB met with experts and interest groups to guide the placement and development of the moose enhancement treatments. Given there was an interest from the roundtable to pursue a trial commercial thin for habitat enhancement the focus for year 1 was to develop treatments within plantations aged 30-45. During field reconnaissance opportunities were identified to enhance moose habitat through potentially increased forage availability, ungulate winter range recruitment, and beaver habitat enhancement. In addition to measures that enhance moose habitat an opportunity to simultaneously study the response of *Vaccinium membranaceum* to various thinning treatments within the project treatment units was identified in early reconnaissance. MT3 was selected as a priority for development in year 1 due to the significant patches of *Vaccinium membranaceum* observed within the plantation. MT7 was also developed for treatment in year 1. Both plantations were considered good candidates for meeting the provincial guidelines for commercial thinning. Treatments have been developed to compare conventional commercial thinning to alternative thinning specifications that may improve habitat features and/or crop tree response.

2024-2025:

In year 2 the layout was finalized, and baseline monitoring data was acquired. Halfway River, Doig River, West Moberly and McLeod Lake were all consulted directly via email, telephone or in-person meetings. The project was met with enthusiasm by correspondents. After lengthy discussions with Authorizing professionals within the Prince George and Mackenzie Natural Resource Districts, a Special Use Permit (SUP) an Occupant Licence to Cut (OLTC) and Road Use Permit (RUP) were submitted in the summer of 2024. Permits were issued in November 2024.

Treatment in MT3 and MT7 was implemented based on treatment objectives and guidance from the planning Round Table. Selective harvesting crews have completed thinning operations, and road maintenance and trucking contractors will be finishing up in April 2025.

Planning and development for the 2025 precommercial thinning treatment unit (MT6) and road rehabilitation have been completed. The permits for the precommercial thinning treatment units were obtained in November 2024. In the winter of 2024-2025 we completed variable thinning and gap treatments within MT3 and MT7 using a harvester forwarder system.

The project has been discussed during presentations at the Northern Silviculture Committee's 2024 field tour, SERNbc's Ecosystem Restoration Plan stocking standard development table, and during CNC's baseline data acquisition. These conversations have attracted the interest of professionals across many different disciplines who wish to be a part of the process. Hydrologists, forest professionals and biologists have all proposed methods to assist in monitoring and we are currently identifying opportunities for collaboration with interested parties.

2025-2026:

In year 3 we completed manual brushing of younger dense monoculture spruce plantations. Tootikoh Contracting (Nak'azdli Whut'en) has carrying out the work. Duz Cho Contracting has completed road restoration of in-block roads and legacy forest road permits. Authorization for road rehabilitation activities were granted by one of the project's industrial partners (Canadian Forest Products) who holds permits for the roads within the project area . We are attempting to reduce linear disturbances closer to 0.6km/km2 which is the threshold for upset predator prey dynamics. CNC and SERNbc will complete the first year of post treatment monitoring within MT3 and MT7.

Goals and Outcomes

The goal of this project is to create a replicable habitat enhancement activity to support First Nation food sovereignty through wildlife habitat recruitment by promoting biodiversity, old forest characteristics and increased landscape heterogeneity.

Overall Objectives

Although this project focuses on moose habitat enhancement it is within SERNbc's mandate to focus on ecosystem restoration as opposed to single species management. It is our intention that all prescribed treatments have been planned to enhance habitat features for a variety of species to increase overall biodiversity. In Year 1 planning and development several treatment objectives were identified that correspond to the overall project goal:

1) **To identify if there is a change in site use by moose in thinning treatments and/or small gaps compared to untreated plantations.**
    - Outcome: Two trial areas (MT3 and MT7) have been laid out, permitted and are currently being treated.

2) **To identify the response of forage species to thinning treatments and gaps.**
    - Outcome: The College of New Caledonia has completed year 1 baseline data acquisition and will be revisiting in the spring.

3) **To identify the response of broadleaf tree species ingress in thinning treatments and gaps and compare those responses against sites that have a history of herbicide use and those that do not.**
    - Outcome: The College of New Caledonia has completed year 1 baseline data acquisition and will be revisiting in the spring.

4) **To identify the response of *Vaccinium membranaceum* (*Vaccinium membranaceum*) to thinning treatments.**
    - Outcome: All *Vaccinium membranaceum* patches have been gps'd and will be monitored in subsequent years post-treatment.

5) **To analyze the ability of industry guidelines for commercial thinning to provide for non-timber values including moose habitat features.**
    - Outcome: Thinning specifications that follow current provincial commercial thinning guidelines have been prescribed and treated to compare to various thinning intensities.

Variable Spaced Thinning Operations

The operational trial commenced in the winter of 2024-2025. This project tweaked conventional commercial thinning to focus on recruiting key wildlife habitat features. Efforts have been made to ensure that these operations serve as an example of best management practices that:

- Break up plantation uniformity through variable spaced thinning and gap creation.
- Recruit interim structure through limb piling, stub trees and girdling.
- Utilize wood fiber in an effort to create a cost-conducive restoration method.

Study Area

Project sites were identified west of McLeod Lake in Wildlife Management Unit 7-24 within the FWCP Peace Region/ Parsnip sub-region. These areas are within McLeod Lake's Traditional Territory and were selected based on proximity to the community, proximity to historically high moose densities, being located within WMU 7-24 and being located outside of critical habitat for woodland caribou. Additionally, the project area was identified in moose habitat models produced by the Moose Working Group through the government-to-government Regional Strategic Environmental Assessment for the Peace (Northeast) Region (RSEA Moose Working Group 2021; Tripp and Jeffries 2020).

Three sites were selected based on site conditions that could support a commercially viable restoration thin. These areas are located between Carp Lake Provincial Park and conditional harvesting Ungulate Winter Range U-7-022 within a transitional zone between the SBS mk1 and SBS wk1. MT3 and MT7 were assessed as being within the SBSmk1 with ecotypes best characterized by the SBSmk1-01 and 06 dominating treatment unit areas on rolling terrain. Within MT7 the SBSmk1-05 occurs on upper slopes on warm aspects and the SBSmk1-09 occurs within depressions associated with drainages. Ecosystem assessments have not been completed for MT6.

All 3 sites consist of monoculture conifer plantations, predominantly spruce, with limited understory vegetation, stand structure or species diversity to benefit a variety of wildlife. MT3 was harvested and broadcast burned in 1986, 4.4ha was mechanically site prepped in 1995, manual brushing to remove broadleaves and overtopping shrubs was completed in 1995 with tree planting occurring over 3 years: 1986, 1987 and 1996. MT6 was harvested from 1999 to 2000, mechanically site prepped in 2000 and planted to 100% spruce in 2001. MT7 was harvested and broadcast burned in 1985, tree planting is assumed to have occurred in 1986, and large portions of the plantation received an aerial herbicide treatment in 1992 to remove broadleaves and shrubs. All three plantations are representative of a significant proportion of the landbase that has been modified by timber harvesting and silviculture activities: they are uniformly spaced conifer stands with low species and structural diversity.

Treatment Methods

Treatment Types

Thirteen treatment units were prescribed in both MT3 and MT7. Treatment units were either variable spaced thinning units, small cleared gaps or girdle strips. Variable spaced thinning and gap treatment units were treated in the winter of 2024/25. All treatment types are described in greater detail below.

