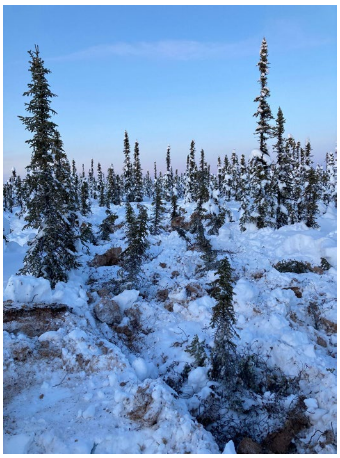
Restoring Conventional Seismic Lines in the Snake-Sahtaneh Caribou Range (Phases I and II)

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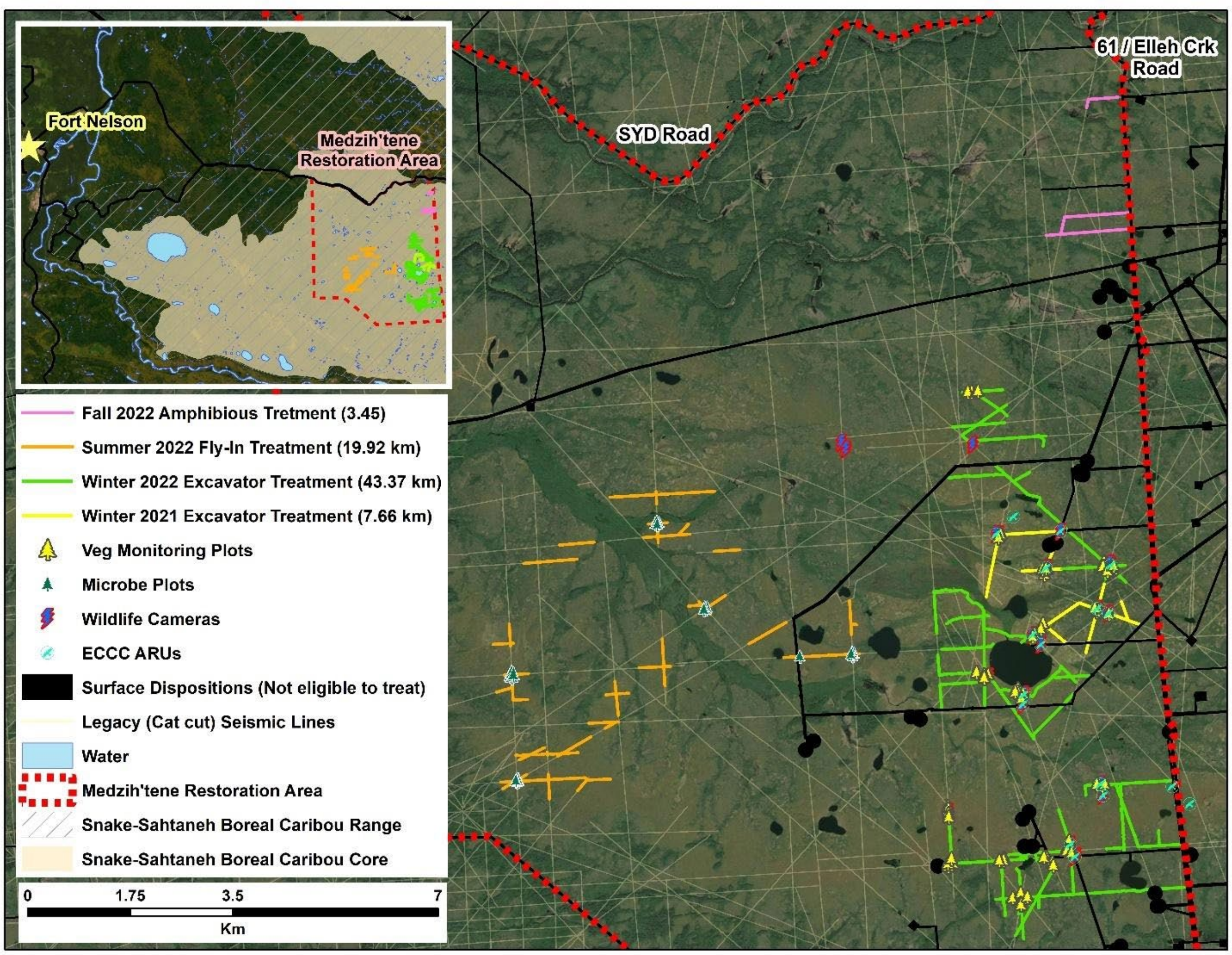
Executive Summary

Grant monies received from the BC Oil and Gas Research and Innovation Society (BC OGRIS) PNG Legacy Sites Restoration Project (hereafter OGRIS funding) facilitated a significant step forward in the planning, delivery, monitoring, and communication of Fort Nelson First Nation's caribou habitat restoration efforts in the Medzih'tene Restoration Area (MRA).

The MRA is an area of high quality "raw", but highly impacted caribou habitat approximately 45 km east of Fort Nelson in the Clarke Core of the Snake-Sahtenah boreal caribou range. Based on previous work undertaken by the Fort Nelson First Nation, the MRA is a high priority area for habitat restoration.

In 2022 we completed of an inventory of linear features, surface dispositions and subsurface tenures in and around the MRA; planned for, scouted, and delivered restoration along a total of 66.74 kilometers of conventional and older-style low-impact seismic lines in three different implementations (bringing our two-year total to 74.4 km restored in the MRA); monitored vegetation and wildlife response to restoration; planned for, scouted, and began opening access and preparing target lines for our upcoming 2022-2023 winter restoration season; and communicated and prepared materials about this work through a series of presentations, newsletters, and videos.



We accomplished these goals using a mix of desktop- and field-based planning and scouting to identify and confirm the availability, need, and accessibility of linear feature restoration targets, collaboration with a variety of partners, and purposeful engagement with a variety of stake- and rightsholders.

Here, we report on all facets of the Project to which OGRIS funding contributed.

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1. Introduction

This report describes work undertaken by Fort Nelson First Nation (FNFN) to conduct landscape-scale restoration planning and delivery along linear features in the Clarke Core of the Snake-Sahtenah boreal woodland caribou (BWC) range, in northeastern British Columbia. The work described in this report was funded in part by the BC Oil and Gas Research and Innovation Society (BC OGRIS) through two grant proposals (hereafter Phase I and Phase II). Phase 1 included planning, implementing, and monitoring winter restoration, and Phase 2 included additional funds to purchase and plant black spruce seedlings on restored seismic lines. These two proposals are part of one overarching effort (hereafter, the Project) to restore seismic lines and other linear features within the Medzih'tene Restoration Area, build capacity to plan and implement restoration by FNFN, and to build external capacity and support for restoration efforts more broadly through strategic communications to other stake- and rights-holders.

We accomplished many outcomes using and leveraging the granted OGRIS monies. Here, we report on the following Project outcomes as a series of grouped components roughly as they occurred in chronological order:

- Pre-treatment inventory and planning to select areas to restore
    - Identification of available target lines
    - Identification of treatment conflicts
- Treatment Implementation I
    - Delivery of winter restoration (winter 2021-2022)
- Restoration Activity Performance Monitoring
    - Vegetation response
    - Wildlife response - cameras
    - Wildlife response - ARUs
- Treatment Implementation II
    - Planning and scouting for summer & fall restoration (2022) and winter restoration (2022-2023)
    - Delivery of summer planting (summer 2022)
    - Delivery of fall restoration (fall 2022) using amphibious excavators
- Treatment Implementation III
    - In-field preparation for winter restoration 2022-2023
- Communication of results, outcomes, and progress to key audiences
    - Newsletters and updates
    - Presentations
    - Professional societies and abstracts

Below, we report out on the methods and results associated with each of these tasks as discrete components of the overall project, and discuss overall impressions and conclusions for all components together.

2. Background Information

This Project focused on restoring legacy seismic lines and older style low-impact seismic (LIS) lines to restore BWC habitat in the Medzih'tene Restoration Area (MRA) (Figure 1). The MRA is approximately 225 km^2 and is an area of high quality "raw", but highly impacted caribou habitat approximately 45 km east of Fort Nelson in the Clarke Core of the Snake-Sahtenah boreal woodland caribou range.

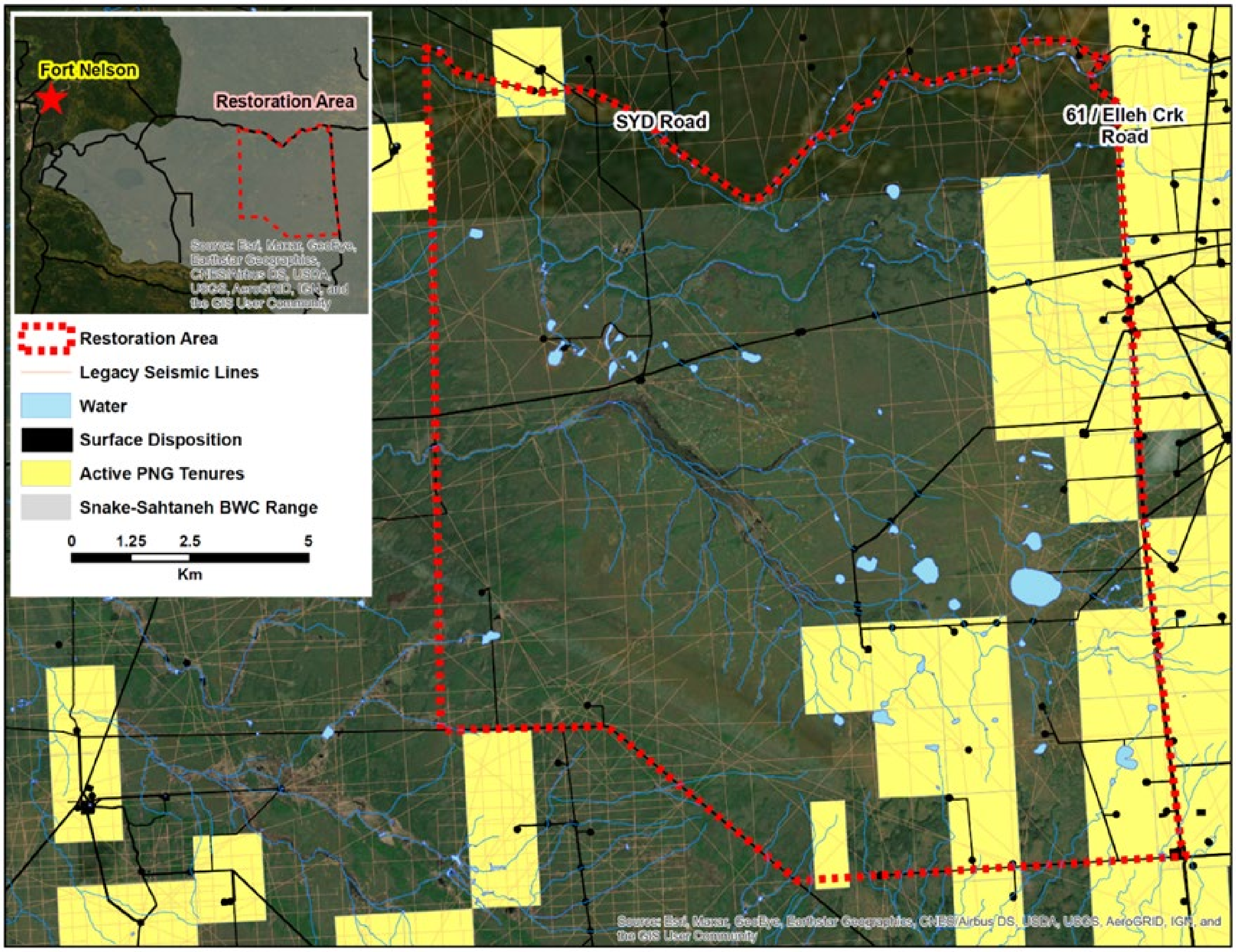


Figure 1. The Medzih'tene Restoration Area (MRA). The MRA is approximately 45 km west of the community of Fort Nelson, BC, in Clarke Core of the Snake-Sahtaneh Boreal Caribou Range.

The MRA consists of large expanses of black spruce dominated, bog peatlands; overlaps Wildlife Habitat Area 9-086 and Ungulate Winter Range U-9-010, provincial designations for protection of core BWC habitats (Figure 2); and is routinely used by caribou (Figure 3). However, the area also overlaps the Elleh gas field. Oil and gas exploration and production (E&P) activities here have been ongoing since the 1960s and as a result, is severely fragmented by a variety of linear features associated with E&P like seismic lines, winter access, and other infrastructure (Figure 4). Incursions by wolves along linear features is well documented in the MRA and reduces habitat security and function for caribou (Figure 5).

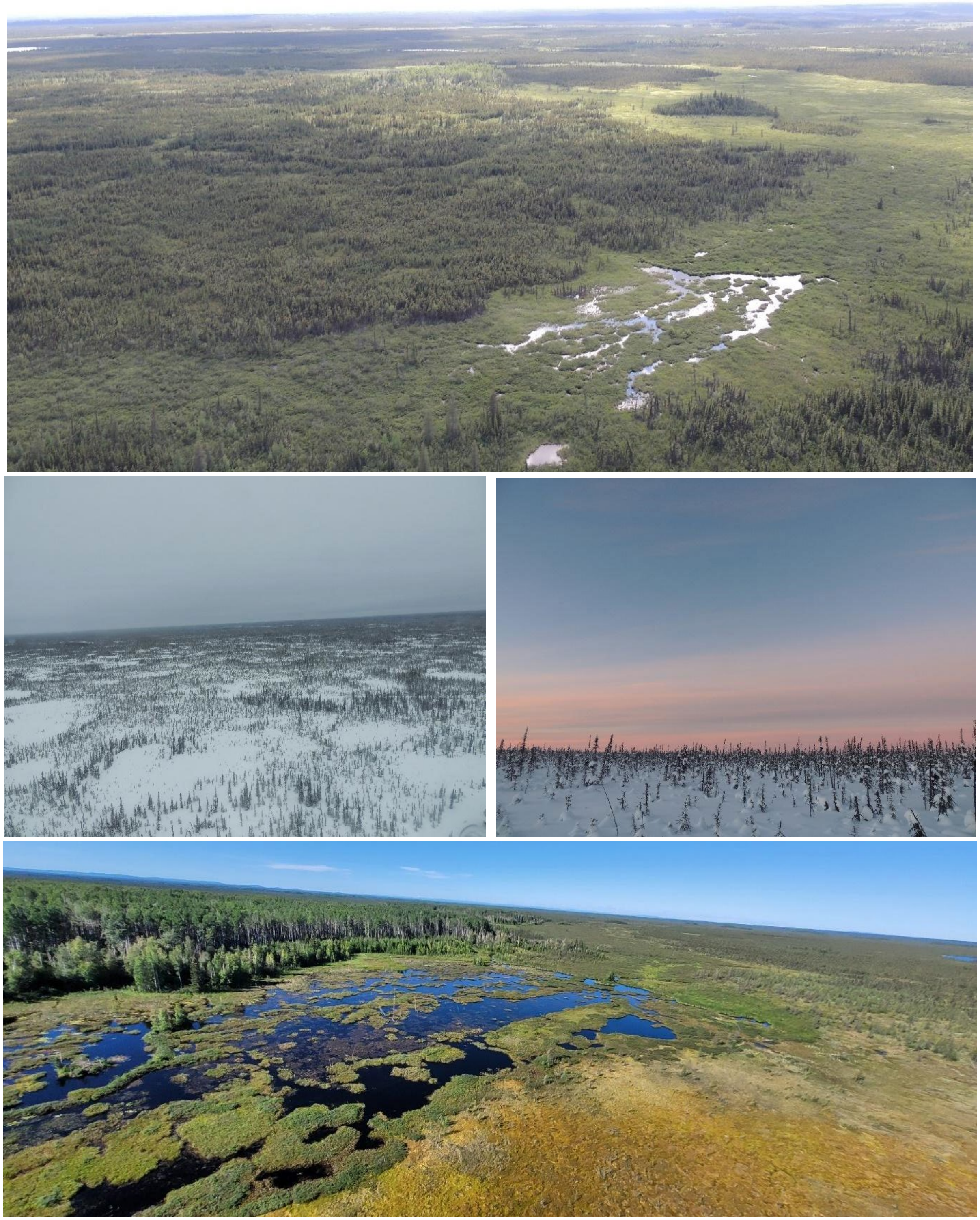


Figure 2. The Medzih'tene Restoration Area (MRA) consists of large expanses of black spruce dominated peatlands and is routinely used by caribou.

Figure 3. Caribou use in the Medzih'tene Restoration Area (MRA) is high. Many individuals and groups have been observed during field work.

Figure 4. Much of the high quality "raw" caribou habitat in the Medzih'tene Restoration Area (MRA) is bisected by liner features associated with oil and gas exploration and production (E&P), especially old seismic lines.

