SERN BC: Caribou Habitat Restoration in the 61 Road / Elleh Creek Area

June 2022

Fort Nelson First Nation Lands Department

Introduction

Across Canada caribou populations are in decline. In boreal biomes, those declines are driven in large part by industrial land uses that alter caribou habitat and caribou ecology. Part of the boreal caribou survival strategy is to select for low productivity, forested peatlands to “spatially separate” themselves from other ungulates and predators. This spatial separation helps caribou to maintain a low predation risk. Linear features used by the oil and gas and forestry sectors to explore for, access, produce, and harvest resources dissolve that spatial separation by providing travel corridors used by predators to move faster and further through caribou habitat. Those altered travel patterns ultimately increase predator encounter with and predation on caribou. In short, lines increase the hunting efficiency of predators in otherwise “poor hunting grounds”, and that is bad for caribou.

Currently, a primary conservation tool to support boreal caribou populations is to restore linear features within delineated caribou range. Often linear features do not recover on their own along expected trajectories and timelines. This means that many lines persist as travel corridors, thereby functioning to maintain an elevated predation risk for caribou, often for many decades. Restoration is used to jumpstart the recovery for trees species along lines thereby short circuiting the behavioural response of predators to use lines. Restoration is meant to reduce predator use of lines, thereby restoring the spatial separation between caribou and their predators and expected predator-prey relationships.

Identifying candidate linear features for restoration is a primary workflow for restoration planning. Which features should be restored? Information about the location and distribution of linear features on a landscape, which of those features are accessible and available to restore, and the current recovery state of those features are all critical to plan efficient and effective restoration programs. Unfortunately, across most Canadian caribou ranges those pieces of information are difficult to obtain.

This report is a summary of two complementary workflows completed to address the two biggest challenges encountered by the Fort Nelson First Nation when planning for and delivering restoration along linear features in northeast BC (NEBC): 1) which lines can be restored, and 2) what is the current recovery status of restorable lines? Funding provided from SERN BC was used to address regional issues and local solutions pertaining to the FNFN Medzih’tene Restoration Area.

The report is broken into two sections. In Section A, we delineate a spatially explicit footprint of the active subsurface tenures and surface dispositions associated with the oil and gas, and forestry sectors, and public infrastructure. These active tenures and dispositions potentially limit restoration feasibility across NEBC. We include “work arounds” and address the next steps needed to reduce these limitations. In Section B, we explore the potential for drone-based reconnaissance to assess the recovery status, accessibility and treatability of linear features.

Study Area

Work summarized in this report is intended to support ongoing restoration in the newly created Medzih'tene Restoration Area (MRA) (Figure 1). Medzih'tene means "caribou trail" in Dene. The Medzih'tene is approximately 225 km^2 in area and contains approximately 774.73 linear kilometres of conventional cat-cut seismic lines.