Variable Spaced Thinning and Gap Creation

Various spaced thinning units had one of the following planned densities: 200, 400, 600, 800 or 1000 Stems per Hectare (SPH) post-treatment targeted. Variable thinning treatment units were mechanically thinned with a harvester-forwarder system. Trails within the treatment units were intentionally curved to reduce sight lines within treated areas.

The harvester-forwarder system utilizes specialized equipment for selective cutting operations which allows for high retention of stems. A Ponsee harvester was used to cut targeted stems and places logs along either side of a trail. Removed stems were processed in block, and limbs and tops were piled along trails to be burned in the fall of 2025 pending burning conditions. During the forwarding phase a specialized log transporter retrieves logs, places utilizable logs in a bunk and carries them to a roadside to be hauled to the purchasing mill. 20SPH of dead trees were targeted to be retained on site post-treatment in the thinning treatment units. Where <20SPH of dead trees were present dead trees were recruited through tree stubbing. The tops of stubbed trees were left on site to reassert Coarse Woody Debris on the forest floor.

Gap treatment units were also mechanically treated with a harvester forwarder system in MT3 and MT7. The cleared gaps created were 0.2 to 1.0 ha in size.

Figure 2. Harvester operating in MT3

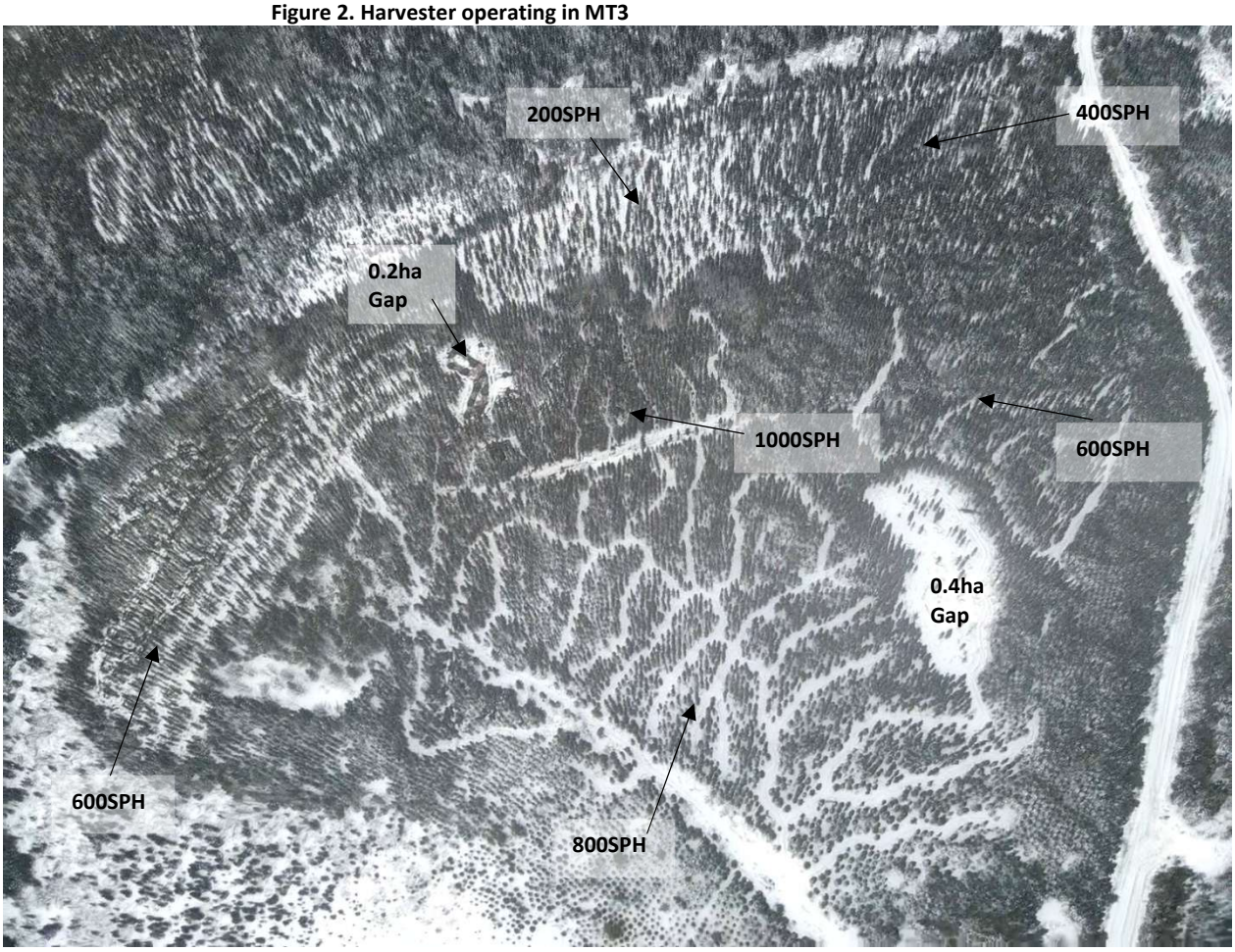


Figure 3. Aerial image of MT3 post-treatment (winter 2025) showing various treatment units.

Harvest Plan Maps detail treatment units and operational considerations and can be found in Appendix 1 and 2.

Huckleberry Special Management Zones

In MT3 two Special Management Zones (SMZs) were identified in the field where a high abundance of Black Huckleberry (*Vaccinium membranaceum*) was present. These areas had prescribed trail orientations to limit forest floor exposure to achieve filtered light conditions at the forest floor post-treatment. Otherwise, the Huckleberry SMZs were managed as per the treatment unit.

The SMZs provided an opportunity to relate stand density to *Vaccinium membranaceum* plant abundance and berry production. Many studies have noted decreases in *Vaccinium membranaceum* plant abundance and cover following precommercial and commercial thinning but did not measure the change in berry production (Beese et al. 2002, Kerns et al. 2004, Clason et al. 2008). We were only able to find one study that measured changes in berry production following various overstory treatments, none of which were precommercial or commercial thinning. Minore (1984) observed an increase in *Vaccinium membranaceum* production following the chemical girdling of 50% of the conifer overstory. There are no known local studies considering the relationship between thinning and *Vaccinium membranaceum* plant abundance or berry production.

Girdle Strips

Corridors adjacent to thinning and gap treatment units were designed to recruit dead standing and coarse woody debris in a plantation devoid of these habitat features. A target of 10SPH will be manually girdled using a chainsaw. Approximately 40% of the girdle strips in MT3 were completed in the winter of 2024/25. The remainder of the girdle strips will be manually girdled in 2025.

Figure 4. Girdled trees outside MT7

No Treatment Areas: Controls and Ecological Anchors

This project was planned to develop a treatment area composed of 30% treatment units, 30% untreated plantation and 30% ecological anchor (mature forest or stand having mature forest attributes). Final areas closely match these planning targets for MT3 and MT7.

Control areas (untreated plantation) were desired to contribute to stand diversity as well as to establish an untreated control for monitoring purposes.

Ecological anchors were an adjacent stand with desirable stand attributes: mature stand condition, wildlife trees, diversity of trees species including broadleaves, that could be considered a point of ecological strength.

Monitoring

The College of New Caledonia (CNC) and SERNbc have developed monitoring protocols under the guidance of the project roundtable. The objective of these measures are to examine the biotic and abiotic benefits and trade-offs of the treatment types. Several monitoring priorities have been identified. SERNbc has undertaken stand measurements and qualified professionals from CNC will manage wildlife, vegetation, air temperature, soil moisture and light regime monitoring.