MRA was previously identified as a high priority area for caribou habitat restoration based on extensive community consultation and landscape prioritization planning during the FNFN Medzih Action Plan (MAP) project released in 2018. Through that process, FNFN knowledge holders placed a high importance on the area for boreal caribou habitat and use. The MAP work was then integrated into the FNFN - Government of British Columbia jointly-developed Boreal Caribou Protection and Recovery Plan (BCPRP). The BCPRP work used both Indigenous knowledge and western science to prioritize protection and restoration locations at broad landscape scales, and in conjunction with a 2019 project funded by the Habitat Conservation Trust Foundation (HCTF), the MRA was identified as an area of high restoration priority to improve functional habitat for boreal caribou.

Figure 5. Wolves routinely use old linear features in the Medzih'tene Restoration Area (MRA), sometimes contributing to encounters with and predation on caribou.

Successful implementation of restoration on the ground required that we first undertook a series of planning and scouting activities to understand which lines are available, valuable, and feasible to treat. We then delivered "boots on the ground" restoration in three different operation phases and monitored and established future monitoring plots during those deliveries. Because we delivered restoration in three phases, we scouted numerous times through summer and fall of 2022 to organize subsequent restoration phases, including planning for our winter 2022-2023 restoration season.

Besides restoring caribou habitat within the MRA, a primary goal of this Project was to build FNFN capacity to plan and deliver restoration treatments at an operational scale, develop a robust framework for monitoring the success of the restoration treatments, and to communicate the results of these efforts to a broader audience.

3. First Nations Participation

Fort Nelson First Nation, a Treaty 8 Nation, held the contract for this work and led the implementation of all described tasks and outcomes reported here. Where possible, FNFN staff were employed for this project, and, in the absence of, FNFN-owned, FNFN member-owned or Indigenous-owned contractors were sought to support all phases of the project. The purpose is twofold: to support capacity development among FNFN and other Indigenous communities (i.e., skills and training, economically) as well as increase opportunities for Indigenous knowledge inclusion throughout various phases of the project. Some examples of this extended participation include:

- FNFN Lands staff led the project team that planned and implemented all planning and delivery of restoration in all seasons. FNFN Lands staff, FNFN Guardians, and band members were involved in delivery of restoration during winter 2021-2022 and summer 2022 seasons, and in monitoring the results of restoration activities;
- Eh Cho Dene GP Ltd. is a general contracting company owned by FNFN, and were contracted to clear helipads for all aspects of the Project, and were contracted to truck equipment and deliver restoration during the winter 2021-2022 season;
- Winterhawk is an FNFN member-owned videography company that has supported communications and video development for this project; and
- ASKI Reclamation LP is a Saulteau First Nation-owned (also a Treaty 8 Nation) reclamation services company and was hired to support tree planting during the summer 2022 season.

4. Methods

4.1 Pre-treatment inventory and planning

The primary use of funding to plan for the implementation of restoration was identification of available target restoration lines and potential treatment conflicts that may preclude implementation of restoration.

4.1.1 Identification of available target lines

Most of the disturbance features available for restoration within the MRA are old seismic lines. Typically, restoration efforts are focused on older style conventional or legacy lines that were prepared using bulldozers. Those lines often recover poorly and persist as open and semi-open features for many decades and facilitate wolf use and access to caribou habitat. Since the early 2000s low-impact seismic (LIS) lines have been used to mitigate impacts associated with seismic lines. LIS lines are prepared with mulchers to remove above ground vegetation without disturbing the ground and soil layers; LIS are often prepared to much narrower widths (Figure 6). In both cases LIS lines tend to recover more quickly and are used less by wolves compared to conventional lines. As a result, LIS lines are often ignored in caribou conservation and restoration planning.

Figure 6. Often many low-impact seismic (LIS) lines recover more quickly than conventional lines and require less active restoration intervention. However, many LIS lines within the Medzih'tene Restoration Area (MRA) are "original style" LIS lines; they are quite wide and show very poor recovery success. In this case the two lines in the mid-ground orientated L-R are early LIS lines and still appear to contribute to wolf movement and increased caribou predation risk.

Often overlooked when considering requirements of conventional and LIS lines is that LIS practices developed over time, not all at once. Many of the early LIS seismic programs were experimental and did not produce the very narrow lines routinely used today. There are numerous LIS lines within the MRA, but anecdotally many of those lines are wide and have shown very poor recovery success. This is likely because the MRA occurs in an old producing gas field and the LIS programs shot here were some of the original ones in northeast BC.

To better understand the inventory of seismic lines in the MRA, and which may tend toward requiring active restoration intervention, we used TRIM data acquired from Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRO) and geophysical data from the BC Oil and Gas Commission (BC OGC) to sort seismic line histories and characteristics in a Geographic Information System (GIS). Specifically, we categorized seismic lines as constructed pre- and post 1996, identified individual seismic programs that overlapped with the MRA since 1996, and categorized lines by construction technique and width as determined and inferred from BC OGC data to determine potential restoration need.

4.1.2 Identification of treatment conflicts

Often restoration efforts for caribou focus on the identification of restoration targets (e.g., which lines to restore) and treatment methods (e.g., how to best restore lines to dissuade animal use and to regrow trees). Far less effort is paid to identifying which lines are actually available for restoration and which are not. Most caribou habitat in BC (and across Canada) overlaps with a variety of land users and uses, and in many cases a suite of long-term and legally binding tenure and disposition rights that preclude restoration activities.

Past restoration work undertaken by FNFN, and associated permitting of that work through MFLNRO, has led to the identification of various restoration conflicts. Those conflicts have occurred as a) active surface dispositions that have a legal entitlement to remain open, and b) active subsurface tenures that may be further developed in the future. In the case of surface dispositions MFLNRO was not allowed to issue restoration permits because dispositions owners had a legally protected right to restrict access and maintain those features as open for intended industrial use. In the case of tenures MFLNRO was hesitant to issue restoration permits because subsequent exploration rights were issued and active and, if exercised, could negate the benefit of any implemented restoration.

Here we used publicly available spatial data from the BC Data Warehouse, and licensed private spatial data, in GIS to identify conflicts associated with linear features created by the oil and gas and forestry sector, both in the MRA and across the six delineated boreal caribou ranges in NE BC. We then used those derived “conflict layers” to streamline planning and implementation of restoration in the field, to engage with companies directly to understand future development planning and gain access to restoration targets unlikely to be impacted in the future, and to engage directly with the BC OGC to identify potential targets to expedite retirement of active but unused dispositions.

4.2 Treatment Implementation I

The initial implementation of restoration treatment associated with Project funding was undertaken during winter 2021-2022.

4.2.1 Delivery of winter restoration (winter 2021-2022)

Winter restoration has been our “standard” method. In the 2021-2022 winter season we built on initial successes of winter 2022-2021 work using small and medium sized excavators to transplant whole hummocks supporting live black spruce trees up to approximately 200 cm tall and tip live trees over target lines.

Planning and scouting for the 2021-2022 season began prior to application and receipt of OGRIS funding and continued after receipt. Scouting is a complex and iterative process. First, a desktop assessment and interpretation of land cover, disturbances, and land rights and ownerships is conducted to estimate which lines require active restoration and which of those are accessible. Then an infield scout is conducted to confirm and revaluate in-office planning. Often, multiple “cycles'' of office and field scouts are required to create a final, implementation-ready plan and map. We describe this process in detail in a video (see Table 5, Section 5.7).

We identified approximately 92 km of conventional and older style LIS lines as targets for restoration (Figure 7), along the 61 Road roughly broken into three areas (southern, central, and northern). We intended to start in the south and work north, as time permitted.

Our overall goal for the 2021-2022 winter restoration season was to begin scaling up to an operational workflow while also testing the following:

- testing efficacy and efficiency of different machines and operational techniques to implement restoration,
- training new operators,
- trialing different logical approaches to preparing target lines for restoration and maintaining access to intended restoration areas,
- trailing different restoration routing schemes with multiple machines, and
- establishing monitoring plots to later evaluate the ecological efficacy of different techniques

All winter restoration was permitted under a Special Use Permit issued by MFLNRO. Note, that permit was extended to include all subsequent restoration implementation phases as well.

During the planning phases of the 2021-2022 winter restoration season, permissions to implement restoration within or atop any active dispositions or tenures was not allowed. However, based on outcomes of section 4.1.2. permission was ultimately granted (see Section 5.1.2).

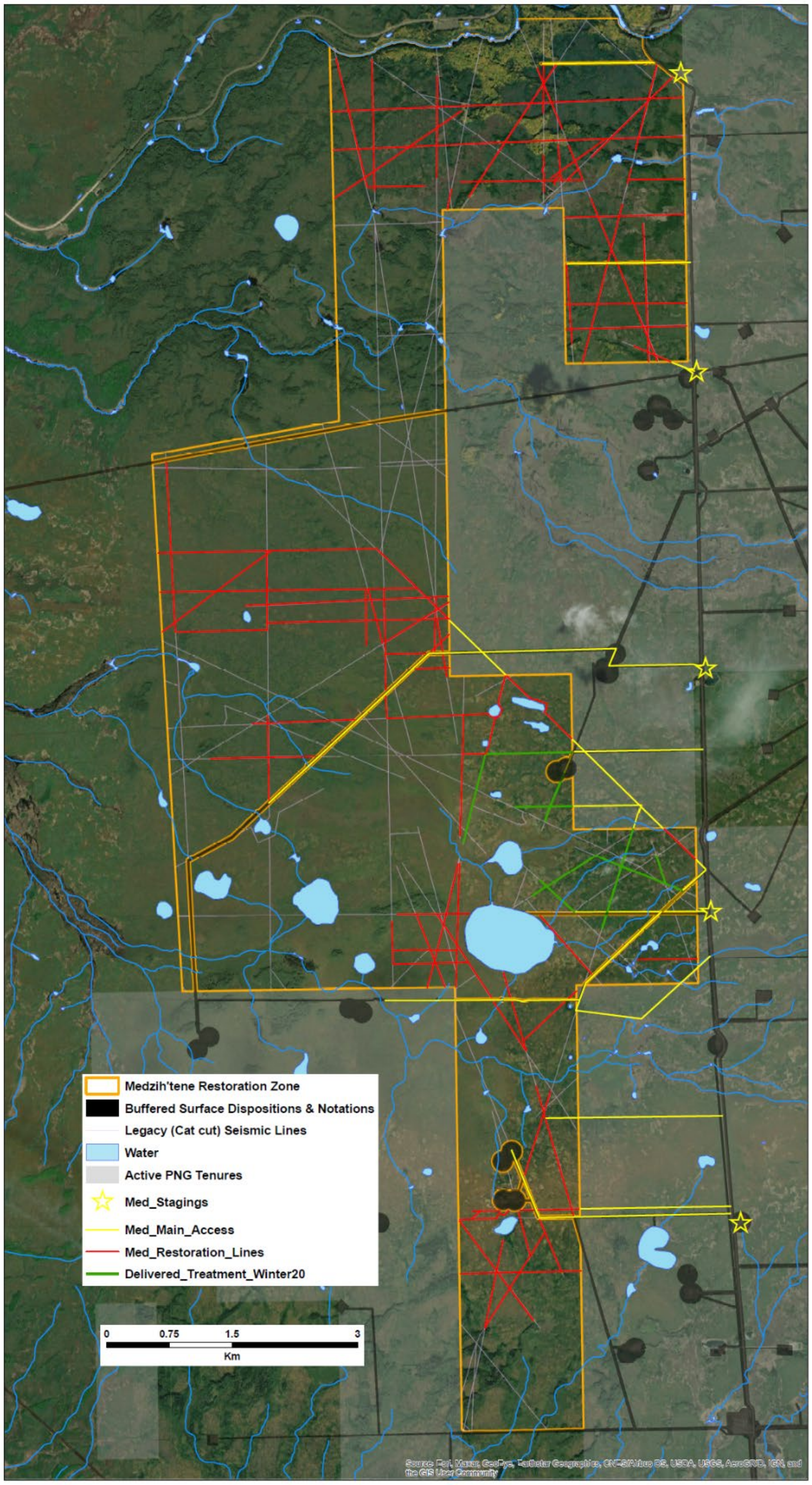


Figure 7. After detailed scouting and planning between June and December in 2020, we identified approximately 92 km of target seismic lines for restoration within the Medzih'tene restoration area (MRA).

4.3 Restoration Activity Performance Monitoring

Simply implementing restoration does not mean that it is meeting its intended goals. Here, our intent is to "translate successes". Through our restoration efforts we are intending to address site limiting factors that prevent passive line recovery, and to reintroduce hummocks and tree cover, and vegetation structure along lines. We then hope successful reforestation of lines will also trigger changes in animal behaviours.

Monitoring restoration outcomes allows us to ensure our approaches are working as intended and facilitate informed operational changes as needed.

4.3.1 Vegetation response

We monitored vegetation response to both transplanted hummocks and tipped trees.

In summer 2022 we sampled both plots established during winter 2020-2021 and winter 2021-2022, thereby measuring years 1 and 2 post-treatment.

4.3.2 Wildlife response – cameras

We monitored mammal response to restoration efforts using wildlife cameras. Wildlife cameras in the MRA are part of a broader array distributed and maintained in both here and in our other restoration study area, the Kotcho Lake Restoration Area (KLRA).

As a part of this Project, we distributed additional cameras in the MRA.

4.3.3 Wildlife response – ARUs

We monitored bird response to restoration efforts using Autonomous Recording units (ARUs) in partnership with Environment Climate change Canada (ECCC). The ARUS are established in place and then monitored remotely, similarly to a wildlife camera. This was a new effort in 2022 to expand monitoring the responses of an additional suite of species, song birds, to line restoration.

4.4 Treatment Implementation II

After completion of winter 2021-2022 restoration, we began scouting and mapping restoration targets for subsequent implementation phases. The second phase of restoration implementation included those scouting activities, coupled with and delivery of summer planting and amphibious excavator treatments in fall.

4.4.1 Planning and scouting for summer & fall restoration (2022) and winter restoration (2022-2023)

Planning and scouting for the next phases of restoration implementation began in spring of 2022. Initially, the effort began as a broad mapping exercise to evaluate "where else" in the MRA could support restoration activities, how those locations could be accessed, and how restoration could best be delivered in identified locations.

Ultimately, we compartmentalized the MRA into different zones in a GIS based on our experience in the region to date (Figure 8). Over the summer and fall we then scouted those zones to build a master list of target lines for future phases of restoration implementation including consideration of different approaches and methods, and chronology of implementation based on ongoing discussions with Provincial agencies about potential expediting retirement of active unused dispositions (see Section 5.1.2).

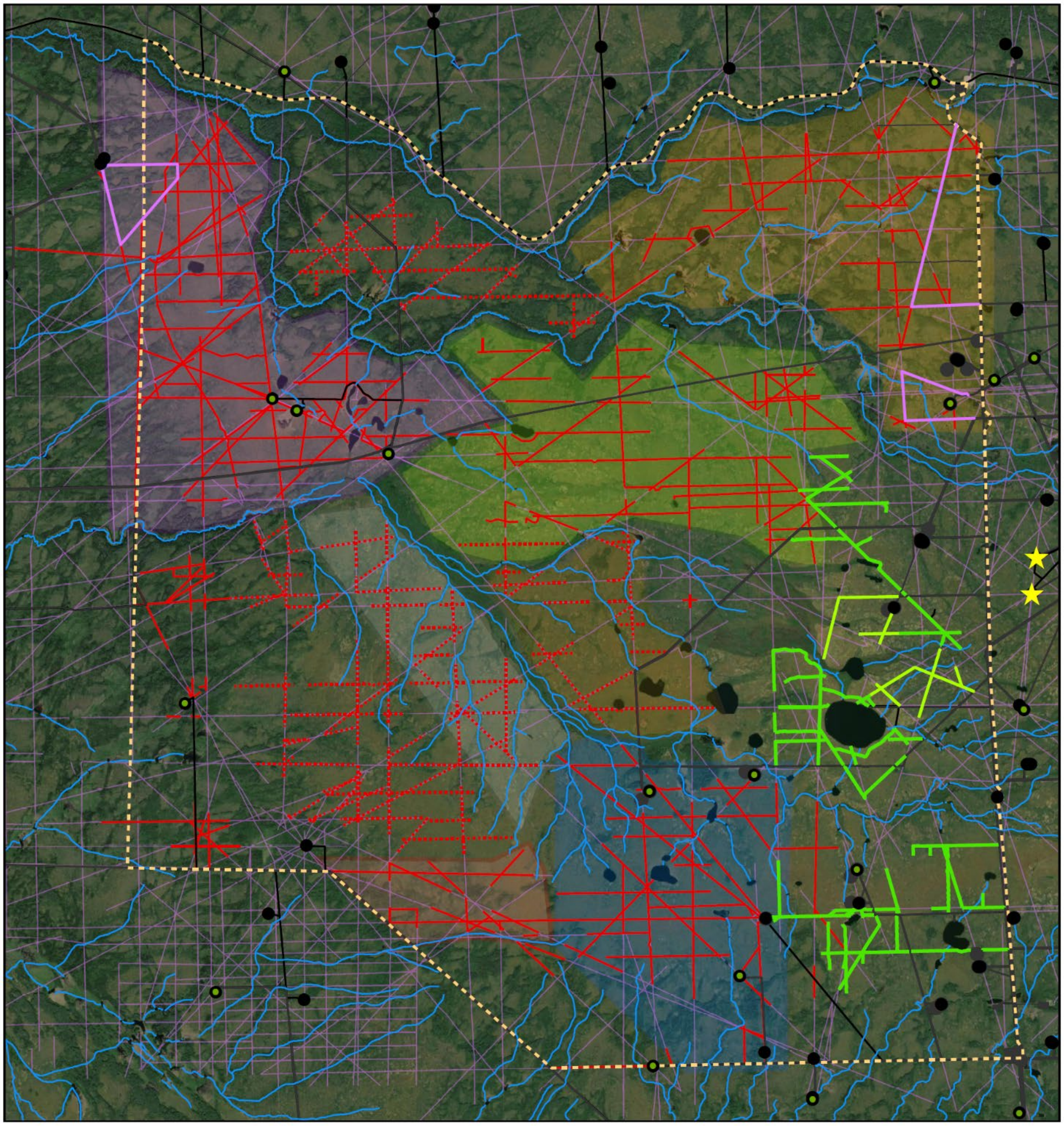


Figure 8. Colour-coded, compartmentalized zones to facilitate long-term restoration planning and identification of remaining restoration targets.