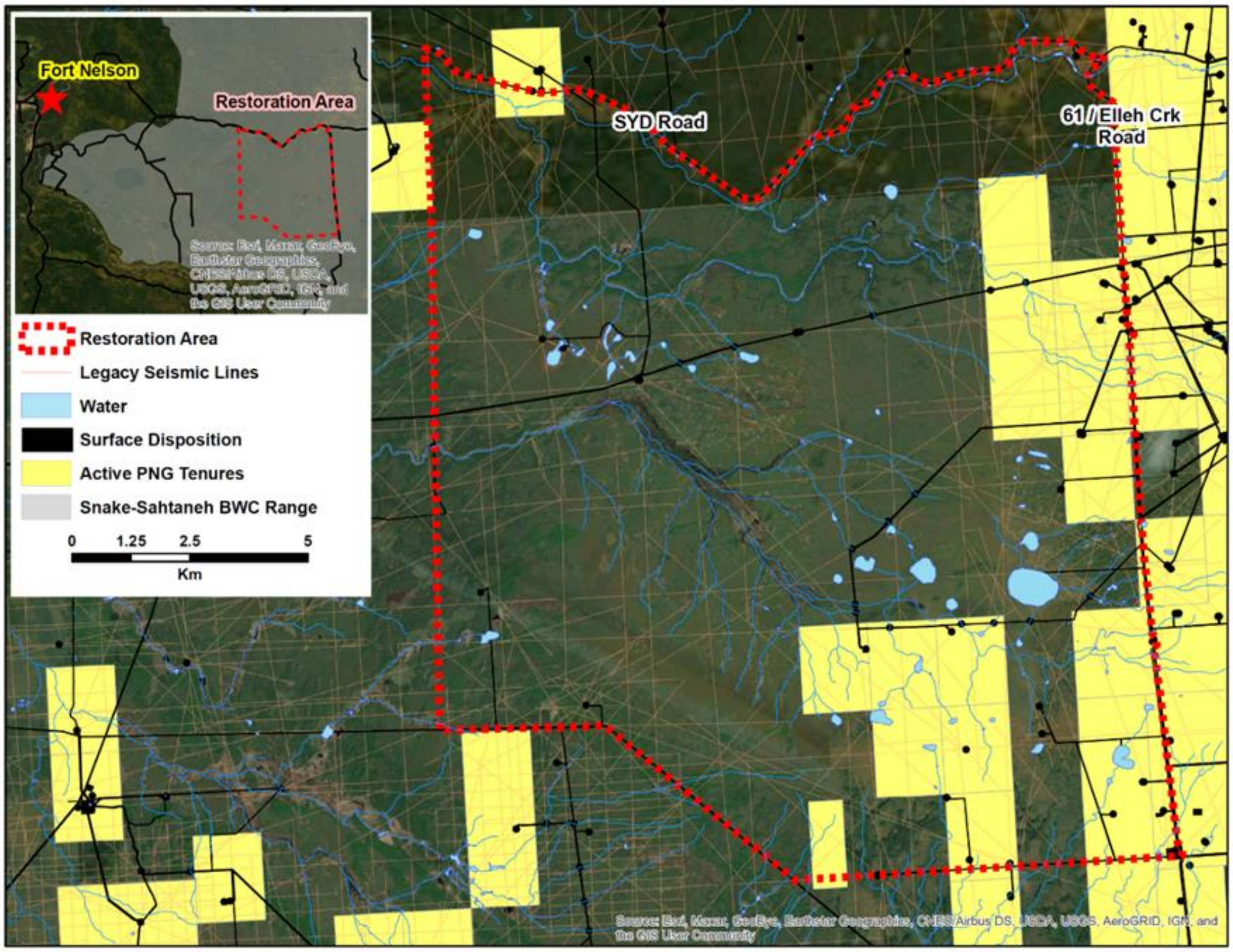


Figure 1. Medzih'tene study area.

Most of the MRA is high quality caribou habitat and consists of extensive forested peatlands (Figure 2). To evaluate the distribution and value of land covers for caribou within the MRA, we used the raster-based Enhanced Wetland Classification available from Ducks Unlimited Canada (DUC) for the area. The DUC data represents 24 land cover classes as 30 m × 30 m cells. We reclassed those land covers into 7 new classes based on their relative value to caribou, alternative prey species, and predators (Table 1). Reclassification was meant to generally identify areas of high vs. low value to caribou, rather than identify seasonally variable caribou selection parameters. For example, land covers that potentially provide food resources and security for caribou were considered high value, and land covers that potentially provide food resources to moose and deer were considered low value.

Figure 2. Lines notwithstanding, the Medzih'tene Restoration Area contains excellent caribou habitat.

Within the MRA, a total of 66% of the land cover is considered high value to caribou (32.41% as treed bog and 33.79% as treed fen, shrubby bog, or conifer swamp; Table 1, Figures 3 and 4). Those landcovers are evenly distributed across the MRA and occur basically everywhere away from watercourses (Figures 3 and 4).

Table 1. Reclassification scheme used to identify high value boreal caribou habitat in the Medzih'tene Restoration Area, NE BC. Land cover data came from the Enhanced Wetlands Classification made available from Ducks Unlimited Canada.