The baseline condition data collected in 2024 included: stand measurements, wildlife monitoring, moose pellet surveys, air temperature monitoring and vegetation surveys. Transects, camera and temperature logger locations are identified on the map below.

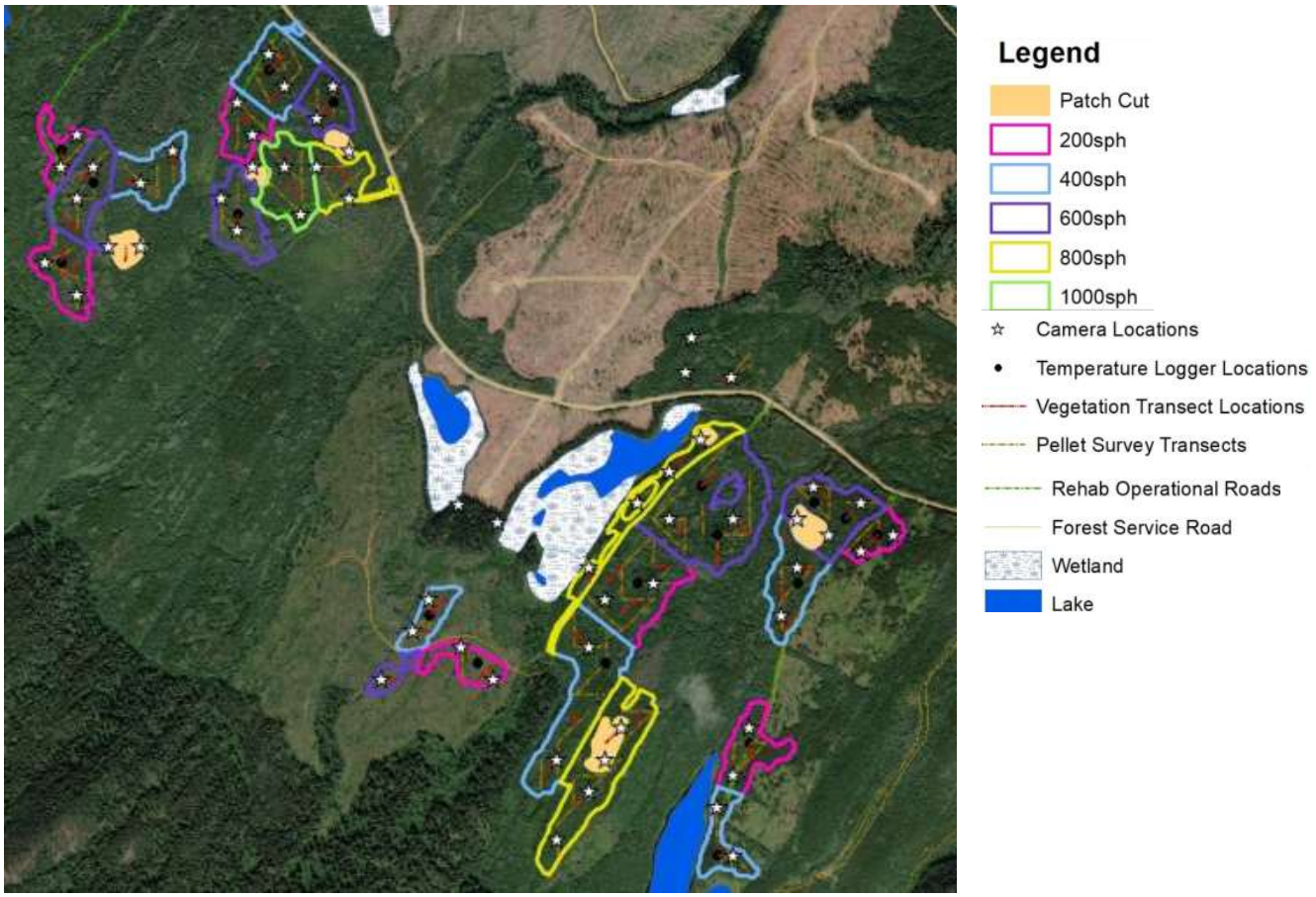


Figure 5. Monitoring Equipment Installments and Transect Location Map from CNC (Uschenko 2024).

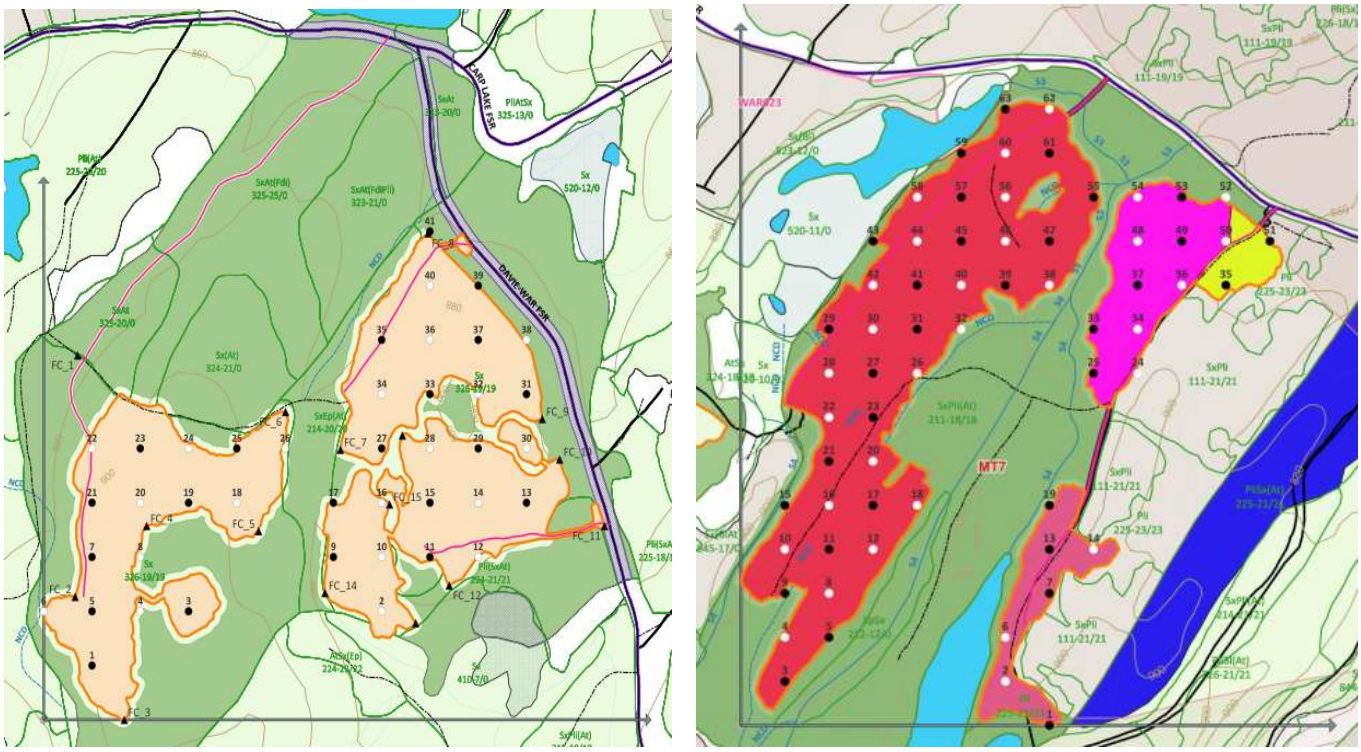
Stand Measurements

The objective is to monitor and compare the growth and abundance of tree species within each thinning or gap treatment unit with untreated portion of the plantations. We predict that thinned plantations will have higher stem diameter and crown growth as well as species diversity and abundance than untreated plantations.