4.4.2 Delivery of fly-in summer planting (summer 2022)

A persistent challenge for restoration efforts targeting seismic lines is difficulty reaching target line segments. Often, target segments are “behind” patches of dense recovery, across large waterbodies or water courses, or beyond expansive fens or other open land covers (Figure 9). These obstacles can render land-based access inefficient, costly, dangerous, and destructive.

Figure 9. A creek with a broad riparian area can make crossing difficult and dangerous with heavy equipment, even in winter.

Many of the conventional and wide LIS seismic lines targeted for restoration showed natural development of online microsites and hummocks. Since 2019 on other restoration projects, FNFN has experimented “free planting” greenhouse grown black spruce and tamarack seedlings into naturally occurring microsites. Short term success rates (to 3 years) have been very encouraging for black spruce seedlings with many establishing and continuing to put on new growth.

The goal of the fly-in planting program was to implement restoration along identified line segments while also trialing a “stepping-stone” evaluation for future, broad-scale planting efforts along difficult-to-access seismic lines within restoration areas. Here we used a “semi-operational” scale to a) train FNFN Guardians and personnel in proper planting techniques and microsite identification, b) evaluate the logistical feasibility and efficiency of fly-in planting as a restoration tool, and c) establish a series of monitoring plots to measure the ecological efficacy of planting and enhancing seedling survival with fungal endophyte mix (hereafter microbes) to promote root growth.

Approximately 29 km of feasible target line (14 primary target kms and 15 secondary kms) was identified for restoration planting (based on scouting discussed in section 4.4.1) (Figures 10 and 11). We flew two planting teams into the prepared helipads to plant 50,000 black spruce seedlings along routes and provided teams with daily maps to guide planting prioritization (Figure 12).

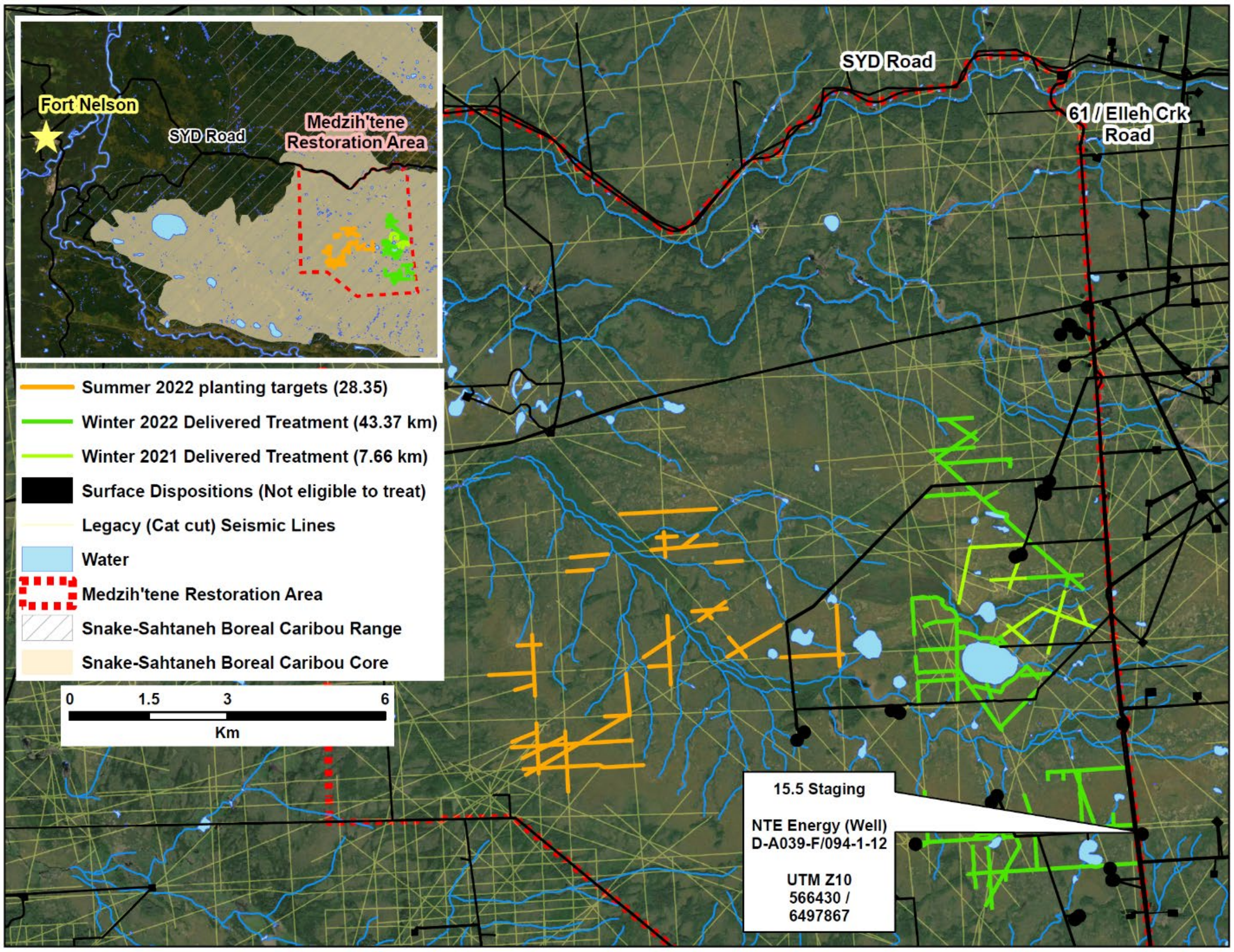


Figure 10. Seismic line segments targeted for fly-in planting in the Medzih'tene restoration area (MRA) in Fort Nelson, British Columbia.

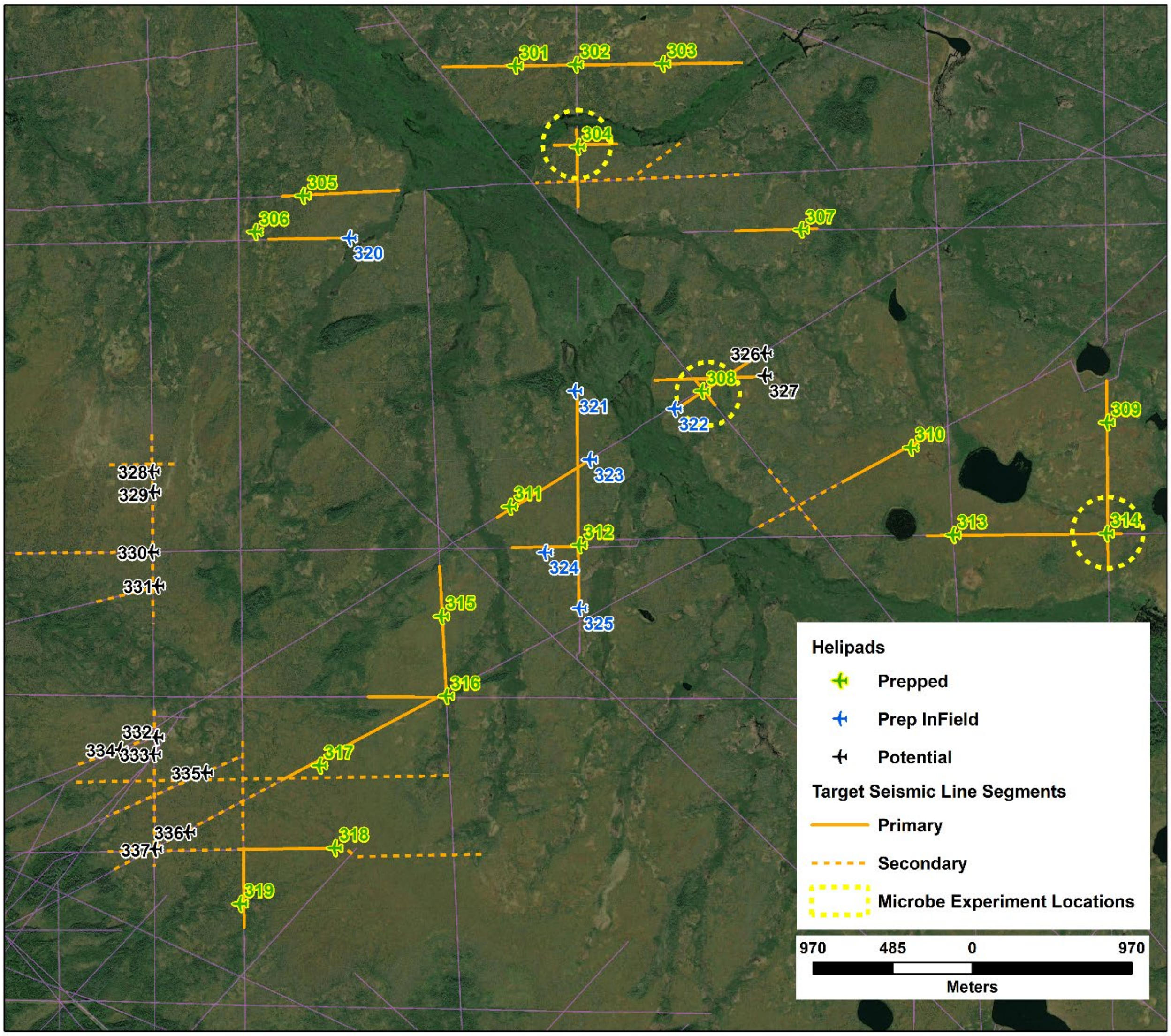


Figure 11. Detail of target seismic lines segments for fly-in planting associated helipads for access.

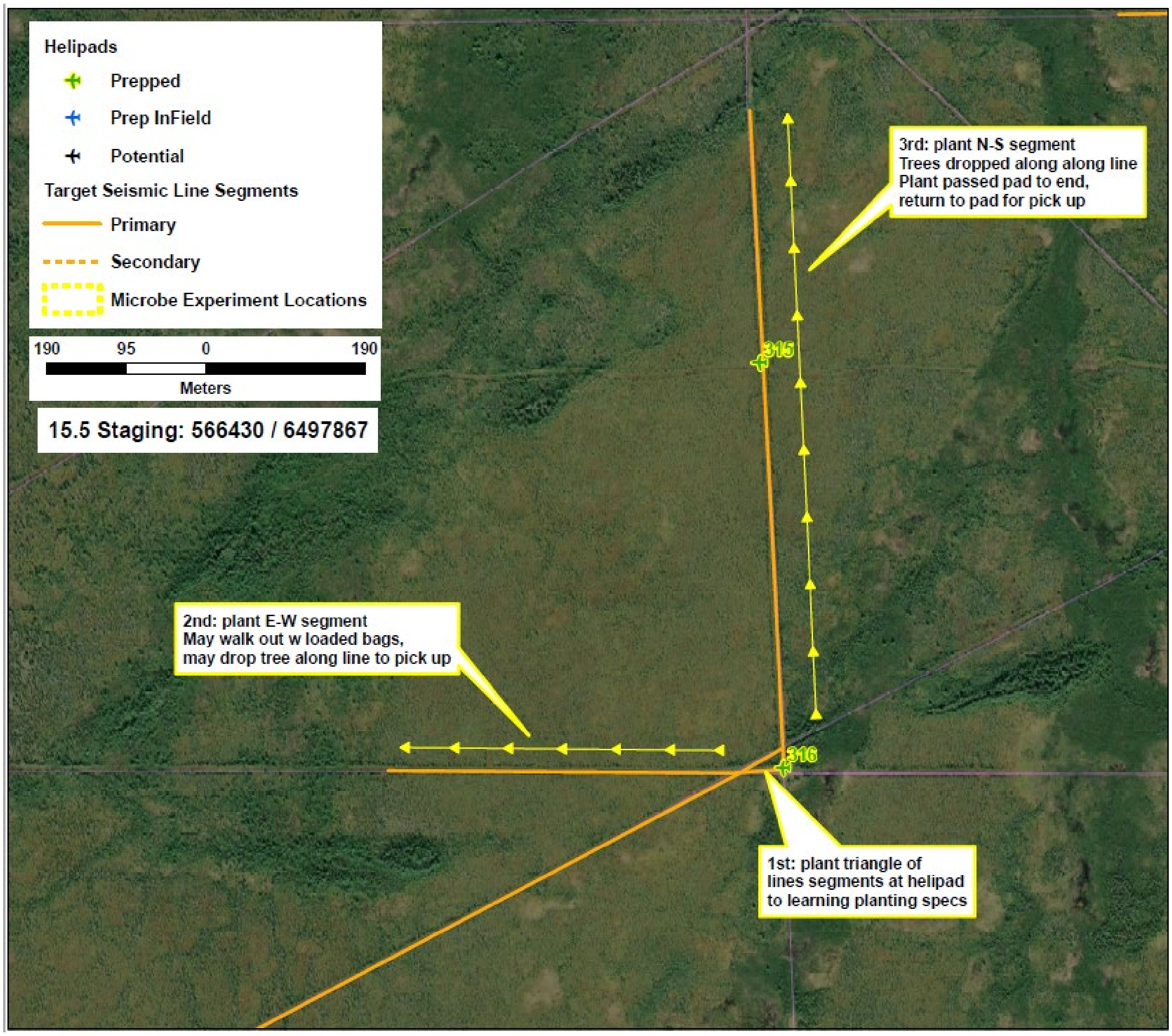


Figure 12. Daily planting map to delineate planting locations for field personnel and prioritize planting targets.

In addition, we established experimental monitoring plots at which we paired treated and untreated seedlings. Plots were established to evaluate the fate of planted seedlings and to compare establishment and growth rates between seedlings treated with microbes and untreated seedlings during summer 2023 (Figure 13). All plots were located at line intersections for ease of establishment and later monitoring, and both treatment and control seedlings were planted along the same line orientation to control for variation in sun exposure.

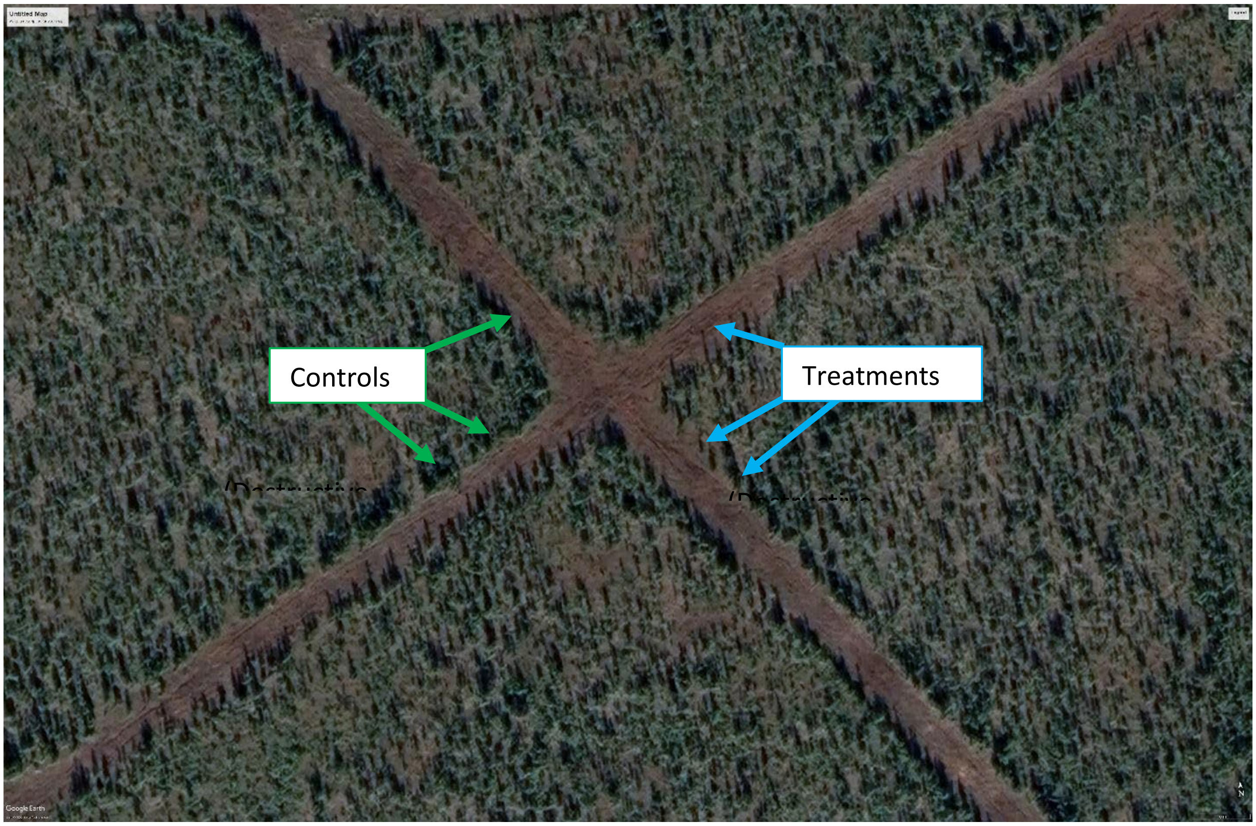


Figure 13. Experimental planting design to evaluate microbe efficacy. Note, each line segment emanating from the intersection is planted with only treated or only control trees to prevent cross-contamination of monitored samples.