DUC Enhanced Wetland Classification for BC			**Reclassified Cover Classification**		
Cover Class [a]	*Cover within the Medzih'tene (km^2)*	*Per cent cover of the Medzih'tene*	*Cover Class (ranked)*	*Cover within the Medzih'tene (km^2)*	*Per cent cover of the Medzih'tene*
Treed Bog	73.61	32.41	3	73.61	32.41
Treed Rich Fen	0.57	0.25	2	76.75	33.79
Treed Poor Fen	22.12	9.74			
Shrubby Bog	47.75	21.02			
Conifer Swamp	6.30	2.77			
Shrubby Rich Fen	16.46	7.25	1	19.13	8.42
Upland Conifer	2.68	1.18			
Open Water	3.23	1.42	0	34.07	15.00
Aquatic Bed	0.27	0.12			
Mudflats	0.00	0.00			
Emergent Marsh	0.02	0.01			
Meadow Marsh	0.04	0.02			
Graminoid Rich Fen	0.28	0.12			
Graminoid Poor Fen	3.38	1.49			
Open Bog	1.09	0.48			
Hardwood Swamp	15.22	6.70			
Mixedwood Swamp	10.54	4.64			
Shrub Swamp	1.77	0.78	-1	21.02	9.26
Upland Deciduous	13.06	5.75			
Upland Mixedwood	6.20	2.73			
Fire < 40 years	0.40	0.17	-2	2.29	1.01
Cutblock < 40 years	1.89	0.83			
Anthropogenic	0.27	0.12	-3	300.00	0.12