The pre-treatment stand was measured in 2024 as per the *Timber Cruising Manual (Updated August 1, 2024)* with live/dead conifer and deciduous stems >7.5cm diameter at breast height (1.3m) included in the cruise and summarized as per the Cruise *Compilation Manual (Updated July 1, 202*3). A metal stake was installed at each measurement plot for

remeasurement (measurement plots are identified in solid black on the cruise plan map images below). Additional data was collected at each measurement plot including secondary stand structure and live crown height and width.

Secondary stand structure was collected with a 3.99m fixed plot radius using the same plot center. All live/dead conifer and deciduous trees with diameters <7.5cm at breast height (1.3m) were tallied by tree species and silviculture layer. Silviculture layers were defined as per the *2023 Silviculture Survey Procedures Manual.* Stand measurements will be reassessed immediately after initial treatment in summer of 2025 and again in summer of 2029.The survey design can be found below.



Figures 6 and 7. Cruise Plan Map images showing grid system sampling design. Left: MT3 (green is reserved areas, orange is single timber type) Right: MT7 (reserved areas are shown in green, timber type 1 in red, timber type 2 in pink, timber type 3 in yellow, and timber type 4 in magenta.

Wildlife Monitoring

The objective is to monitor wildlife use and habitat selection across thinning and gap treatment units, with a focus on moose. We predict increased moose use in low-density stands during summer and early winter due to improved forage availability (Uschenko 2024b).

A grid-based camera deployment system has been used, with two trail cameras per block (28 blocks total), placed ≥100 m apart where feasible. A total of 65 trail cameras and 70 SD cards have been used. Batteries are being replaced and data downloaded at least once prior to winter (2024/2025) (Uschenko 2025 pers. comm.).

Climate and Air Temperature Monitoring

We will examine the values of thermal cover on the landscape, and track local weather conditions throughout the study period to assess how climatic variability may affect vegetation and wildlife responses. To monitor these changes, we will focus assess the local climate and compare temperature conditions in: all treatment types, untreated plantation, and available adjacent mature forest. We hypothesize that weather anomalies will influence short-term trends in soil moisture, vegetation growth and animal presence. We predict that these influences will vary depending on the treatment type due to changes in the light regime. We anticipate that daily average temperatures will immediately increase in low density stands

(<800sph). However, these stands will reflect similar values to those recorded among mature forest habitat over the longer term (10+ years) (Uschenko 2024b).

To monitor local climate; a fully equipped, fixed weather station has been installed in a recent cutblock (<5-year-old). The station has been recording precipitation, air temperature, soil moisture, relative humidity, barometric pressure, solar radiation, and wind speed/direction and will continue to do so for the full duration of the monitoring regime. (Uschenko 2025 pers. comm.).

To compare quantify air temperature differences a total of 24 temperature loggers with solar radiation shields have been installed across all treatments and control areas (4 per treatment strata, plus 2 each in the untreated plantation and mature forest). All loggers have been installed ≥1.5 m above ground and protected from direct solar radiation, wind, and precipitation. Data will be supplemented by the weather station. (Uschenko 2025 pers. comm.).

Moose Pellet Surveys

To quantify moose use across thinning treatments, permanent 100 m × 1 m belt transects were established in all treatment types, control areas, and adjacent unharvested mature forest using a randomized 50 m grid overlay. Transects were spaced to avoid overlap and, where possible, placed away from block edges to reduce edge effects. Transect density was based on a target of 1% area coverage, resulting in 86 transects surveyed in 2024 (Uschenko 2024b).

Each transect was navigated in the field from a predetermined grid point, with azimuth recorded. Surveyors walked the transect line, visually detecting moose pellets within 50 cm on either side (1 m total width). For each pellet group, species, season (winter/summer), and distance along the transect were recorded. Questionable cases were measured from the centerline and included only if within bounds. All recorded pellets were removed or destroyed to prevent double-counting in future sampling (Uschenko 2025 pers. comm.).

Vegetation Surveys

The objective is to assess plant community response to thinning treatments, including changes in species composition, abundance and forage quality. We predict increased plant diversity and a shift toward shade-intolerant species in low-density treatment units. (Uschenko 2024b)

Vegetation will be sampled using 25 m line transects, spaced 100 m apart and located >30 m from treatment edges. A total of 46 transects will be installed based on treatment area. Coverage, density, frequency, species diversity, and browse intensity have been recorded. Additional focus is being placed on *Vaccinium membranaceum* sites (Uschenko 2025 pers. comm.).

Soil Moisture and Light Regime Monitoring

The objective is to track changes in soil temperature and moisture across treatments and controls to understand effects on understory establishment and stand resilience. We predict that lower density reductions (≤800 sph) will initially increase soil temperature and reduce early spring soil moisture due to greater solar exposure, but will increase growing season soil moisture at 20 cm depth. Over 5–10 years, soil temperatures in denser treatments (>800 stems/ha) is expected to be similar to baseline levels as vegetation recovers (Uschenko 2024b).

To document this, we are planning the installation of 14 soil monitoring stations in the summer of 2025 across all treatment, control strata and unharvested mature forest. Soil moisture sensors will be placed at 5 cm and 20 cm depths, with associated relative humidity and temperature probes. All stations will be placed >30 m from treatment edges to minimize transitional effects. Soil texturing will be completed for sensor calibration. Where possible, installations have been co-located with *Vaccinium membranaceum* sites (Uschenko 2025 pers. comm.).

Snow Depth Interception

The objective is to quantify winter snow depths as influenced by canopy interception across treatment types, providing insights into moose winter habitat conditions. We predict that deeper snowpacks will persist in low-density treatments due to reduced canopy interception (Uschenko 2024b).

Sixteen snow monitoring stations will be established (2 per strata), co-located with wildlife trail cameras. Snow depth will be passively recorded throughout the winter using meter sticks placed in representative open areas outside of tree wells. (Uschenko 2025 pers. comm.).

Recommendations and Learning Outcomes

At present, it is not possible to evaluate differences between treatment types, as only baseline data have been collected. Nevertheless, several potential operational efficiencies have been identified:

- Road maintenance and transportation costs were the largest factors impacting economic feasibility in this thinning operation. Although best practices identified by the project roundtable recommended winter harvest, road maintenance should be a primary consideration when planning operations. Creating an economy of scale by utilizing multiple contractors up the same road network, or selecting stands favorable to summer logging would significantly increase cost savings.

- Timber harvesting in conditions below -15° C caused significantly higher rates of limb shatter and stick matting over much of the forest floor. This may increase wildfire risk and limit vegetation response in the short term. Avoiding timber harvesting operations during periods where temperatures are below -15° C to mitigate debris build up and increase piling efficiency would mitigate this.