4.4.3 Delivery of fall restoration (fall 2022) using amphibious excavators

In 2019 the initial FNFN linear feature restoration trials were completed during later summer and fall during non-frozen conditions. While the delivered restoration treatments performed well ecologically (e.g., created microsites greened up and vegetation survived and continued to grow), access to target sites and implementation of restoration once at sites was difficult. As a result, the idea of machine-based summer treatments was partly abandoned in favor of winter restoration activities (but see planting above).

We trialed an amphibious excavator from Great Excavations / Caribou Tracks during fall, non-frozen conditions. Great Excavations / Caribou Tracks is an Alberta-based company that provides restoration services and equipment across western Canada; the company has completed many linear feature restoration projects during non-frozen ground conditions in caribou habitat to date.

Our goal for this trial was simple. We wanted to "see for ourselves" whether Great Excavations / Caribou Tracks could a) safely and efficiently operate within the wet muskeg peatlands in far NE BC, b) deliver restoration treatments at least equivalent in quality to the treatments we normally deliver during winter with mid-size "normal" excavators, and c) deliver restoration treatments at least as quickly as we normally deliver treatment during winter with mid-size "normal" excavators.

FNFN contracted a 7.5-ton amphibious excavator with a 20-foot reach, an experienced operator, and a program supervisor to demonstrate machine operability and function in the field and to restore as much as possible within a few days.

We identified several kilometers of target seismic lines to conduct trials close to the 61 Road, in the NE corner of the MRA.

4.5 Treatment Implementation III

4.5.1 In-field preparation for winter restoration 2022-2023

We began preparing for winter 2022-2023 operations in fall with continued scouting, and application to virus industry proponents for use and crossing of infrastructure.

We have identified approximately 125 km of conventional and older LIS seismic line for restoration during winter 2022-2023. These target lines will integrate into previously delivered restoration to improve habitat function and quality for a large portion of the MRA (Figure 14).

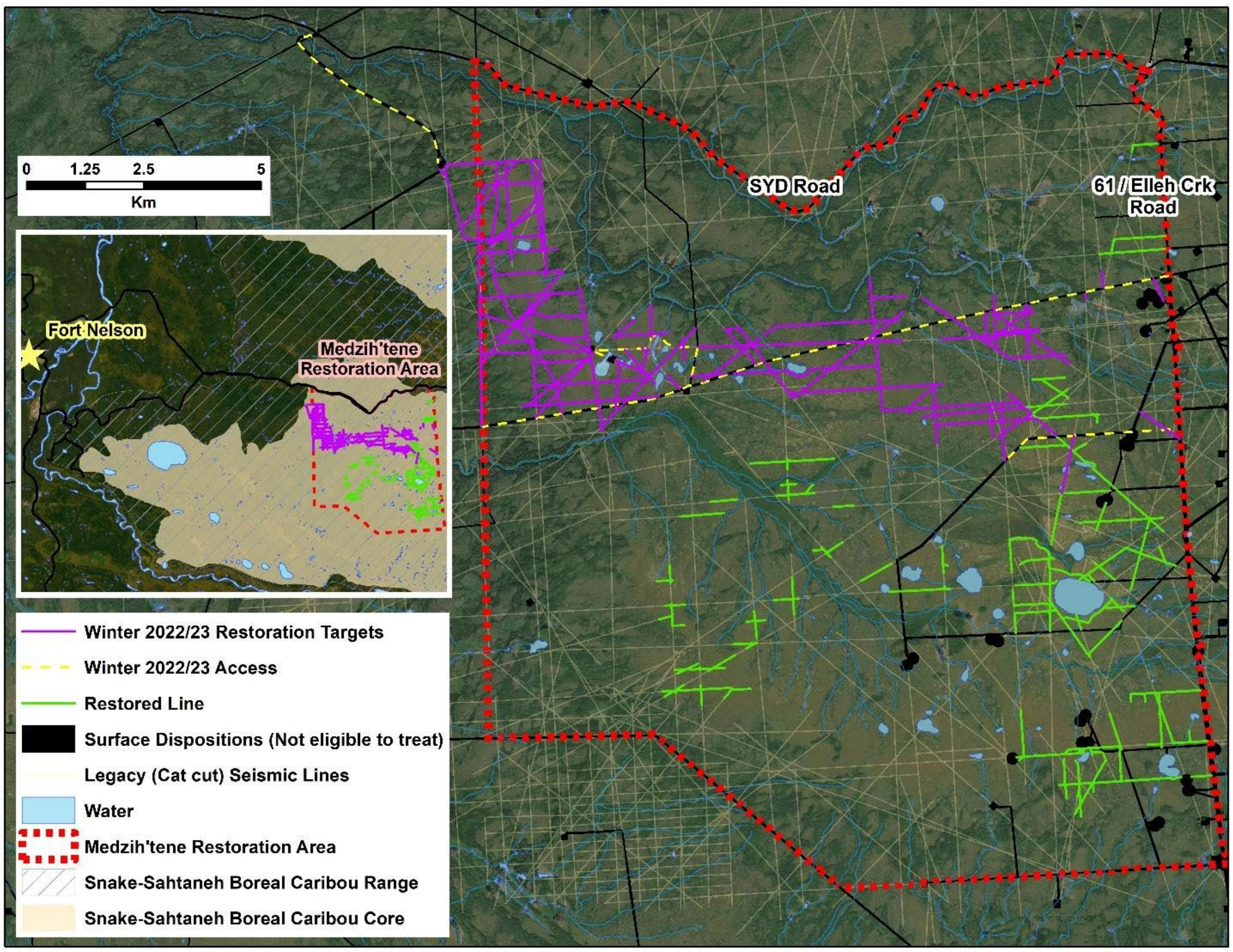


Figure 14. We have targeted 125 km of seismic line for restoration in the Medzih'tene Restoration Area for winter 2022-2023. Preparations for restoration are now under way in the field.

5. Results

5.1 Pre-treatment inventory and planning

5.1.1 Identification of available target lines

We identified six individual LIS seismic programs that overlapped the MRA in the BC OGC databases.

Of those six programs, four were regional 2D programs (e.g., few, long lines spaced out) and two were large 3D programs (e.g., many lines in a grid pattern) (Figure 15).

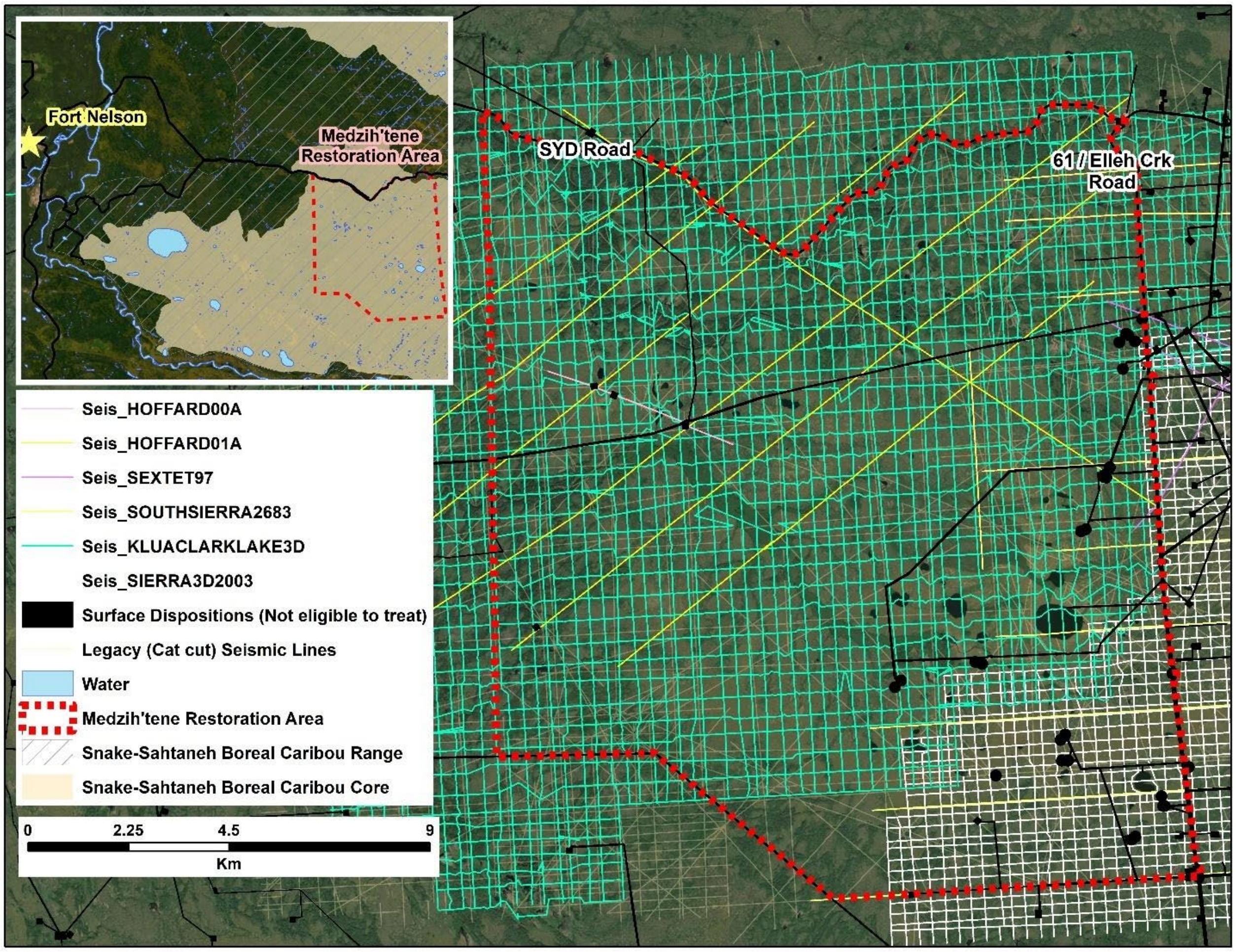


Figure 15. Low-impact seismic (LIS) programs overlapping the Medzih'tene Restoration Area (MRA).

All LIS programs overlapping the MRA were among the earliest recorded LIS programs in NE BC. All 2D programs were completed in the 2000-2001 winter season and earlier, and the 3D programs were completed in the 2001-2002 and 2002-2003 winter seasons. In all cases lines on these programs were constructed using early LIS technology and to wider widths. On both of the 3D programs, source lines were constructed to 5 m wide and infield observation revealed those lines needed restoration treatment (Figure 16). Unfortunately, most of the LIS lines overlapping the MRA are not appropriately georeferenced.

Figure 16. Two examples of different, but similar seismic lines in the Medzih'tene Restoration Area (MRA). On the left is a 9 m wide conventional line, and on the right a 4.5 m older style low-impact seismic (LIS) lines from a program cut in the 2002-2003 winter season. Although more LIS lines tend to recover more quickly on their own, many of the older ones do not.

5.1.2 Identification of treatment conflicts

We found that active surface dispositions and subsurface tenures covered a significant portion of all six boreal caribou ranges in NE BC (Figures 17 and 18), including many of each overlapping the MRA.

While broadly interesting and of consequence for caribou conservation and planning, the ramifications of those regional findings are outside the scope of this Project. Instead, for the purposes of streamlining restoration within the MRA and surrounding areas for FNFN, this work produced two critical outcomes. First, identification of overlapping subsurface tenures, review of associated Provincial regulations, and discussions with regulators at MFLNRO provided a better understanding of the legal rights conferred by subsurface tenures. Tenures confer rights to explore subsurface resources, but not access to the land or surface above the subsurface resources. Thus, tenure holders cannot prevent access, or in this case restoration, within active tenure blocks.

MFLNRO was still hesitant to issue restoration permits for active tenure blocks because further exploration activities could negatively impact presumed benefits of implemented restoration. We worked with MFLNRO to facilitate conditional restoration approvals, if after direct engagement with tenure holders we could a) demonstrate permission to restore unused seismic lines, and b) could locate restoration activities away from areas likely to see additional exploration (e.g., identify active tenures unlikely to be executed).

We approached several of the tenure holders overlapping the MRA and ultimately received permission and approvals to implement restoration. See Appendix A for an example request. This facilitated a broad expansion of potential restoration features, and enabled restoration to occur where old seismic lines intersected the 61 Road (Figure 21).

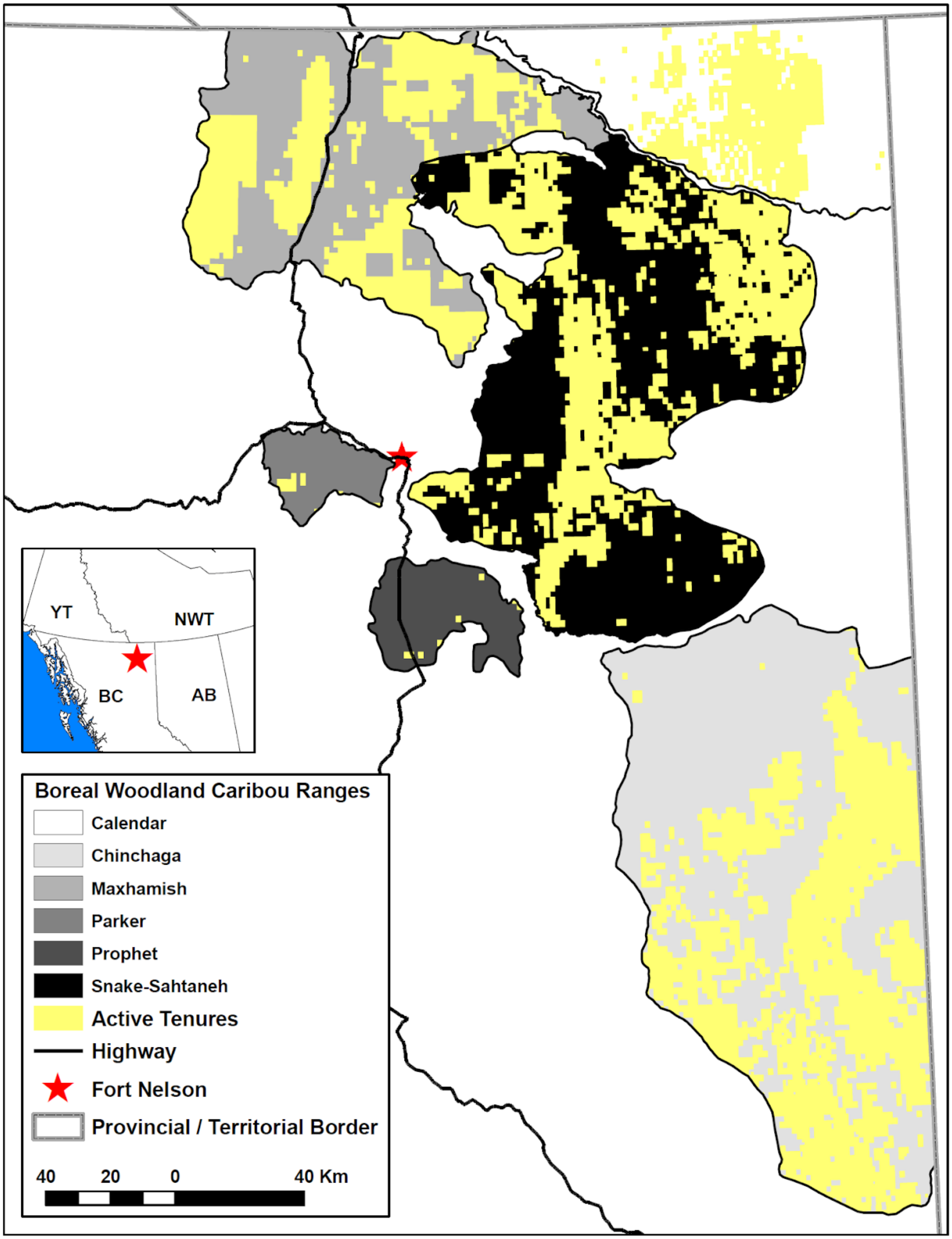


Figure 17. Active subsurface Petroleum and Natural Gas (PNG) tenures within the six delineated boreal woodland caribou ranges in NE British Columbia.