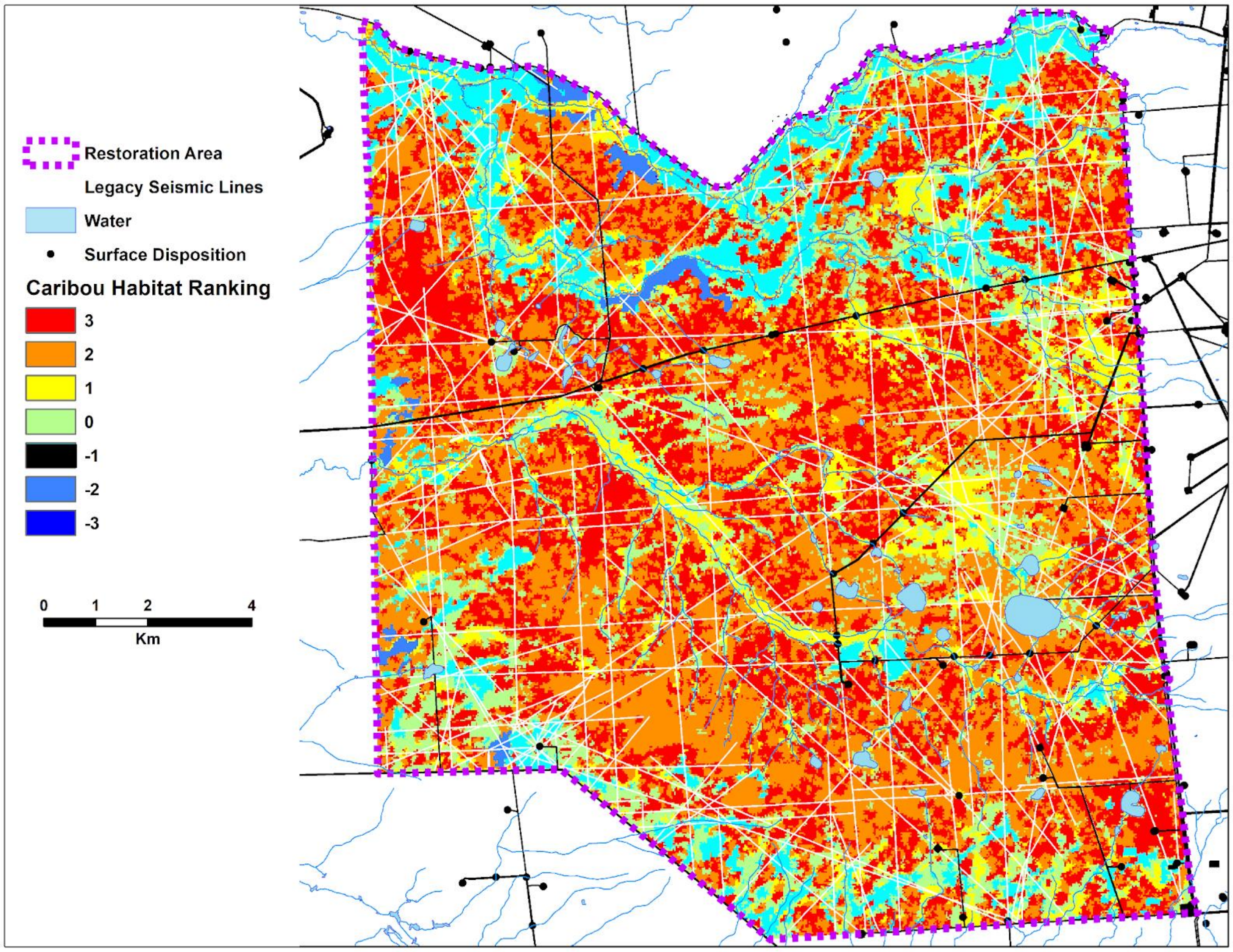


Figure 3. Most of the study area is estimated to be high value caribou habitat (reclassification values 2 and 3), based on GIS analyses of raster land cover data from Ducks Unlimited Canada.