- High density patches of 1000SPH were difficult to achieve through mechanical methods. Treatment units planned for 1000SPH were completed as planned in MT3 but in MT7 any treatment unit planned for 1000SPH was changed to 800SPH as the desired result could not be achieved in MT3. The 1000SPH treatment units in MT3 had minimal to no thinning in the areas off the trails, resulting in cleared linear features between untreated strips.

- Treatment boundaries were cut in first by operators to reduce the possibility of harv[illegible]passes. Although operators were given instructions to meander trails, how the harvesting boundary was managed was not specified. The lines created along the boundary resulted in pronounced sightlines that would be best avoided where habitat enhancement objectives apply.

Acknowledgements

This moose habitat restoration project was managed and delivered with financial support from the Fish and Wildlife Compensation Program. www.fwcp.ca. SERNbc gratefully acknowledges the financial support of the Fish and Wildlife Compensation Program to deliver on this project. Additional contributions for monitoring have been provided by MITACS and media creation by the Silviculture Innovation Program.

This project has been a collaborative effort that could not have happened without the consistent input of passionate individuals from various disciplines and organizations:

Nathan Prince- McLeod Lake Indian Band
Eran Spence- McLeod Lake Indian Band
Stephanie Rocheleau- McLeod Lake Indian Band
Debra Pinkston- McLeod Lake Indian Band
Mariah Curry- McLeod Lake Indian Band
Tania Solonas- McLeod Lake Indian Band
Chelsea Regina, RPBio- Fish and Wildlife Compensation Program
Vanessa Uschenko, RPBio- The College of New Caledonia
Carl Pollard, RPF - The College of New Caledonia
Roy Rea, PhD, RPBio- The University of Northern British Columbia
John DeGange, RPF- Ministry of Forests
Matt Scheidman, RPBio- Ministry of Water Land Resource Stewardship
Jeff Werner, PhD, RPBio- Ministry of Water Land and Resource Stewardship
Britney Grunerud, RPF- Ironwood Resource Professionals
Carrier Lumber
Freya Logging
Duz Cho Contracting
Canfor

Collectively, we are grateful to have the opportunity to plan and deliver a habitat enhancement thinning trial and hope that this project can help serve future resource management and restoration practices.

References

Anderson M, Proctor C, Scheideman M, Schindler H, Thacker C, Hodder D, Gannon K, and Bohm H. 2023. Factors affecting moose population declines in British Columbia – May 2022 progress report. Ministry of Forests, Victoria, BC.

Beese WJ, Sandford JS, Harrison ML, Filipescu CN. 2022. Understory vegetation response to alternative silvicultural systems in coastal British Columbia montane forests. Forest Ecology and Management 504: 119817.

Belovsky GE, Jordan PA, Botkin DB. Summer browsing by moose in relation to preference and animal density: A new quantitative approach. In Proceedings of the North American Moose Conference and Workshop 1973 (Vol. 9, pp. 101-122).

Beyer HL, Ung R, Murray DL, and Fortin MJ. 2013. Functional responses, seasonal variation and thresholds in behavioral responses of moose to road density. Journal of Applied Ecology 50:286-294

Birch L abd McNay RS. 2021. Williston moose limiting factors investigation 2015-2020: A report on extended monitoring and mortality investigations. Report No. 737. Wildlife Infometrics Ltd., Mackenzie, BC, Canada.

Boucher, N.P, Anderson M., Ladle A., Proctor C., Marshall S., Kuzyk G., Starzomski B.M., and Fisher J.T. 2022. Cumulative effects of widespread landscape change alter predator-prey dynamics. Scientific Reports 12(1): 10.1038/s41598-022-15001-3.

Bunnell, F.L., K.A. Squires, and I. Houde. 2004. Evaluating effects of large-scale salvage logging for mountain pine beetle on terrestrial and aquatic vertebrates. Mountain Pine Beetle Init. Work. Paper 1, 2004-2, Center for Appl. Conserv. Res., Univ. B.C. and Nat. Resour. Can., Can. For. Centre

Bunnel FL and Dupuis LA. 1993. Riparian habitats in British Columbia: Their role and nature. Riparian habitat management and research: A special publication of the Fraser River action plan. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network, held in Kamloops, B.C., 4-5 May, 1993.

Clason AJ, Lindgren PMF, Sullivan TP. 2008. Comparison of potential non-timber forest products in intensively managed young stands and mature/old-growth forests in south-central British Columbia. Forest Ecology and Management 256:1897-1909.

Francis AL, Proctor C, Kuzyk G, and Fisher JT. 2020. Female Moose Prioritize Forage Over Mortality Risk in Harvested Landscapes. The Journal of Wildlife Management DOI:10 1002/jwmg.21963:1-13

Kerns BK, Alexander SJ, Bailey JD. 2004. *Vaccinium membranaceum* abundance, stand conditions, and use in Western Oregon: Evaluating the role of forest management. Economic Botany 58(4):668-678.

Kuzyk, G., and D. Heard. 2014. Research design to determine factors affecting moose population change in British Columbia: testing the landscape change hypothesis. B.C. Minist. For., Lands and Nat. Resour. Operations. Victoria, BC. Wildl. Bull. No. B-126. 16pp.

Leblond, M., Dussault C., and St-Laurant MH. 2015. Low density spruce plantations increase foraging by moose In a northeastern temperate forest. Forest Ecology and Management 347: 228-236

McKenzie HW, Merrill EH, Spiteri RJ, and Lewis MA. 2012. How linear features alter predator movement and the functional response. Interface Focus 2:205–216

Minore D. 1984. Vaccinium membranaceum berry production seven years after treatment to reduce overstory tree canopies. Northwest Science 58(3): 208-212.

Mumma MA and Gillingham MP. 2019. Determining factors that affect survival of moose in Central British Columbia. A report to the Habitat Conservation Trust Foundation for Grant Agreement CAT19-0-522.

Schwab, F.E. 1985. Moose Habitat Selection in Relation to Forest Cutting Practices in Northcentral British Columbia. A thesis submitted in partial fulfillment of the requirements for the degree of doctor of philosophy. Faculty of Graduate Studies (Department of Plant Science), U.B.C.

Sittler KL. 2020. Williston Moose Limiting Factors Investigation 2015-2019. Wildlife Infometrics Inc. Report No.708_Wildlife Infometrics Inc., Mackenzie, British Columbia, Canada.