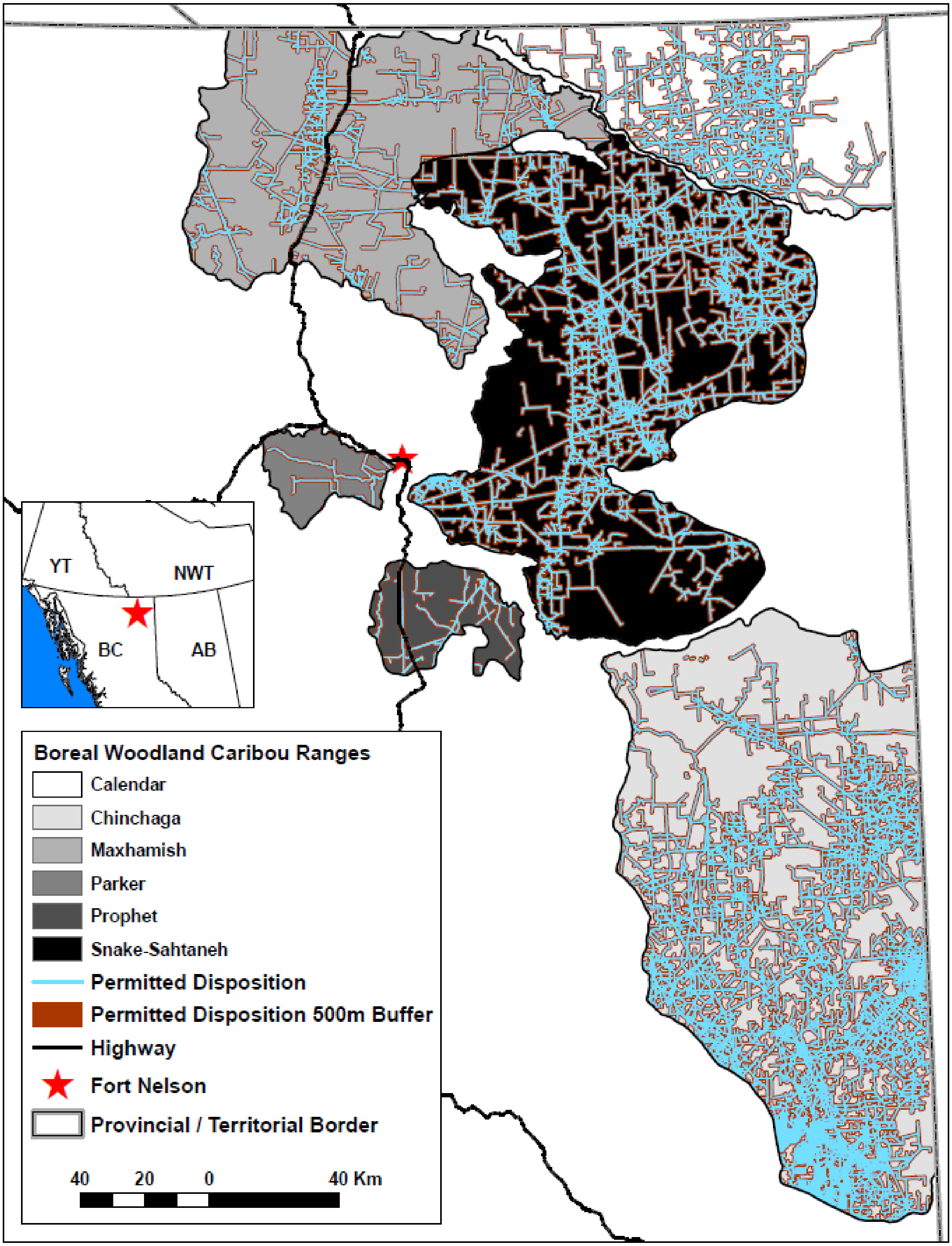


Figure 18. Active surface dispositions for resource roads, pipelines, and linear infrastructure, and private land holdings within the six delineated boreal woodland caribou ranges in NE British Columbia.

Second, critical outcome to be identified by mapping treatment conflicts was the identification of "active, but unused" surface dispositions. Most surface dispositions for oil and gas related activities are permitted as a tenure or Right-of-Way (ROW) (in reference to the Provincial legislations and nomenclature of the hierarchy of dispositions, not the colloquial term for a road or pipeline). Once a ROW is issued it is valid until no longer needed. However, the determination of need can be unclear, and individual infrastructure features can pass through and be retained across various databases thereby duplicating individual dispositions in spatial datasets (Figures 19 and 20). In both cases we identified numerous individual active but unused dispositions – either because final closure and remediation have not yet been completed, or because a retired disposition is considered active in a duplicate entry.

We are currently working with the BC OGC to rectify these issues and to prioritize retirement of unused dispositions to facilitate strategic closure of existing infrastructure to complement restoration activity.

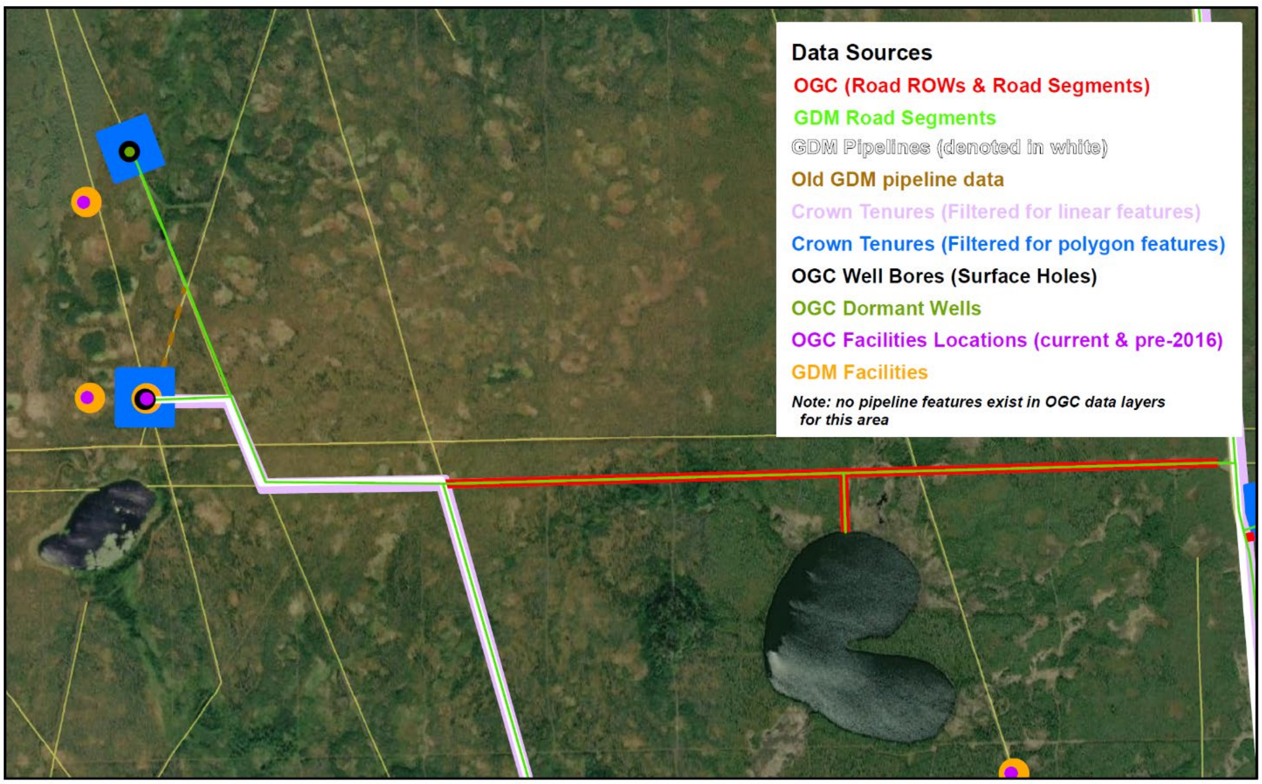


Figure 19. A typical oilfield development – a pipeline, access, and well pads – duplicated across many different datasets.

Figure 20. At left, an unused road and inactive pipeline (in a single ROW), but under active disposition. In both cases, these features connect to wells that have been removed, have been filed into the dormant and orphan well scheme, or are otherwise inactive. On the right, one of the wells that the pipeline and road access. There is no standing infrastructure left on the well site. Persistence of active dispositions on these features stymies restoration potential.

5.2 Treatment Implementation I

5.2.1 Delivery of winter restoration (winter 2021-2022)

We transplanted hummocks and tipped trees between January 3 – March 21, 2022.

In total, we restored 43.37 km of target line (Figure 21, Table 1).

Based on discussions with MFLNRO and energy companies (Section 5.1.2) we were able to treat some lines we had originally thought were outside of our restoration permit area (Figure 21). Ultimately, we treated the intended southern and most of the central treatment zones to “restore off a block” of forested peatland habitat between large water courses and upland stands. By leveraging natural recovery and landscape patterns, we were able to target restoration in a purposeful way.

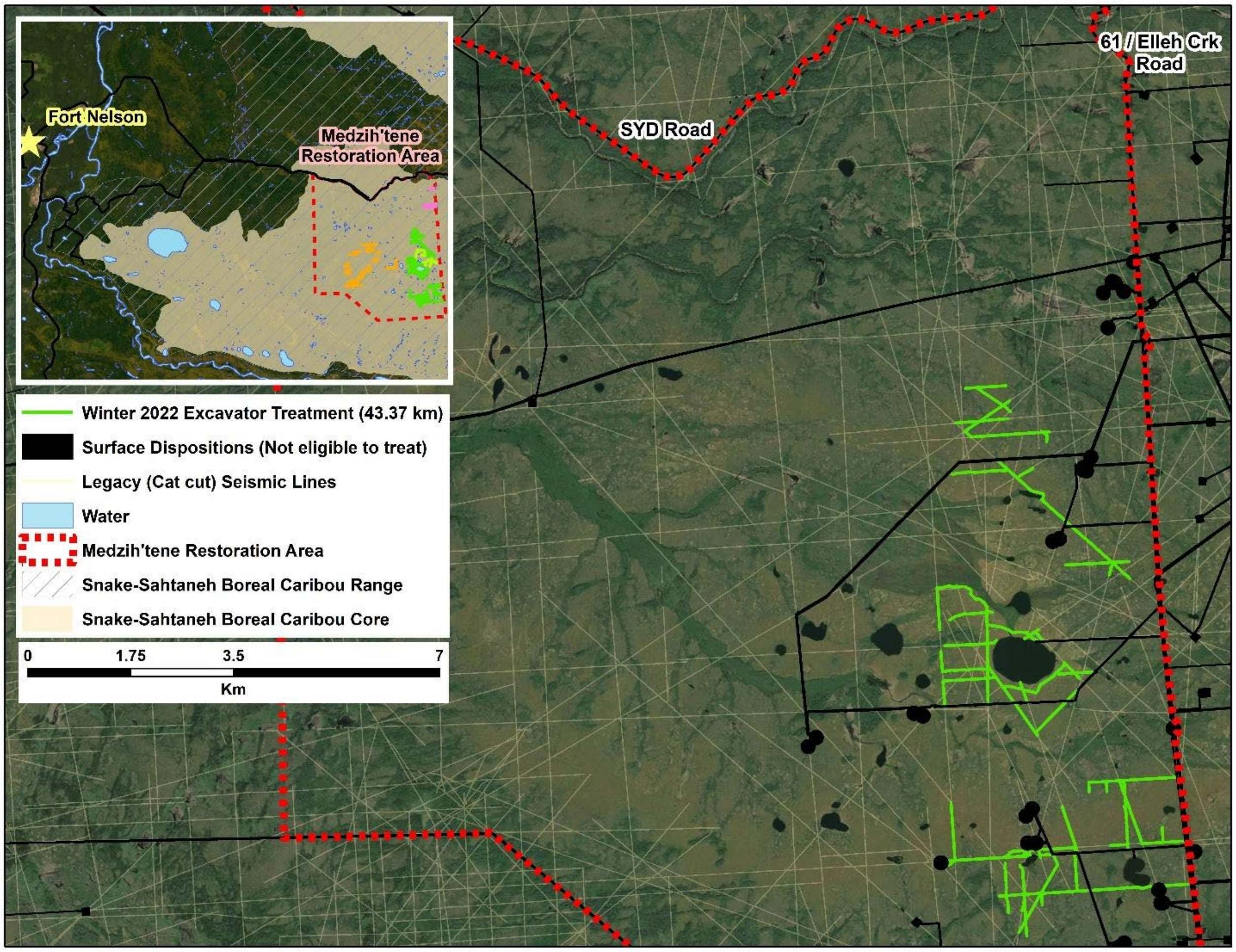


Figure 21. Lines restored during winter restoration treatment, in the Medzih'tene Restoration Area during winter 2021-2022.

Table 1. Site restoration summary for winter 2021-2022 restoration implementation

Site Location	Number of Sites (e.g., number of unique seismic line segments)	Treatment Method(s)	Total Area Restored (linear meters)
MRA	1	Planting black spruce seedlings into naturally occurring hummocks	419.3
MRA	2		52.8
MRA	3		627.9
MRA	4		190.9
MRA	5		590.0
MRA	6		499.7
MRA	7		359.0
MRA	8		560.8
MRA	9		207.1
MRA	10		282.0

MRA	11		23.0
MRA	12		947.3
MRA	13		893.0
MRA	14		251.7
MRA	15		110.8
MRA	16		185.4
MRA	17		1030.4
MRA	18		66.2
MRA	19		438.5
MRA	20		43.7
MRA	21		419.1
MRA	22		48.4
MRA	23		33.7
MRA	24		189.6
MRA	25		481.3
MRA	26		198.0
MRA	27		839.2
MRA	28		66.1
MRA	29		232.4
MRA	30		398.8
MRA	31		601.2
MRA	32		203.6
MRA	33		449.8
MRA	34		605.1
MRA	35		435.3
MRA	36		603.6
MRA	37		370.5
MRA	38		147.5
MRA	39		1020.2
MRA	40		478.5
MRA	41		238.3
MRA	42		405.4
MRA	43		365.5
MRA	44		622.3
MRA	45		302.3
MRA	46		299.7
MRA	47		237.3
MRA	48		522.5
MRA	49		603.8
MRA	50		612.1
MRA	51		373.0
MRA	52		1655.8
MRA	53		171.6
MRA	54		653.3
MRA	55		343.0
MRA	56		772.8
MRA	57		895.1
MRA	58		417.8
MRA	59		621.9
MRA	60		640.3

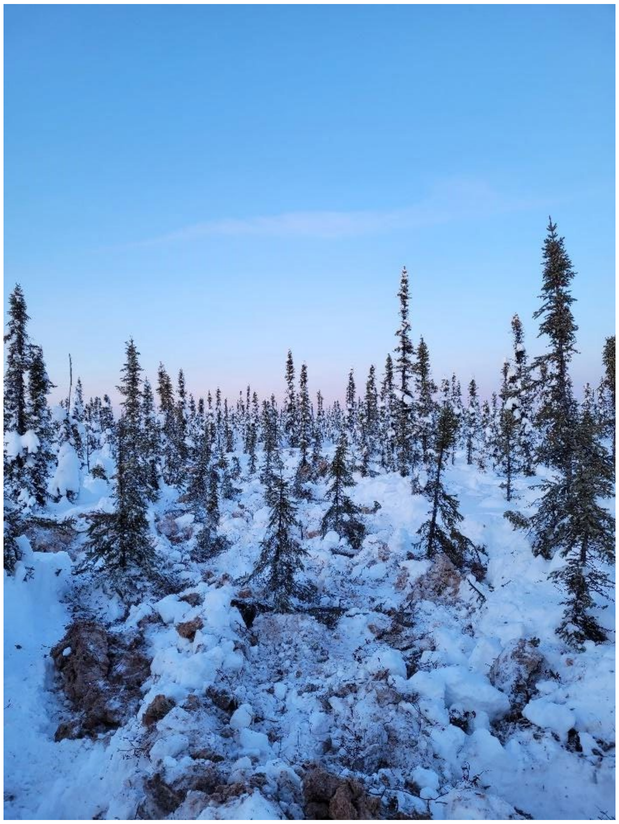
MRA	61		96.5
MRA	62		557.1
MRA	63		627.9
MRA	64		178.0
MRA	65		168.4
MRA	66		358.2
MRA	67		397.7
MRA	68		265.4
MRA	69		2054.7
MRA	70		816.0
MRA	71		133.1
MRA	72		203.9
MRA	73		894.5
MRA	74		481.5
MRA	75		414.4
MRA	76		319.4
MRA	77		227.1
MRA	78		463.5
MRA	79		960.2
MRA	80		312.9
MRA	81		711.5
MRA	82		419.5
MRA	83		214.8
MRA	84		283.2
MRA	85		775.1
MRA	86		385.0
MRA	87		124.0
MRA	88		385.0
MRA	89		124.0
MRA	90		273.8
MRA	91		135.3
MRA	92		152.8
MRA	93		94.5
MRA	94		53.0
MRA	95		896.6
MRA	96		515.7
MRA	97		997.6
MRA	98		431.8
MRA	99		230.4

We used two different excavators to implement restoration, a John Deere 85G and a Cat 308 (Figure 22). Both machines performed well, and better than smaller excavators used in previous years. We do not water in target restoration lines to facilitate easier and more effective implementation of restoration treatments. Based on our experience in the field, the 308 is the upper size limit that is safely usable without watering lines to create deeper ice and more support. We were not able to cross some land covers, like open fens, with either machine.