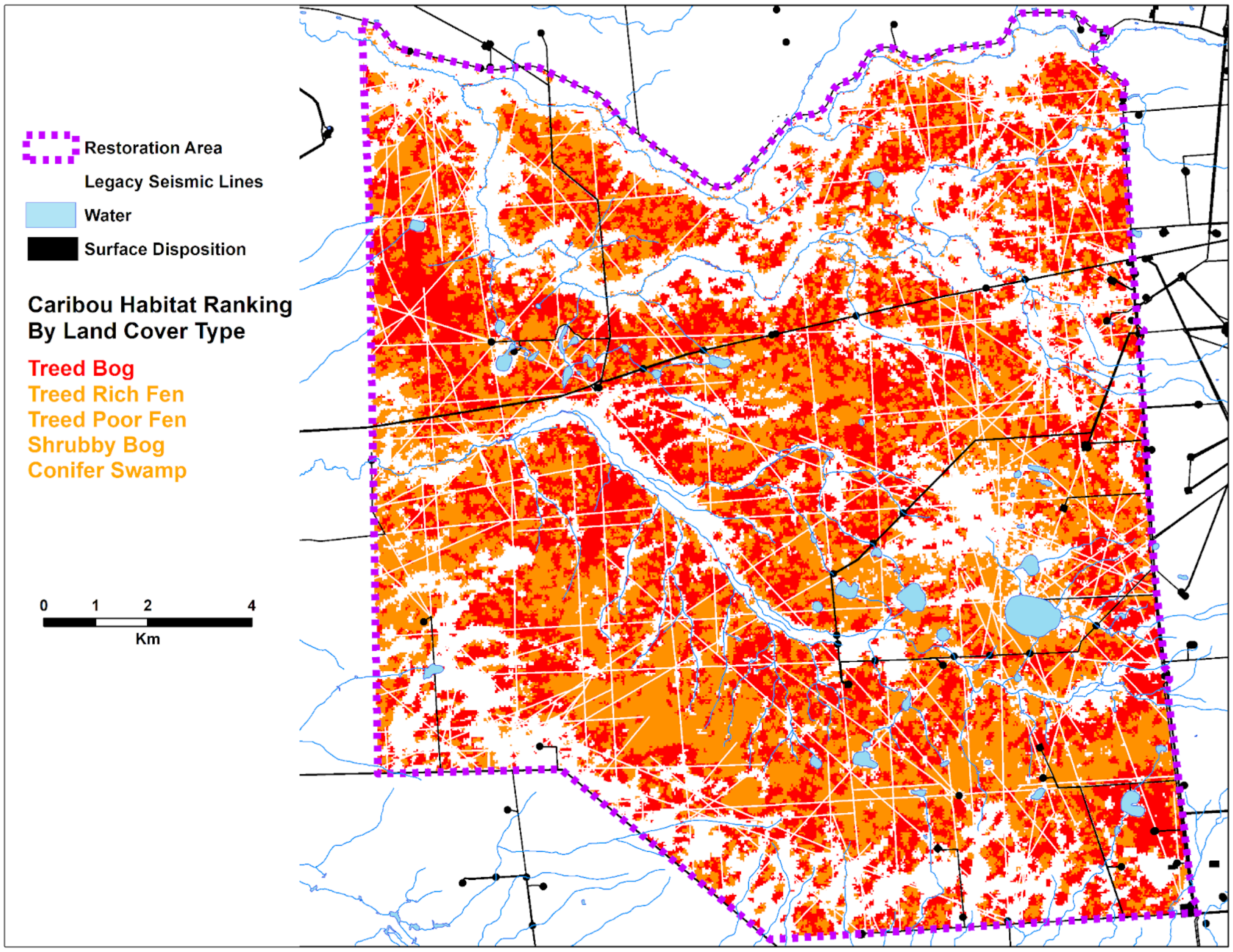


Figure 4. High quality caribou habitat types, comprised of treed bogs (class 3 in Table 1 and Figure 3) and treed fens, and shrubby bogs and conifer swamps (class 2 in Table 1 and Figure 3), are well distributed across the entire MRA study area.

Part A – Active subsurface tenures and surface dispositions of resources roads, pipelines, and municipal linear features and private land in the study area

The restoration of linear features such as inactive roads, pipelines, trails, seismic lines, and various utility lines has emerged as a primary conservation tool to restore habitat function for caribou. Whereas caribou attempt to separate themselves from other ungulates and potential predators, linear features can alter movement and habitat selection patterns – particularly of wolves – in ways that negatively impact caribou. This change in habitat selection reduces "habitat function" for caribou by increasing predation risk in otherwise high-quality peatland habitats. Unfortunately, across western Canada, available spatial data representing linear features are poorly organised, often scattered across many different repositories, and usually incompletely attributed.

Across a variety of jurisdictions, significant efforts have been made to collate disparate datasets of surface disturbance footprints. Often those efforts are designed to build "complete" coverage of existing features for research and management needs by leveraging existing data and infilling missing features using remotely sensed imagery. Outcomes of those efforts usually aim to identify lines in space, and organise lines into different classes, when possible (e.g., a conventional or low-impact seismic line, roads, transmission line, etc.). Such layers have been instrumental for our work, enabling us to analyse the distribution of lines in space to conceptually identifying restoration needs. However, simply knowing that a line occurs in space is insufficient to build out restoration plans because it does not inform whether there is legal standing to an identified feature that may preclude it restoration.

Most caribou habitat in western Canada is crowded with a variety of land uses and users. In many cases those uses have been granted a suite of rights by government agencies through formal and legally-binding permitting procedures. For example, a company interested in drilling for oil can't simply "head out onto the land" to build a road, a well pad and a pipeline; those activities must first be permitted. Once awarded, the conferred rights attached to permits are guaranteed to permit holders by codified legislation over a set duration of time. Put more simply, not every mapped disturbance feature on a landscape is available to restore. Rather, some have been conferred rights that are in direct conflict with restoration efforts meant to close lines in ways that prevent travel by predators. Complicating matters further, the active portions of awarded permits may persist long after those features are seemingly abandoned.

Understanding the location of active permits that may impede restoration is obviously a critical component to planning and executing habitat restoration for caribou. Because restoration is in its nascency, these considerations and the complexities inherent to identifying active permits has received little attention to date. Unfortunately, there is no single "ledger" that reports on active permits. Instead, a variety of land uses across a variety of sectors may incur similar disturbance footprints as they relate to caribou management, but are regulated by different agencies along different trajectories and regulatory workflows. Often the management of those footprints and the associated permit data occur "in house" within regulating agencies. Thus, collating active permits requires review and interpretation of a variety of data sources to effectively translate the Greek of industrial land use, associated permitting, and resulting surface disturbances to the Russian of restoration needs and requirements to obtain restoration permits.

In this Section we used the six delineated boreal woodland caribou ranges in NE BC (Calendar, Chinchaga, Maxhamish, Parker, Prophet, and Snake-Sahtaneh; Figure 5) as a case study to identify and map a subset of active permits related to the oil and gas and forestry sectors, and to public utilities and infrastructure. We focused on those sectors because they represent by far the largest component of the current disturbance footprint in the region and are the most likely contributors of future footprints. We included public utilities and infrastructure to include permitted features that contribute to broader societal functions (e.g., public highways and electrical transmission lines) and account for private land ownership were incorporated.