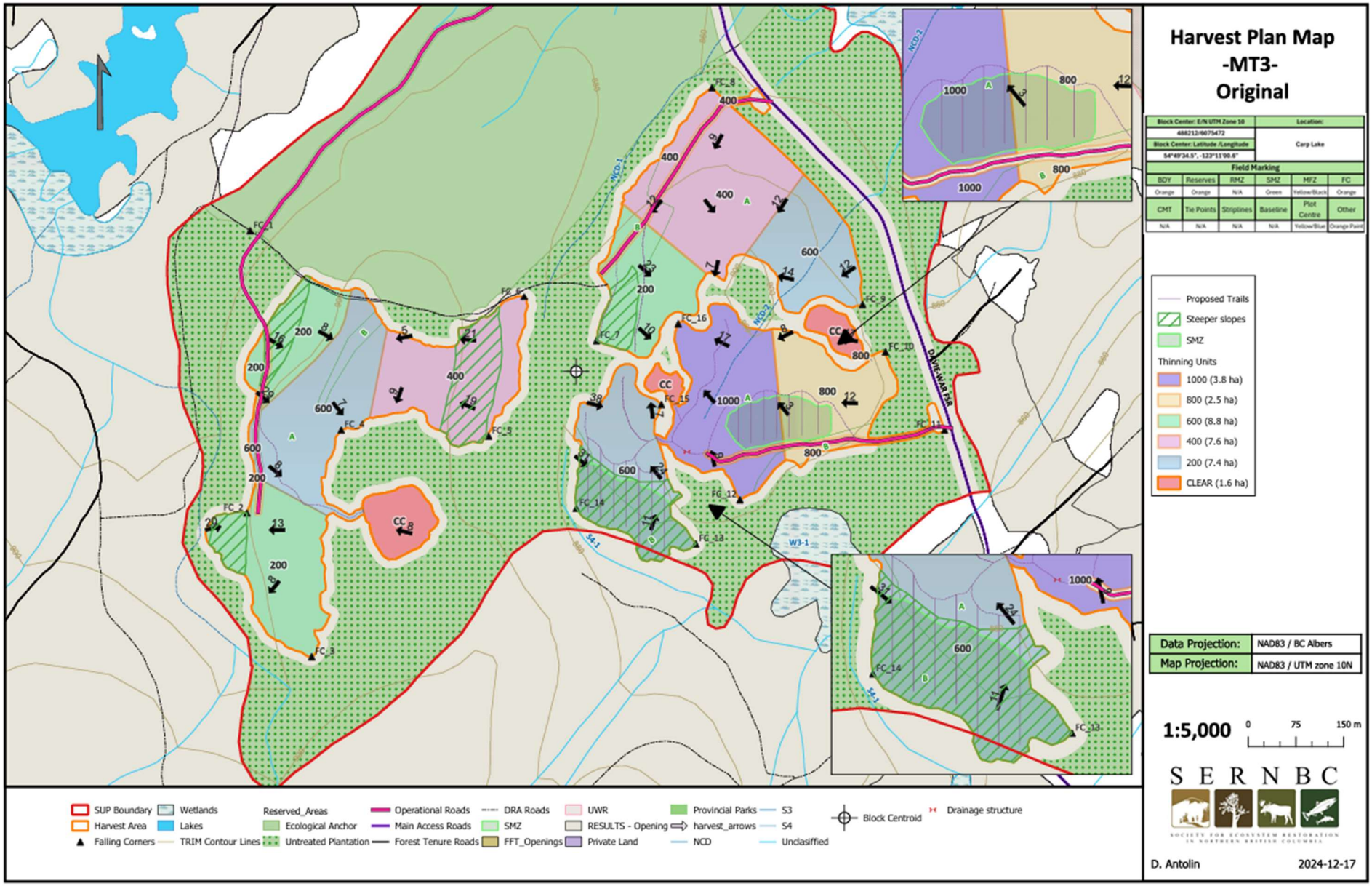
Street G.M., Rodgers A.R., and Fryxell J.M. 2015. Mid-day temperature variation influences seasonal habitat selection by moose. The Journal of Wildlife Management 79(3):505-512

Uschenko V. 2024a. McLeod Lake Moose Enhancement Summary Update 2024, College of New Caledonia Research Forest.

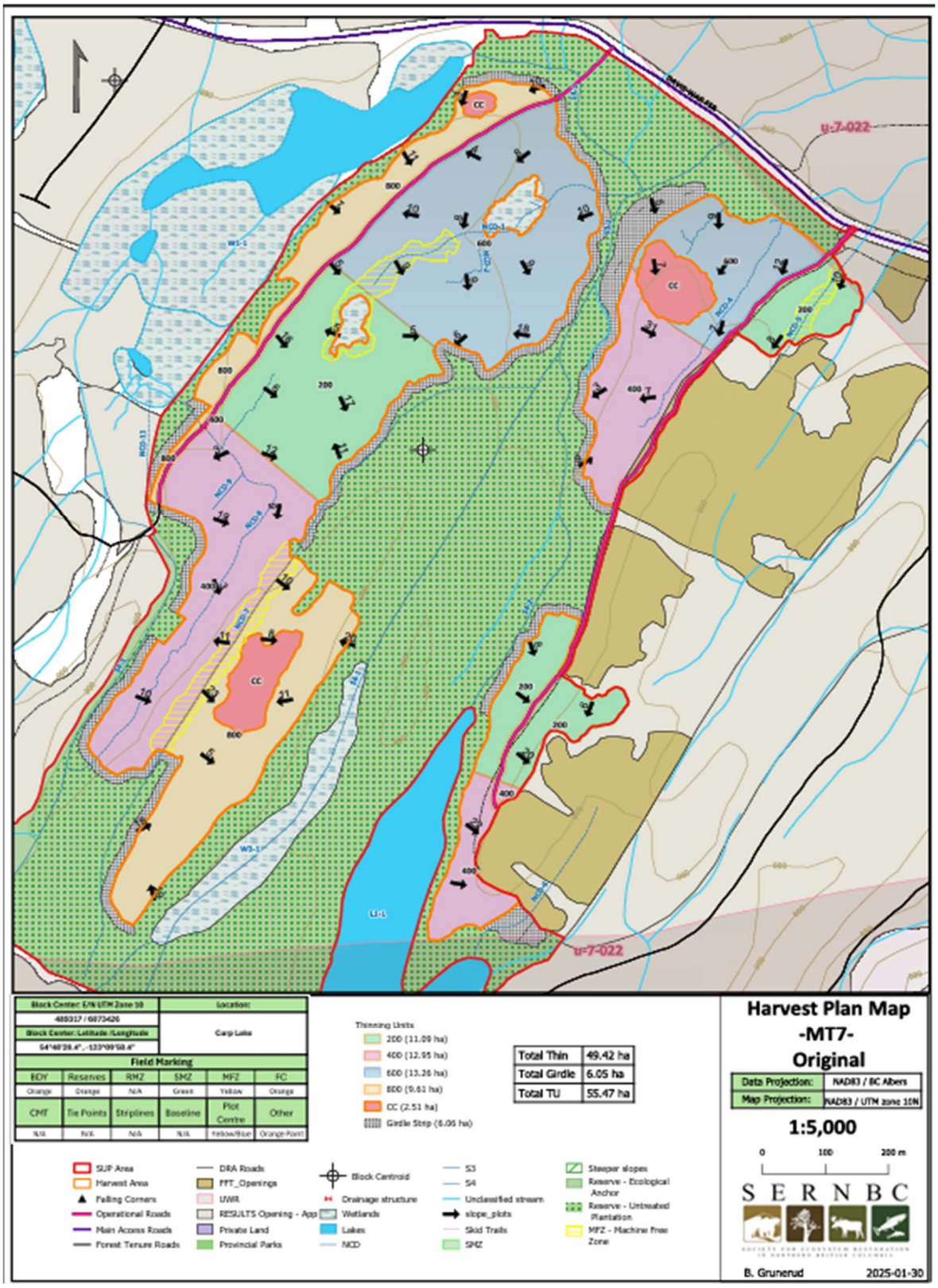
Uschenko V. 2024b. Draft Proposed Monitoring Plan for the McLeod Lake Moose Enhancement Project as prepared by the College of New Caledonia Research Forest

Uschenko V. Personal Communication. Research Assistant, College of New Caledonia Research Forest, College of New Caledonia, Prince George, BC Canada.