Figure 22. Implementation of restoration during winter 2021-2022 was accomplished using Deere 85G (L) and a Cat 308 (R) excavators. Both machines are smaller mid-sized excavators.

We trained three operators in hummock transplanting and tree tipping techniques. Delivered treatments were of excellent quality in both machines and all operators were proficient in delivering treatment (Figure 23). Operators navigated to target lines using interactive maps displayed in Avenza (Figure 24). Maps worked well to ensure operators reached and treated lines appropriately, however, operators often worked at different speeds which presented logistical challenges for multiple machines working in proximity. At times, even slightly different areas offered very different tree and hummock density for transplanting making some line segments difficult and thus slower to "fill in" with transplants. Other times, the speed of paired operators was very different. Regardless, often one operator would have to pause treatment delivery until the other could move past "treat-in points". Moving forward, increased training time will improve and expand the pool of high-quality operators and even out inconsistent pace across operators. Improvements were made once we put machines further apart and operators could implement "zones" of more self-contained treatment. That increased travel and ferrying times in the mornings and evenings for operator transport, but was workable.

We established 549 monitoring plots to evaluate hummock transplanting success, and 115 plots to evaluate outcomes of tipped trees (Figure 25). This brings our total number of plots to 782 plots for hummocks and 309 for tipped trees in the MRA.




DEERE

Figure 23. Implemented treatments during winter restoration in 2021-2022 in the Medzih'tene Restoration Area. Target lines were treated by transplanting hummocks and live black spruce trees from adjacent lines and by tipping liver trees over lines.

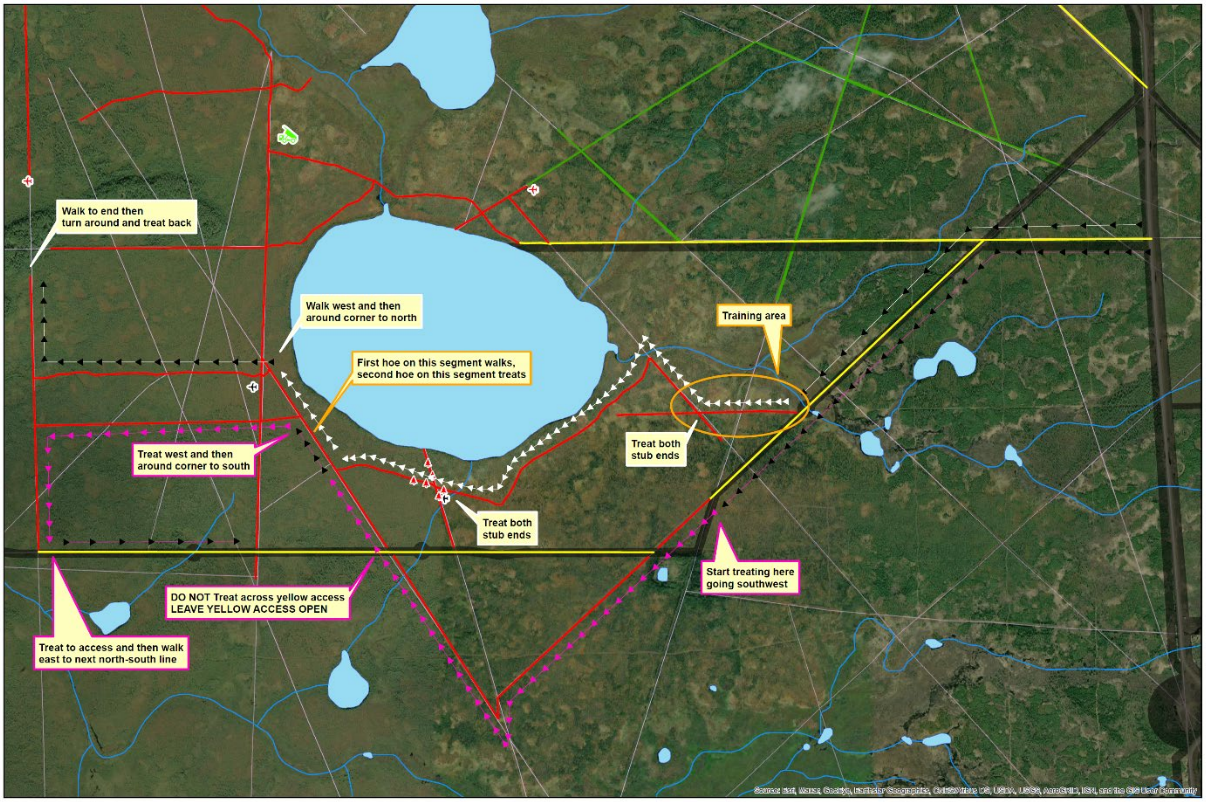


Figure 24. Daily operator map showing restoration targets and routing per operator.

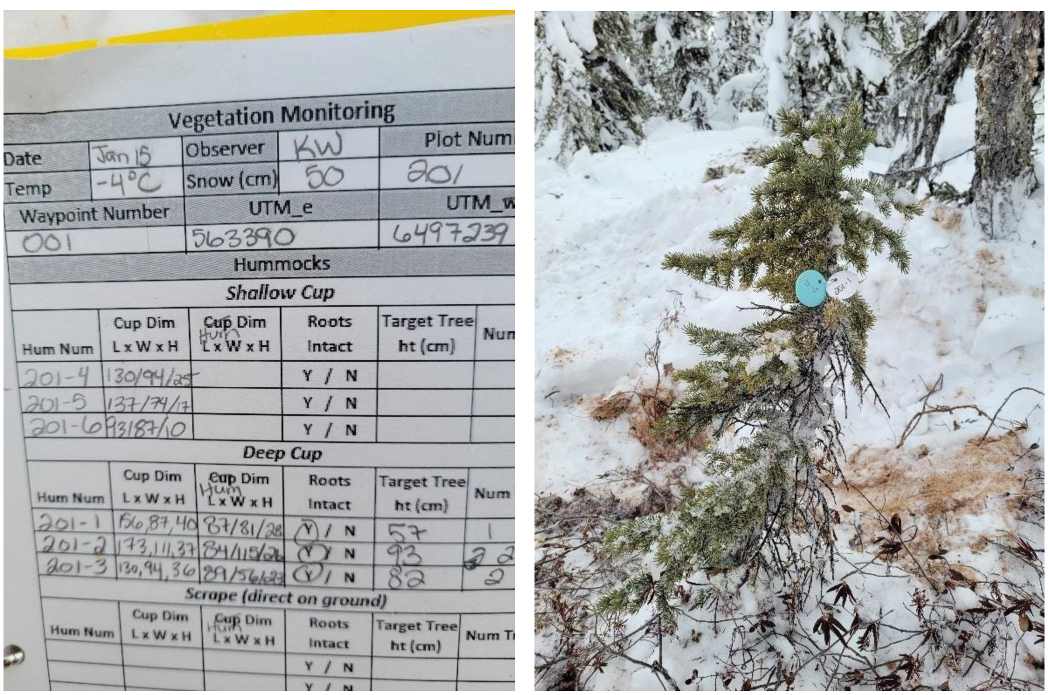


Figure 25. We established 549 monitoring plots to evaluate survival of transplanted hummocks.

5.3 Restoration Activity Performance Monitoring

We established vegetation monitoring plots, wildlife cameras, and ARUs across delivered restoration treatments in the MRA (Figure 26).

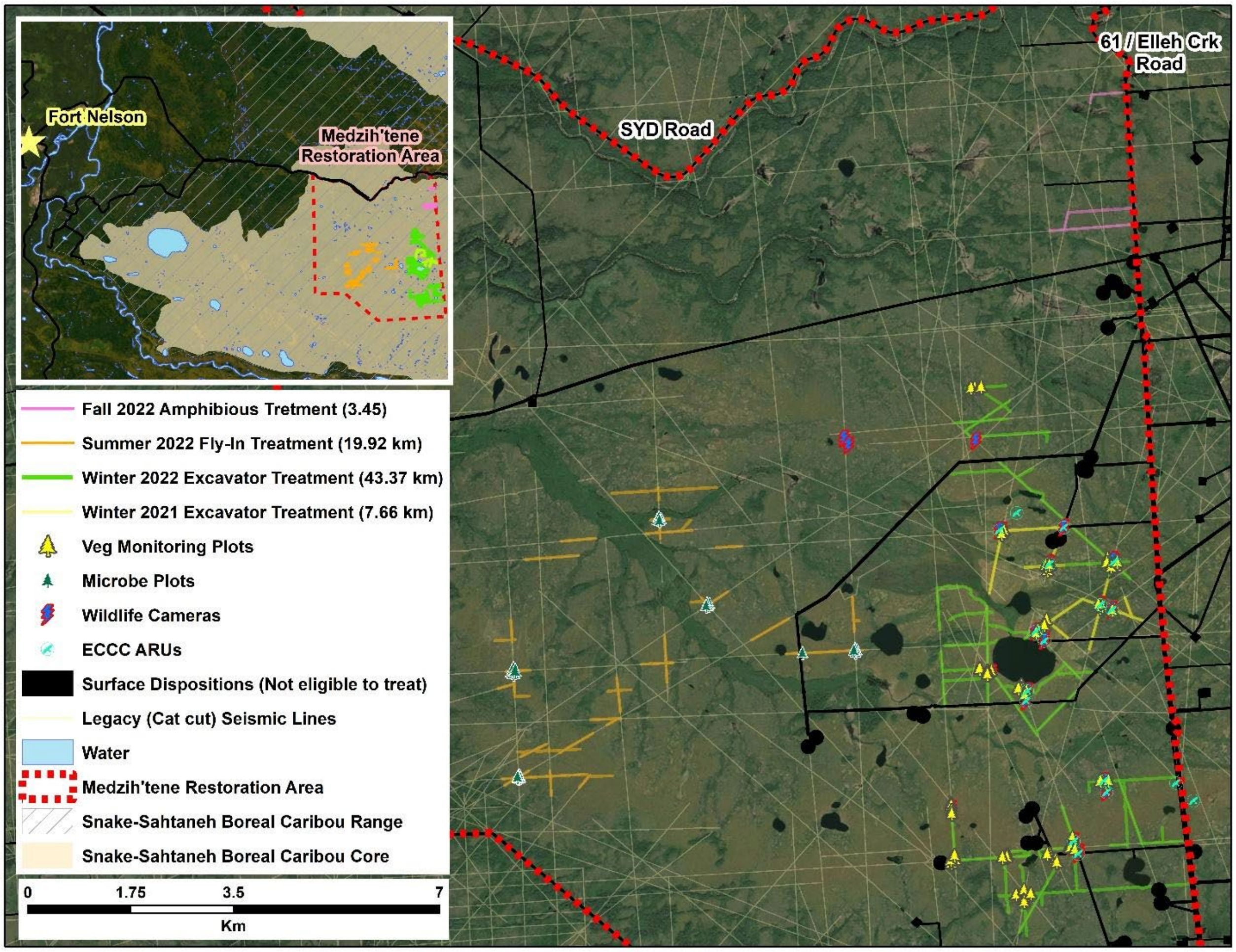


Figure 26. locations of all monitoring sites – vegetation, wildlife cameras, and ARUs – in the Medzih'tene Restoration Area.

5.3.1 Vegetation response

In July, 2022 we monitored the vegetation response of restoration implemented in both winter 2020-2021 and winter 2021-2022. We used a detailed protocol to assess the fate of transplanted hummocks, associated trees and plant cover, and associated soil temperature and moisture processes; and the fate of trees tipped across restored lines (Appendix B).

We measured outcomes at 346 transplanted hummocks (Table 2, Figure 27).

Table 2. Vegetation Monitoring Activities & Findings

Activity Monitored	Summary of Findings
Hummock transplants - overall	Most hummocks transplanted well, but performance was improved when transplants were placed into a shallow scrape.
Hummock transplants – hummock integrity	Hummocks that were too small or supporting very large trees sometimes cracked or crumbled apart. Intactness was improved when hummocks were placed in small scraped.
Hummock transplants – moisture	Hummocks tended to dry out if not in direct contact with some moisture (either standing water on lines or “fresher moss” exposed by slight scraping. Moisture gradients of transplanted hummocks were similar to adjacent hummocks suggesting transplanting could improve moisture regimes on treated lines.
Hummock transplants – supported live trees	The trees in transplanted hummocks survived and continued to put on new growth, but growth rates were slower than adjacent trees.
Hummock transplants – integration & settling	Transplanted hummocks settled into place between years 1 and 2, and by year two moss had begun “connecting” transplanted hummocks to transplant sites thereby “integrating into place”.
Hummock transplants- non-target vegetation	Moss and vascular shrub stems on hummocks persisted, but survival was variable. In some instances hummocks were “vibrant”, in other cases significant non-target vegetation had “died back”.
Tree tipping – survival	Survival of tipped trees is approximately 50%.
Tree tipping – growth	Of those surviving tipped trees, some have put on new terminal growth that spans upwards converting into “new trees” along the treated lines.

Figure 27. Vegetation monitoring response during summer 2022 in the Medzih'tene Restoration Area.

5.3.2 Wildlife response – cameras

We deployed 16 additional wildlife cameras in the MRA during winter operations in 2021-2022, bringing the total to 23 deployed in the MRA. Cameras are located at treatment and control lines. During summer 2022 all cameras were revisited and maintained.

Picture binning and evaluation of wildlife response is ongoing.

5.3.3 Wildlife response – ARUs

We worked with ECCC to deploy a total of 17 ARUs in the MRA in 2022 (Figure 28). ARUs were located at treatment and control lines, and within areas away from disturbance within the MRA.

ARUs were established in April and May, 2022 and taken down in July, 2022. During removal we visited the field with ECCC staff to exchange knowledge about restoration and bird ecology and sampling.

Figure 28. An ARU (above, left) and wildlife camera (below left) deployed on a tree, and exchanging knowledge in the Medzih'tene Restoration Area.

5.4 Treatment Implementation II

5.4.1 Planning and scouting for summer & fall restoration (2022) and winter restoration (2022-2023)

Between June 15 – November 15, 2022 we flew multiple scouting missions in the field to assess line conditions and identify treatment line locations (Figure 29).

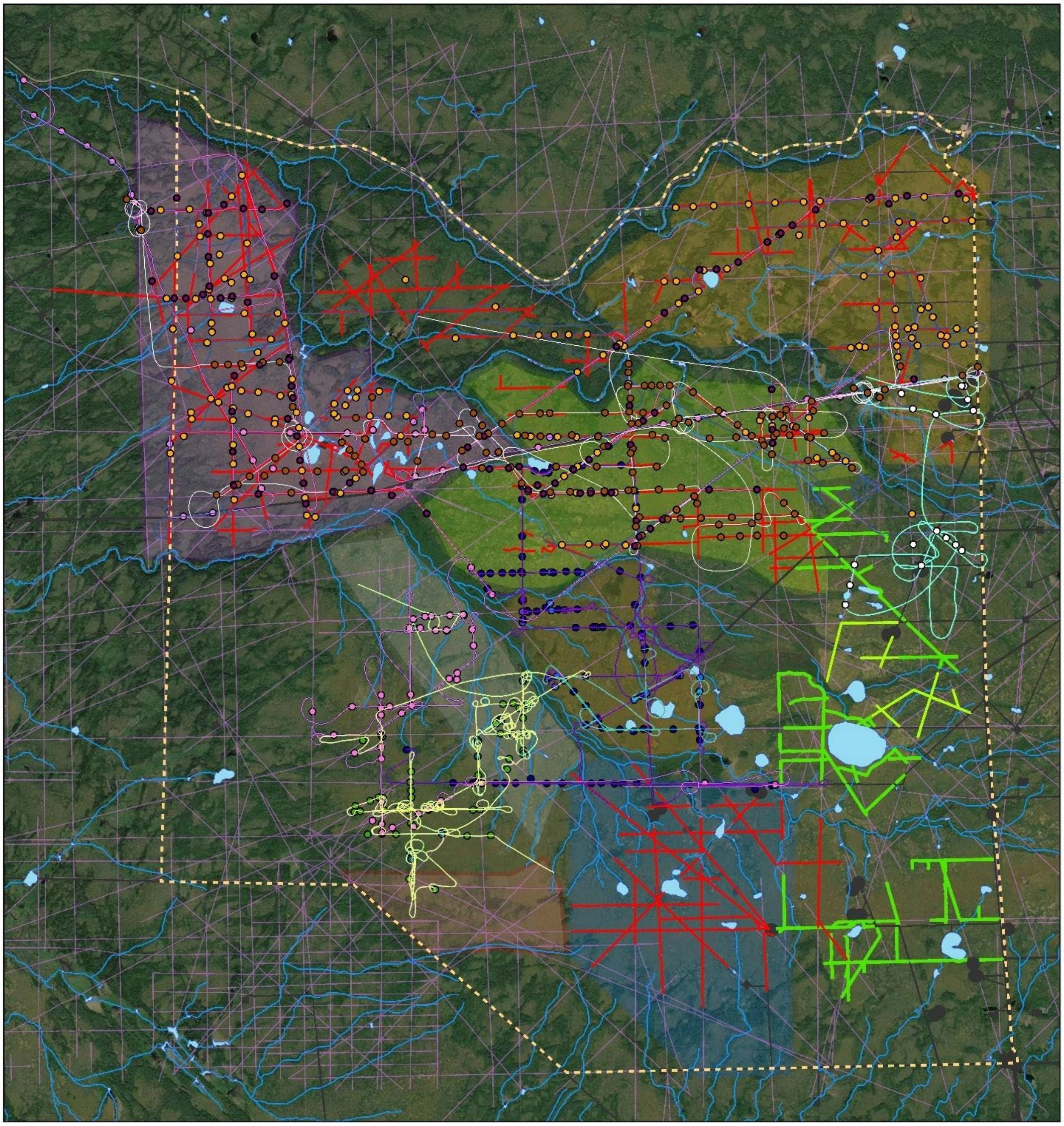


Figure 29. Scouting events between summer and fall, 2022 to facilitate long-term restoration planning and identification of remaining restoration targets in the Medzih'tene Restoration Area.