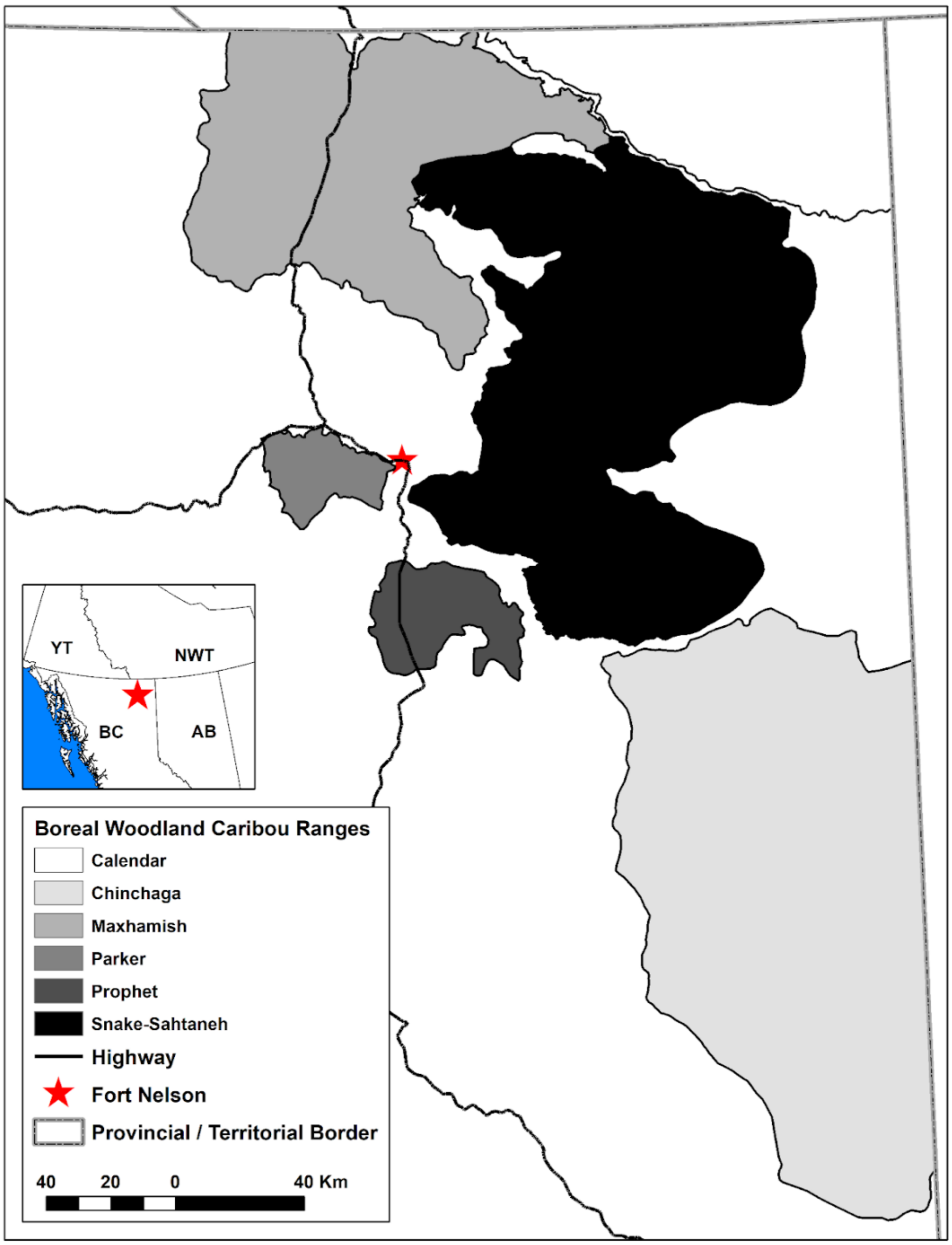


Figure 5. The six delineated boreal woodland caribou ranges in northeast British Columbia.

Restoration permitting and understanding the problem

Like other land uses in British Columbia, restoration activities require a series of permits; the permitting authority for restoration in this case is the Ministry of Forests, Lands, Natural Resources Operations and Rural Development (FLNRO). Any group interested in conducting restoration must apply to FLNRO for a permit to conduct specific restoration activities at a specific location (e.g., planting trees along a specified section of linear feature). While straightforward in theory, that process is complex in practice for three related reasons.