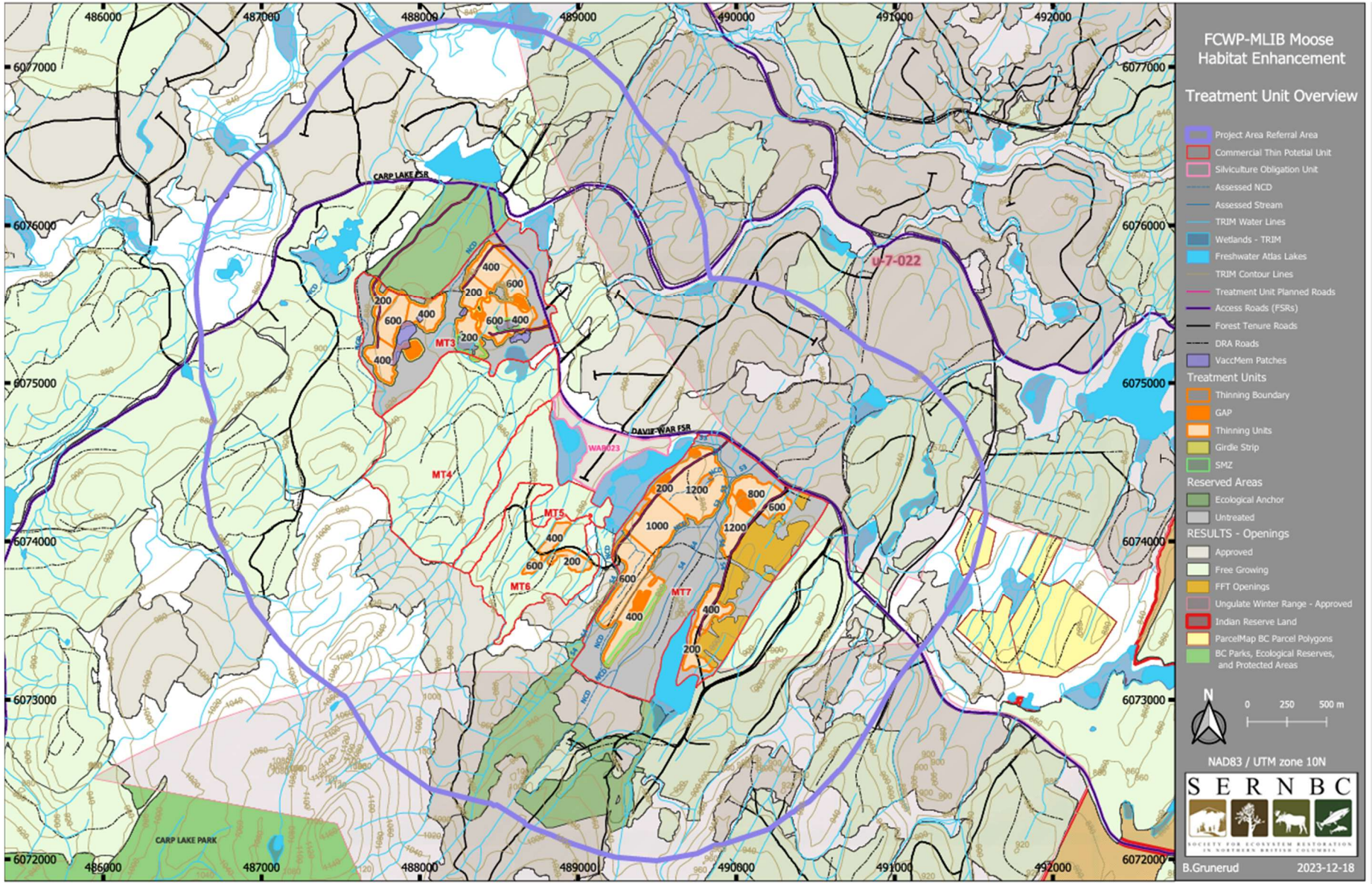
Appendix 1-MT3-Harvest Plan Map



Appendix 2-MT7- Harvest Plan Map



Appendix 3-MT7- Harvest Plan Map



Appendix 4-MT3- Cruise Summary

NOT FOR APPRAISAL PURPOSE — Section Page: 1 Main Page: 9

Timber Pricing Branch - 2023.00 — Cutting Permit Summary (Average Line Method) — MT3 Da 20240814 undersized, all trees.cpm

CompMatePC 1.7.0.0 — Useless Volume Excluded — 2024-11-27 5:08:42 PM

License Number:	A40873	PSYU:	22 - Crooked River - 117	Region:	6 - Omineca	Licencee:	The Society of Ecosystem Restoration in Nothern BC
Cutting Permit:		FIZ:	I	District:	1 - Prince George	Cruised By:	Ironwood
Net Area:	TUs: All: 32.9						

		Total	Conifer	Decid.	B	S	PL	AT
Utilization Limits								
Min DBH	cm (M)				7.50	7.50	7.50	7.50
Stump Ht	cm (M)				30	30	30.00	30
Top Dia	cm (M)				5.00	5.00	5.00	5.00
Log Len	m				5.0	5.0	5.00	5.0
Volume and Size Data								
Gross Merchantable	m3	6120	5711	410	49	5054	607	410
Net Merchantable	m3	5887	5592	294	49	4955	588	294
Net Merch - All	m3/ha	179	170	9	1	151	18	9
Distribution	%	100	95	5	1	84	10	5
Decay	%	1		22				22
Total Cull (DWB)	%	4	2	28	1	2	3	28
Basal Area/Ha	m2/ha	33.7	31.6	2.1	0.4	28.4	2.8	2.1
Stems/Ha (Live & DP)		1544.0	1335.0	209.0	39.3	1167.4	128.4	209.0
Avg DBH (Live & DP)	cm	16.7	17.4	11.4	10.7	17.6	16.7	11.4
Snags/Ha								
Avg Snag DBH	cm							
Gross Merch Vol/Tree	m3	0.12	0.13	0.06	0.04	0.13	0.14	0.06
Net Merch Vol/Tree	m3	0.12	0.13	0.04	0.04	0.13	0.14	0.04
Avg Weight Total Ht	m	14.3	14.2	16.0	11.6	14.0	15.7	16.0
Avg Weight Merch Ht	m	11.6	11.6	11.3	8.9	11.5	13.2	11.3
Avg 5.0 m Log Net	m3	0.06	0.06	0.03	0.03	0.07	0.06	0.03
Avg 5.0 m Log Gross	m3	0.06	0.06	0.04	0.03	0.07	0.06	0.04
Avg # of 5.0 m Logs/Tree		1.96	2.01	1.64	1.17	1.99	2.47	1.64
Net Immature	%	97.7	100.0	53.5	100.0	100.0	100.0	53.5
Slope Average	%	14						
LRF and Log Summary								
Net Merch - Stud	%	91.5	96.3		100.0	95.9	100.0	
Net Merch - Small Log	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Net Merch - Large Log	%							
Avg LRF All	bdft/m3				120.9	146.9	147.9	109.9
Statistical Summary								
Coeff. of Variation	%	55.7	53.9	306.7	317.9	58.6	336.1	306.7
Two Standard Error	%	20.5	20.0	94.2	203.6	19.5	207.1	94.2
Number and Type of Plots		MP = 19	CP = 15					
Number of Potential Trees		110						
Plots/Ha		1.0						
Cruised Trees/Plot		5.6						