5.4.2 Delivery of fly-in summer planting (summer 2022)

We planted seedlings in two separate events, first between August 9 – August 20, 2022, and next between September 16 – September 20, 2022.

In total, we planted 19.92 km of target line (Figure 30, Table 3).

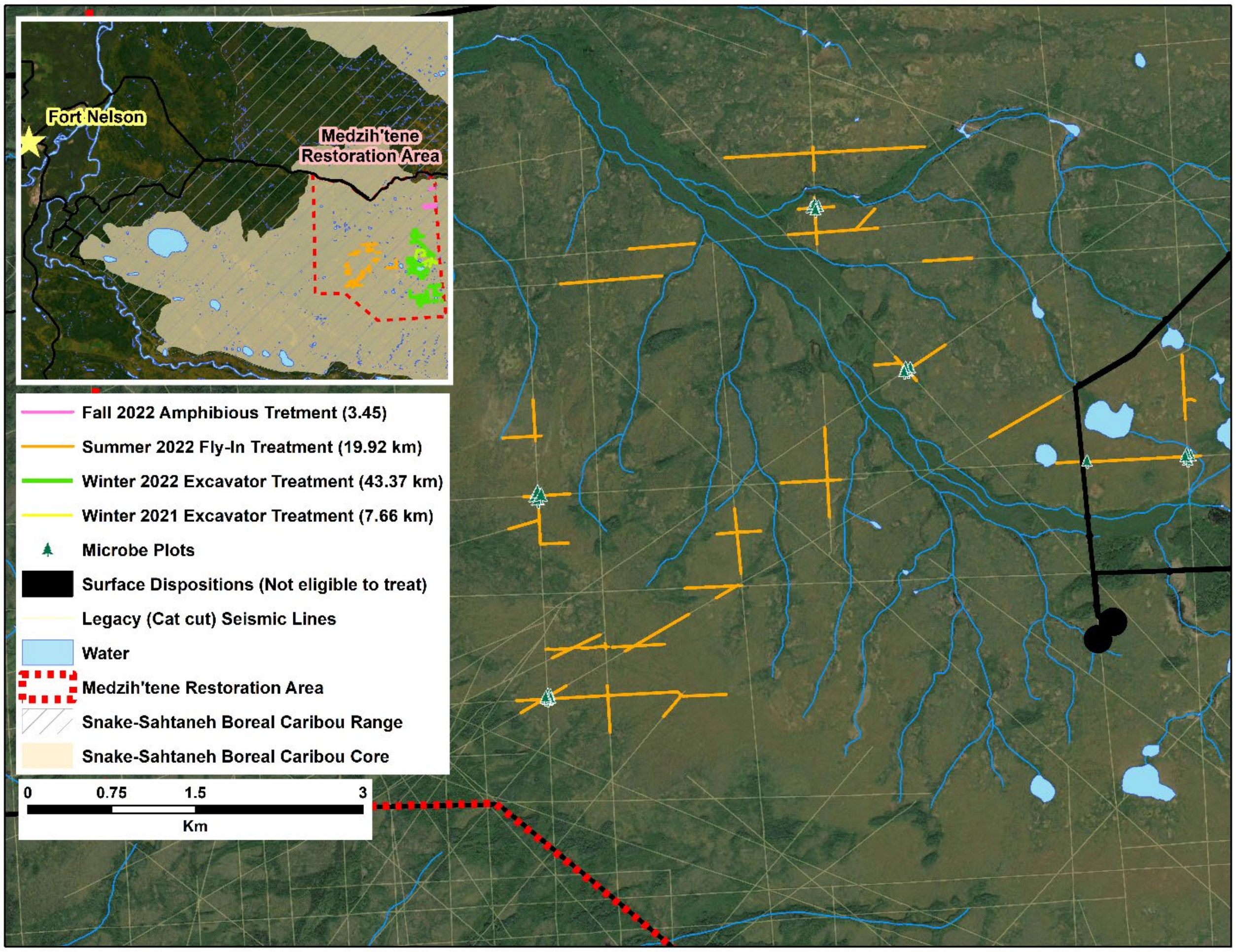


Figure 30. Lines restored during fly-in planting, and microbe monitoring plots established, in the Medzih'tene Restoration Area in late summer 2022.

Table 3. Site restoration summary for fly-in summer 2022 planting restortion implementation

Site Location	Number of Sites (e.g., number of unique seismic lines)	Treatment Method(s)	Total Area Restored (linear kilometers)
MRA	1	Planting black spruce seedlings into naturally occurring hummocks	1.35
MRA	2		1.79
MRA	3		1.42

MRA	4		1.39
MRA	5		0.25
MRA	6		0.23
MRA	7		0.32
MRA	8		0.29
MRA	9		0.44
MRA	10		1.29
MRA	11		2.09
MRA	12		0.95
MRA	13		1.89
MRA	14		0.47
MRA	15		0.64
MRA	16		0.9
MRA	17		0.51
MRA	18		0.65
MRA	19		0.1
MRA	20		1.03
MRA	21		0.28
MRA	22		0.47
MRA	23		0.58
MRA	24		0.35
MRA	25		0.24

On August 8 and 9, 2022 we held infield training to describe planting techniques and planting density, and to identify appropriate naturally occurring microsites into which seedlings could be successfully planted (Figure 31). Crews of 2 – 3 people, depending on planted line widths, were deployed to plant a target density of black spruce at approximately 3,600 stems per ha (3,000 linear km of target line). Planting spacing was approximately every 1 m with a minimum of 30 cm, assuming sufficient moss on establishing hummocks was available above the water table. Planting density here was slightly denser than other planting schemes typically used in forestry applications to ensure sufficient "wall to wall" coverage of planted seedlings along target lines (Figure 32).

Figure 31. Planting training session in the field on August 9, 2022 in the Medzih'tene Restoration Area.

Figure 32. Planters, planted seedlings, and prepping helipads in the Medzih'tene Restoration Area

Paired monitoring plots were established at six different helipads. In total we tagged 240 control seedlings and 220 treated seedlings (Figure 33). We will revisit those seedlings in summer 2023 to record a variety of growth and vigour characteristics to evaluate seedling health and compare outcomes of microbe treatment. In addition, we planted an additional 80 control and 80 treated seedlings at two helipads for destructive sampling to compare microbe growth on seedling roots.

Figure 33. Planted and tagged seedlings for growth, vigour, and microbe loading monitoring in summer 2023.

Overall, this fly-in planting "stepping stone" demonstrated feasibility and efficacy of the method as a tool to restore lines. Most target lines and line segments contained sufficient plantable microsites to treat at reasonable densities, and distributing crews and seedlings was reasonable for scaling this method more broadly. At times, seedling drops mismatched line distance requirements (e.g., planters ran out of seedlings). Further attention must be paid to ensure appropriate drop intervals. It is likely clustering shorter segments of planted line will improve outcomes.

5.4.3 Delivery of fall restoration (fall 2022) using amphibious excavators

We conducted the field trial between October 3 – October 5, 2022.

The field trial included demonstrating floatability of the excavator in a range of land cover conditions; delivery of treatment options including digging, mounding, and hummock transplanting, and stem bending and tree tipping; and dead walking speed and maneuverability through different types and densities of standing vegetation.

Overall, we were very satisfied with the outcomes of the amphibious excavator (Figures 34, 35, 36). Operations were safe and efficient, delivered treatments were of high quality, and delivery timing was equivalent to our own winter restoration.

We delivered a total of approximately 3.54 km of restoration treatments along five (5) different seismic lines (Table 4, Figure 37). Two of the three trial days were considered full treatment days. On those days we treated 1.9 km (October 3) and 1.4 km of line, and that delivery rate is equivalent to winter delivery rates. Dead walking of the amphibious excavator was somewhat slower than the normal excavators used during winter, but not significantly slower to avoid use. Like winter restoration workflows, here we transplanted hummocks from the bush onto target lines and tipped trees across the lines to mimic wind-throwing.

We established four monitoring plots each with 9 transplanted hummocks (36) and 5 tipped trees (20) to compare ecological efficacy to winter deliveries in time.

Figure 34. Before (L) and after (R) treatment with the amphibious excavator. Note the long boom arm in the image at the right. This enabled the excavator to reach many potential off line transplants without having to move its tracks and re-position ultimately improving operational efficiency.

Figure 35. The difference of treatment (background) and no treatment (foreground). The amphibious excavator was able to transplant hummocks and live trees onto target restoration lines and tip trip to mimic wind-throwing.

Figure 36. Close up of transplanted hummocks and tipped trees on a restored segment of line and flagged monitoring plots for follow-up visits in summer of 2023.

Table 4. Site restoration summary for fall 2022 amphibious excavator restoration implementation

Site Location	Number of Sites (e.g., number of unique seismic lines)	Treatment Method(s)	Total Area Restored (linear kilometers)
MRA	1	Hummock transplants & tree tipping	1.4
MRA	2	Hummock transplants & tree tipping	0.3
MRA	3	Hummock transplants & tree tipping	1.1
MRA	4	Hummock transplants & tree tipping	0.15
MRA	5	Hummock transplants & tree tipping	0.5

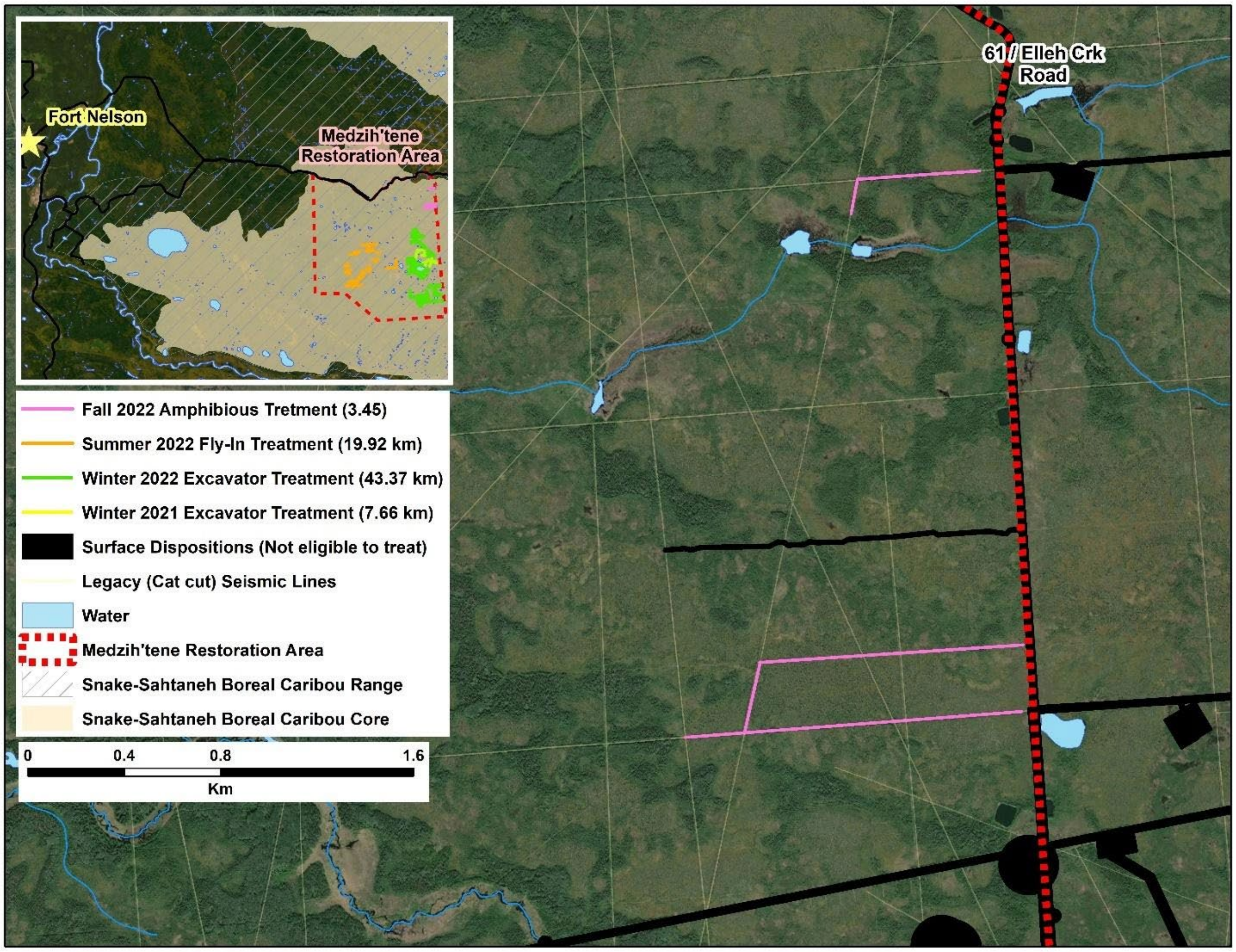


Figure 37. Lines restored using the amphibious excavator in the Medzih'tene Restoration Area in fall 2022.

5.5 Treatment Implementation III

5.5.1 In-field preparation for winter restoration 2022-2023

To date we have begun putting in access, ground scouting, and safety-checking target restoration lines. To date we have prepared approximately 30 km of target seismic line for restoration beginning mid-January 2023.

We have also secured use of Tourmaline Road and well site for access and staging and are awaiting final permission to use an active NorthRiver Midstream pipeline and inactive CNRL pipeline for access.

5.6 Project Training Initiatives

We leveraged this project to provide a variety of in-field and office-based training opportunities (Table 5).

Table 5: Training summary for Project RMC-2022-01 & RMC-2022-02

Training Received	Total Number of Members/Staff Trained	Issued Certifications (if applicable)
Tree planting and equipment training (provided by Geoterra LP)	5 (FNFN Project Manager and FNFN Guardians)	n/a
Training Eh Cho Dene GP Ltd. equipment operators (and band members). Training included transplanting hummocks and tipping over trees.	4 operators	n/a
GIS Training & Mapping	1 FNFN Lands Department Staff	n/a
Data Entry & QA/QC	1 FNFN Lands Department Staff	n/a
Vegetation data collection and monitoring; monitoring plot establishment	4 FNFN Guardians	n/a

5.7 Project Communications

Communication and outreach have been a core component of this Project. Fort Nelson First Nation has actively communicated Project information and outcomes to a range of audiences in various ways (Table 6). Our goal for Project communications has been to share knowledge and information to a range of stake- and rights-holders that is accessible for end users. Communications have ranged from written to presented to visual formats, and as small "tidbits" of information using jargon-free language to complex and in-depth analysis and interpretation of methods and findings.

Table 6: Summary of communications for Project RMC-2022-01 & RMC-2022-02

Type	Details	Date	Reach
Newsletter & Informational Fliers	Monthly updates via FNFN member newsletter (12 updates provided)	January - December, 2022	FNFN band members
Newsletter & Informational Fliers	Occasional updates created and disseminated via social media (Twitter and LinkedIn) and via direct email campaigns. See Appendix C	April, November, and December, 2022	Broad distribution
Presentation	FNFN presentation to ECCC staff on restoration program (online)	April 5, 2022	50 staff
Presentation	FNFN presentation to Ecologically Suitable Restoration Workshop (Fort St. John - OGC)	May 18, 2022	Approximately 100 attendees
Presentation	2022 Caribou Habitat Restoration Methods Workshop (Prince George, Canada)	June 2, 2022	Approximately 50 attendees

	Title: A Holistic approach to Habitat Restoration in FNFN Territory: For Us, By Us [Part I: Planning]		
Presentation	2022 Annual Conference of the Interstate Oil & Gas Compact Commission (Baltimore, USA) Title: Fort Nelson First Nation Restoration Program	October 17, 2022	Approximately 100 attendees
Presentation	Legislating a legacy of disturbance: disposition rights along linear features prevents caribou habitat restoration. Presentation to UNBC Colloquium Series	October 21, 2022	Approximately 50 attendees
Working Group Participation	Ongoing, regular participation on the National Boreal Caribou Knowledge Consortium - Restoration Working Group https://www.cclmportal.ca/nbckc-habitat-restoration-working-group-hrwg	Quarterly meetings, which include regular updates	Includes approximately 20 practitioners from across Canada
Professional Society Workshop (accepted)	One day workshop as part of the 2023 North American Caribou Workshop & Arctic Ungulate Conference (Anchorage, USA) Title: Implementing Boreal Caribou Habitat Restoration in Practice: a practical approach for Indigenous communities. https://www.wilderness.org/news/article/north-american-caribou-workshop-and-arctic-ungulate-conference-2023# See Appendix C	May 2023	Proposed for 40 participants
Professional Society Presentation (submitted)	Talk abstract submitted to the 2023 North American Caribou Workshop & Arctic Ungulate Conference (Anchorage, USA) Title: Legislating a Legacy of Disturbance: Disposition rights along linear features prevents caribou habitat restoration. See Appendix C	May 2023	TBD
Video	Instructional video providing overview of scouting for preparation of a linear feature restoration program. this is the first of three planned instructional videos Title: Caribou Habitat Restoration | Scouting Link: https://vimeo.com/782942069	December 16, 2022	Broad distribution

5.8 Employment Information

The project relied on existing FNFN staff (e.g., Project Manager, Guardians) and on contractors to fulfill the majority of the work. Where possible, FNFN staff took the lead on elements of the project, and FNFN-owned or Indigenous-owned services provided support for specific tasks. Other FNFN staff (e.g., the GIS Manager and GIS Technician) were involved in elements of this project, but hours were in-kind, not funded under BC OGRIS.