FLAGS: Compile All Trees, Wet Belt Fir

Appendix 5-MT7- Cruise Summary

NOT FOR APPRAISAL PURPOSE — Section Page: 1 Main Page: 9

Timber Pricing Branch - 2023.00 — Cutting Permit Summary (Average Line Method) — MT7 Da 20240814 incl undersized, all 5cm top.cpm

CompMatePC 1.7.0.0 — Useless Volume Excluded — 2024-11-27 5:03:46 PM

License Number:	A40873	PSYU:	22 - Crooked River - 117	Region:	6 - Omineca	Licencee:	The Society of Ecosystem Restoration in Nothern BC
Cutting Permit:		FIZ:	I	District:	1 - Prince George	Cruised By:	Ironwood
Net Area:	TUs:	All: 79.5					

		Total	Conifer	Decid.	S	PL	E	AT
Utilization Limits								
Min DBH	cm (M)				7.50	7.50	7.50	7.50
Stump Ht	cm (M)				30	30.00	30	30
Top Dia	cm (M)				5.00	5.00	5.00	5.00
Log Len	m				5.0	5.00	5.0	5.0
Volume and Size Data								
Gross Merchantable	m3	14950	13072	1879	8783	4289	45	1834
Net Merchantable	m3	13972	12829	1143	8626	4203	36	1107
Net Merch - All	m3/ha	176	161	14	108	53		14
Distribution	%	100	92	8	62	30		8
Decay	%	4		33			13	34
Total Cull (DWB)	%	7	2	39	2	2	20	40
Basal Area/Ha	m2/ha	34.2	29.7	4.5	22.0	7.7	0.1	4.4
Stems/Ha (Live & DP)		1604.4	1216.1	388.3	1013.0	203.1	2.4	385.9
Avg DBH (Live & DP)	cm	16.5	17.6	12.1	16.6	22.0	20.4	12.1
Snags/Ha								
Avg Snag DBH	cm							
Gross Merch Vol/Tree	m3	0.12	0.14	0.06	0.11	0.27	0.23	0.06
Net Merch Vol/Tree	m3	0.11	0.13	0.04	0.11	0.26	0.19	0.04
Avg Weight Total Ht	m	14.4	14.4	14.6	13.3	16.8	18.7	14.5
Avg Weight Merch Ht	m	11.9	12.0	10.8	10.8	14.6	14.7	10.7
Avg 5.0 m Log Net	m3	0.06	0.07	0.02	0.06	0.09	0.06	0.02
Avg 5.0 m Log Gross	m3	0.06	0.07	0.04	0.06	0.09	0.08	0.04
Avg # of 5.0 m Logs/Tree		1.89	1.98	1.63	1.80	2.89	3.00	1.62
Net Immature	%	92.9	100.0	12.6	100.0	100.0		13.0
Slope Average	%	10						
LRF and Log Summary								
Net Merch - Stud	%	85.3	93.0		99.7	79.1		
Net Merch - Small Log	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Net Merch - Large Log	%							
Avg LRF All	bdft/m3				143.5	168.3	154.7	105.2
Statistical Summary								
Coeff. of Variation	%	38.9	45.8	216.5	53.8	164.3	141.4	220.7
Two Standard Error	%	16.2	16.1	121.7	20.2	49.7	200.0	125.5
Number and Type of Plots		MP = 26	CP = 28					
Number of Potential Trees		158						
Plots/Ha		0.7						
Cruised Trees/Plot		5.6						

FLAGS: Compile All Trees, Wet Belt Fir

PROJECT STANDARDS

The primary goal for this project is to reduce tree canopy to allow available light to reach the forest floor. Our objective is to increase plant and animal diversity by reducing crop tree distribution and recruiting temporary structure. Although, we are focused on the larger ecosystem, the project has been designed specifically around moose response.

THINNING The two stands that we have developed for thinning sit around 1400-1600 stems per hectare. Our target densities have been chosen to monitor a variety of responses: understory vegetation, overstory response, animal usage, soil moisture, and snow accumulation.

1) **Target Densities-** Remain overstory after treatment
    a. **200 SPH-** Will be very open and trails should be unnoticeable Thinning densities measured to include trails.
    b. **400 SPH** Will be open, and Trails Should still be unnoticeable Thinning densities measured to include trails.
    c. **600 SPH-** Attention will need to be given to trail placement. Inter tree distance should still limit trail visibility. Thinning densities measured to include trails.
    d. **800 SPH (Traditional Commercial Thin)-** Densities will be determined by EXCLUDINJG TRAILS. Attention should be given to curve trails to limit sightlines
    e. **1000 SPH-** This will be a very light thin. Densities will be determined by EXCLUDINJG TRAILS.

2) **Inter Tree Spacing-** Desired spacing between overstory crop trees/ crop tree clumps (Spruce, Pine, Balsam)

Treatment Density Targets		
Density (Stems Per Hectare)	Trees Per Plot (3.99m plot chord)	Maximum Distance Between Trees (meters)
1000	5	3.4
800	4	3.8
600	3	4.39
400	2	5.37
200	1	7.6

Example1: Limited Sightlines

Example 2- Natural Spacing

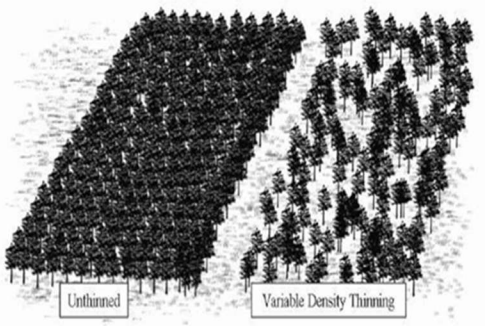


Figure 29.—Stylized representation of variable density thinning: (a) unthinned stand; (b) thinned stand displaying horizontal variation in stand density including gaps, skips (unthinned areas), and lightly thinned matrix.

TRAIL LAYOUT -Trails may or may not be visible depending on treatment density. Each trail could potentially open sightlines and promote predation within the treatment.

1) **Curve trails to limit sight lines**
2) **Offshoot trails in different directions**
3) **NCD's and wet areas have yellow ribbon. Designate crossings to limit impact.**
4) **Limit width where possible**

Example 1: Open sightlines DON'T DO **Example 2**: Curved Trail

LEAVE TREE SPECS- Our goal is to increase structure and promote alternative vegetation. The restoration effort will be more successful if we leave target vegetation and existing habitat features.

1) **Deciduous-** Aspen, Birch, and brush species
2) **Balsam and Least Dominant Conifer Species.**
3) **Trees with Defect-** In treatments 600,800,1000 retain forks, dead standing, broom rust, etc…
4) **Small Clumps and Small Skips in Treatment-** Where trees are close together leave clumps.
5) **Obvious understory-** Balsam, spruce, etc…
6) **Cameras and Monitoring Equipment-** Avoid if possible. If not then cut stem and leave as CWD.

Example 1: Broom Rust **Example 2:** Understory

STRUCTURE TARGETS -attempt to recruit dead woody debris and dead standing trees.

1) **Coarse Woody Debris-** Prioritize pulp logs above 15cm. Target 20 per hectare.
2) **Dead Standing-** Stub trees below live crown. Target 20 per hectare
3) **Limb Sort/ Critter Pile-** Create small piles every 5-20m. Keep piles more than 15m away from block boundary.