In terms of contractor support, FNFN worked primarily with two contractors: The Firelight Group (FLG) and Swamp Donkey (SD), both of which have specialized knowledge that were important to the delivery of this work. FNFN also worked with a communications team from Fuse Consulting Ltd. to support developing the training video; Ryan Dickie from Winterhawk (FNFN member) was also very involved in developing the video, while Eh Cho Dene GP Ltd. (FNFN-owned company) delivered the restoration treatments.

Despite a large amount of hours being dedicated to FNFN Guardian involvement across the phases of this project, internal capacity for Guardians to be working across multiple projects for FNFN was problematic. FNFN's Guardian program is in continuous development, with the aim of improved employment, involvement in restoration work, and data collection. However, FNFN was able to build capacity in terms of data management across the past two years, bringing in FNFN staff to support data analysis, management and collection protocols (in-kind), which Guardians will be trained on in future years of caribou habitat restoration work. Ultimately, in lieu of greater Guardian involvement, there was a heavier reliance on contractors to complete project objectives, and the success of restoration work.

For a summary of hours by FNFN staff and contractors, see Table 7.

Table 7: Employment Summary for Restoring Conventional Seismic Lines in the Snake-Sahtaneh Caribou Range

Position or company	**Category**	**People Employed**	**Total hours**	**Notes**
FNFN Project manager	Staff	1	778	FNFN staff member involved throughout the life of the project
FNFN Admin Support	Staff	2	200	FNFN staff members involved throughout the life of the project (finance and admin support)
FNFN Guardian	Staff	4	289	Trained field guardians that supported tree planting, data collection and monitoring.
Swamp Donkey	Contractor	1	873	Applied ecology company that provided technical, in-field and project management support across the life of the project.
The Firelight Group	Contractor	7	1001	Indigenous-owned research and consulting company that provided technical and project management support across the life of the project.
Winterhawk	Contractor	1	135	FNFN member-owned videography business involved in short film development.
Eh Cho Dene GP Ltd.	Contractor	7	680	FNFN-owned contractors involved in helipad clearing

				and tree-felling, operating, managing, and repairing equipment.
Fuse Consulting Ltd.	Contractor	3	204	Science communications consulting firm supporting the development of short films under this funding
Great Excavations	Contractor	2	80	Excavator specialists that supported fall 2022 work with equipment and crews.
Geoterra Integrated Resource Systems Ltd.	Contractor	1	35	Consulting firm with offices in Fort Nelson that specialize in integrated resource management as well as best forest and land management practices. Supported FNFN in training for planting and restoration work. All hours can be tied to training and capacity-building.
ASKI Reclamation LP	Contractor	2	30	Reclamation services company operating under Saulteau First Nation's Mistahiya Development Corporation. Supported tree planting in Summer 2022.

6. Conclusions and Discussion

Monies provided by OGRIS facilitated a major step forward for FNFN to plan and implement complex restoration projects. Ultimately, this project improved internal capabilities and expanded our "quiver" of restoration implementation and monitoring tools and methods.

FNFN is now in a position to plan for and deliver year-round restoration in the field.

7. Appendix A: Example Permission Request to Restore in Subsurface Tenures

Fort Nelson First Nation

Medzih'tene Restoration Area

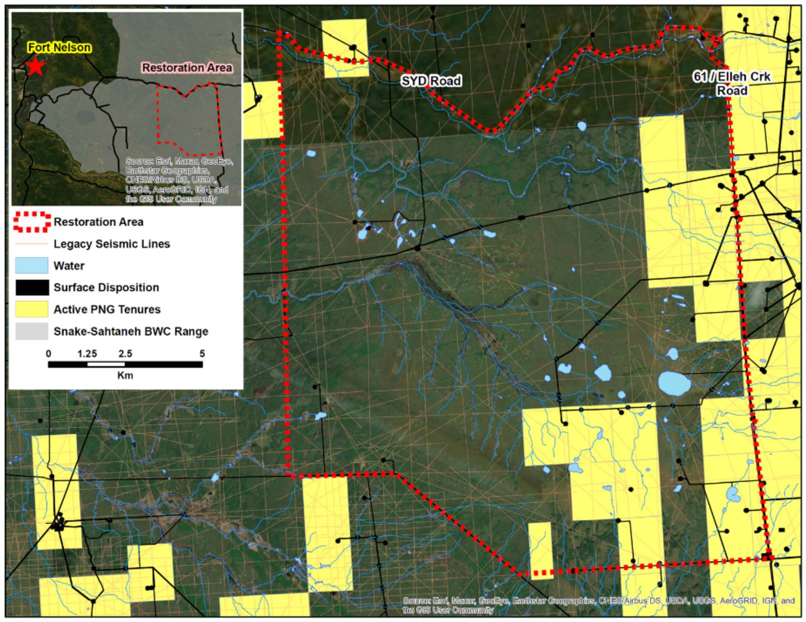
Linear Feature Restoration

Permission request

For the past three years, the Fort Nelson First Nation has been actively restoring open and semi-open seismic lines in support of caribou habitat conservation.

We are expanding restoration efforts in a new location - the Medzih'tene study area ~45km east of Fort Nelson.

Medzih'tene is a Dene phrase that translates to "Caribou's trail".



Why Restoration?

Within the Medzih'tene area many caribou are currently using excellent "raw" caribou habitat, but that habitat is bisected by many old, open and semi-open seismic lines. Those lines make it easier for wolves and black bears to encounter and kill more caribou compared to in habitats with fewer lines.

By "closing" lines using a variety of tree and hummock transplanting, tree modification, and seedling planting techniques, we are effecting converting old lines back to forested black spruce peatlands and restoring the habitat quality back into the Medzih'tene.

Caribou predators like wolves and black bears can travel "faster and farther" along open linear features making it more likely they find and kill caribou in areas with many lines than in areas with fewer lines.

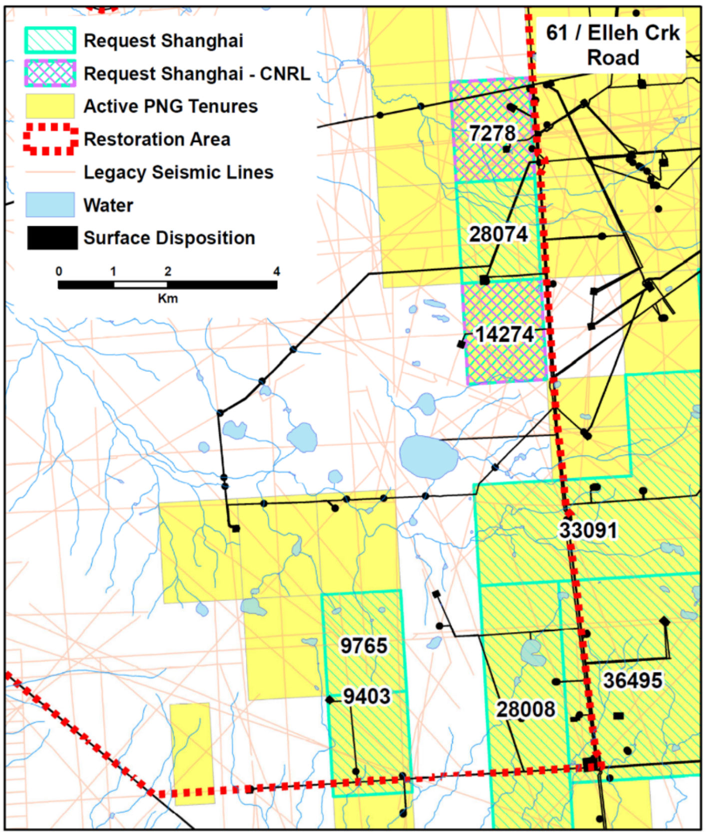
Restoration of lines can slow and stop predator movement to restore habitat functionality to caribou habitat.

What is our request?

To restore segments of old "orphan" seismic lines within select active Petroleum and Natural Gas (PNG) Tenures owned and partially owned by Shanghai Energy Corporation.

Because restoration is a new activity, permitting rules are being "written in real time". Currently, permits for restoration are issued by the Ministry of Forests, Lands, Natural Resources Operations & Rural Development with referral to both the Ministry of Energy, Mines, and Low Carbon Innovation and the BC Oil and Gas Commission for comments on PNG tenures and surface dispositions.

To date, we have been denied permission to restore old "orphan" seismic lines within active PNG tenures. However, many of the best candidate lines occur within tenures. We are directly contacting tenure holders to discuss restoration opportunities that do not impact exploration intentions as a way to build partnerships in caribou conservation and demonstrate to permitting agencies that successful restoration does not preclude exploration opportunities.



We are seeking permission to restore old seismic lines within the following tenure blocks held by Shanghai Energy Corporation and jointly held by Shanghai and CNRL in the Medzih'tene study area:

100% Ownership, Shanghai

- 28074
- 33091 (west of the 61 / Elleh Creek road only)
- 36495 (west of the 61 / Elleh Creek road only)
- 28008
- 9765
- 9403

Joint ownership (a separate request has also been made to CNRL)

- 7278 (60% Shanghai, 40% CNRL)
- 14274 (58% CNRL, 42% Shanghai)

We are not requesting permission to restore any surface dispositions.

For more information, please contact Katherine Wolfenden at:

(250) 774-6313, or katherine.wolfenden@fnnation.ca

Document created by Jesse Tigner. Photo of caribou group running © Ryan Dickie, all other photos by FNFN Lands Department.

8. Appendix B: Vegetation Monitoring Protocol

Summer 2022 Vegetation Monitoring Protocol – Restoration Treatments

The goal of this protocol is to describe which data are to be collected, and how those data should be collected, to evaluate outcomes of restoration delivered in the Kotcho Lake and Medzih'tene Restoration Areas between fall 2019 and winter 2021/2.

Collected data are intended to answer two primary questions:

- Does hummock transplanting work?
    - Are transplanted hummocks surviving?
    - Are transplanted hummocks equivalent to undisturbed hummocks occurring offline?
    - Do site prep methods or hummock characteristics influence hummock survival?
    - Do surround site conditions influence hummock survival?
- Do transplanted hummocks transfer ecological processes back onto seismic lines?
    - Are moisture and temperature gradients in transplanted hummocks equivalent to undisturbed hummocks occurring offline?
    - Do ecological parts "spread out" from transplanted hummocks to untreated portions of treated lines?

In 2022 we will collect data at treatments delivered during fall 2019 and 2020 restoration seasons in the Kotcho Lake Restoration Area (KLRA S and KLRA N, respectively), and at treatments delivered during winter 2021 and 2022 restoration seasons in the Medzih'tene Restoration Area.

Note, in the KLRA S area, duff piles and scrapes were also delivered as restoration methods and will be monitored in 2022.

Terminology

In each restoration season, a cluster of treatment replicates were clustered in space. Here we refer to the clusters as a ***site*** and the multiple replicates at a site as ***plots***.

Monitoring design

To test whether hummock transplanting success may be influenced by transplant method, we used different site preparation treatments during transplanting efforts. In Kotcho Lake in both 2019 and 2020, and in Medzih'tene in 2021, hummocks were placed directly on the ground / snow, and were placed into small scrapes. In Medzih'tene in 2022, hummocks were placed directly on the ground / snow or into shallow or deep cups.

At each site we attempted to pair (or triple) plots evenly by different restoration treatments (years 2019-2021, 1 snow to 1 scrape; year 2022, 1 snow to 1 shallow cup to 1 deep cup). During summer 2022 monitoring, we will measure a single online 1 × 1 m plot ground plot and a single offline hummock and single offline 1 × 1 m ground plot for each paired or tripled transplanted hummock. This is the **Core Protocol**.

For a subset of plots, we will also measure moss cover at hummocks and permafrost information along 10 m transects. We will attempt to collect these enhanced measures at one plot per site, time dependent.

Core protocol – per plot

Transplanted hummock

The actual hummock

- Can hummock be picked up? *Yes / No*
- Measure hummock dimensions (W × L × H), *in cm*
- Per cent of hummock edge anchored to ground *(Has the hummock moss "grown into" the substrate? If yes, what per cent of the edge of the hummock circumference?)*
- Is the hummock broken?
    - Not broken / Intact
    - Broken in half
    - Crumbling
    - Other
- Per cent cover of live & dead separately, *at scale of whole hummock, may add to > 100% because of layering*
    - **Lichen**
    - **Moss**
    - Herb
    - Carex spp.
    - Cotton grass
    - Other graminoid
    - Ericaceous shrubs (eg, lab tea, leatherleaf, bog laurel, bilberry/blueberry)
    - Tall shrubs (eg, willow, alder)
- Shrub count (all stems, live and dead)
    - Stems of ericaceous, mode height, *in cm*
    - Stems of tall shrubs, mode height, *in cm*
- Moisture & temperature probe, *single measure location, record point number stored in reader*
    - Hummock crown *(measure at top of hummock, insert probe fully and straight down)*
    - Hummock toe / trough *(measure at "seam" between hummock and ground, insert probe fully and parallel to ground)*

Hummock trees

- Target tree
    - List species
    - Alive? *Yes / No*
    - Fallen over? *Yes, No, Leaning*
    - Measure total height, *in cm*
    - Measure terminal growth *(new growth for year), in cm*
- Non-target trees (if present, per stem if > 1)

- List species
- Alive? *Yes / No*
- Measure total height, *in cm*
- Measure terminal growth *(new growth for year), in cm*

For adjacent offline hummock, select a hummock of equivalent dimensions with a tree of equivalent size to the transplanted hummocks online. Offline hummock should be 5 – 10 m offline.

Online ground plot (1 × 1 m plot)

- Along the treated line, not related to transplants, are hummocks / microtopography naturally starting to form on lines? *Yes / no*
- Number of intersecting hummocks*, 1 × 1 m plot*
- Per cent cover of live & dead separately, *1 × 1 m plot, may add to > 100% because of layering*
    - **Lichen**
    - **Moss**
    - Herb
    - Carex spp.
    - Cotton grass
    - Other graminoid
    - Ericaceous shrubs (eg, lab tea, leatherleaf, bog laurel, bilberry/blueberry)
    - Tall shrubs (eg, willow, alder)
    - Wood
    - Bare
    - Water
- Stem count *(in 1 × 1 m plot)*
    - # Stems of ericaceous shrubs, mode height, *in cm*
    - # Stems of tall shrubs, mode height, *in cm*
- Germinated conifer *(in 1 × 1 m plot)*
    - Species & height per stem*, in cm*
- Moisture & temperature probe, *single measure per location, in or adjacent to 1 × 1 m plot, record point number stored in reader*
    - If no hummock formation, 1 single reading on ground, *insert probe fully and straight down*
    - If hummock formation, top and toe readings on natural hummock as above
- Depth to water, *in cm up to 100 cm. 0 cm = standing water at surface*
- Depth to permafrost, *in cm up to 100 cm. None = no permafrost encountered*

In the offline ground plot, depth to water and permafrost should be measured from ground surface (eg, from elevation equivalent to hummock bottom not from the hummock top).

Borrow Pit

- Per cent standing water in borrow*, % of entire pit*
- Depth of deepest water in borrow*, in cm*

- If standing water around borrow, extent of water from borrow edge*, in cm*
- If dead moss around borrow, extent of dead from borrow edge*, in cm*

Free Plants & Pos – per site

Free planted trees

- Per stem
  - List species
  - Alive? *Yes / No*
  - Measure total height, *in cm*
  - Measure terminal growth *(new growth for year), in cm*

Push Overs

- Per PO (and per stem in a PO, if ≥ 1 stem)
  - Species
  - Angle (approximate degree (90° = straight up and down), GD for flat on ground)
  - Stem attached to base? *Yes / no*
  - Alive? *Yes / no*
  - Measure terminal growth *(new growth for year), in cm*

9. Appendix C: Communications Materials

Attachments