First, data on the location, permits status, and the conferred rights attached to issued permits are not readily available. For a group trying to permit restoration, it is difficult to compile information about how a landscape has been legally partitioned, and how to interpret the status of those issued permits (e.g., allowed vs disallowed activities, active vs. inactive permits, permit expiry dates, etc.). Second, many features requiring restoration are outside the managing purview of FLNRO. For example, many linear features like roads, pipelines, and seismic lines are permitted and managed through the BC Oil and Gas Commission. Thus, FLNRO is ultimately tasked with authorizing restoration along disturbances overseen by an entirely different agency, sometimes without fully understanding the operational nuance, permitting trajectories, or regulatory stipulations of the permits issued for those disturbances. Third, permitting processes and their associated activities often unfold along complex and multi-faceted pathways. For example, a given disturbance feature may require several types of permits issued by different Ministries or governing bodies; and sometimes a feature is permitted to one user but eventually taken over by another in a different sector, subject to oversight by a different governing body. Often the result is that a single feature is represented across multiple permitting databases, sometimes with different statuses and no clear indication of transfer date, expiry, current user, or most importantly, which status is "correct".

Restoration is a relatively new activity and FLNRO's application and permitting process is being "written in real-time". Fort Nelson First Nation is entering it's fourth year of restoring linear features (2019-2022, inclusive), and in each calendar year has undertaken a different permitting process. Currently, no set policies have yet been enacted by FLNRO to establish a prescriptive approach to restoration permitting. Instead, authorization of permits, including allowable activities and locations, are made by Statutory Decision Makers (SDMs) within FLNRO (e.g., an assigned case manager for an incoming restoration permit application). Restoration applications do not go out to referral to other agencies. Instead, a FLNRO SDM reviews and interprets available spatial data on permits and the legislation conferring associated rights without direct consultation with other provincial ministries and agencies to clarify inconclusive permit status or potential discrepancies. The SDM approach to permitting offers flexibility but also translates to a default of disallowing restoration and or placing caveats on issued restoration permits where existing land use permits are listed in those data layers reviewed by an SDM during the application process.

In short, neither an applicant for a restoration permit nor the permitting agent has a clear picture, per se, of what restoration activities are allowed where.

Delineating active land use permits within boreal caribou range

Our interest here was not to solve, but to more clearly define the scope of the problem associated with identifying pertinent land use permits that may conflict with restoration goals, from the perspective of a restoration practitioner, so that clear and targeted solutions can be developed.

Which permit types may preclude restoration activities?

In British Columbia land uses are regulated and managed using a series of permits issued through a range of provincial agencies and ministries. Those permits, the rights they confer, and in the case of habitat restoration, which kinds of competing uses they may preclude, are established and enforceable through a variety of provincial legislative Acts and laws. The regulatory processes are extremely complex and well beyond those scope of this report, but the complexity of the terminology attached to permits is important to clarify.

The specific terminology used to describe permits can depend on the geographic location for which a permit is issued (public or private land), the type of land use being permitted, and the developmental stage of a land use for which a permit is required. That specificity can relate to the types of rights and permissions conferred. It is virtually impossible to accurately capture that specificity without careful reference to a variety of pertinent Acts and laws. And, often terms and shorthand reference to permit types are diluted as they are used colloquially or in industry-specific ways.

Here we refer to two types of permits: subsurface tenures and surface dispositions. Subsurface tenures are a class of permits issued to provide exclusivity for future activities within a spatially explicit surface representation under which a company has an interest in the subsurface resource potential. Subsurface tenures are issued for a variety of land uses and, generally, represent a spatial area (e.g., a block) within which specific activities leading to surface footprint features may occur but are unlikely to result in a "fully disturbed" tenure with a wall-to-wall footprint. In contrast, surface dispositions are a class of permits issued in support of specific activities and footprint features with narrowly defined spatial extents (e.g., a road or pipeline right-of-way, or a well pad). Surface dispositions may include a wide variety of permit types across a wide variety of land uses, but a commonality is that a surface disposition defines an actual and delineated habitat disturbance.

Our starting point for accessing and interpreting permit statuses was a list of over 100 spatial layers used by FLNRO to review potential conflicts during a restoration application review. The list was provided by FLNRO and all layers are accessible from the BC Data Catalogue (https://catalogue.data.gov.bc.ca/). We conducted an initial review of the prevalence of active subsurface tenures and surface dispositions within and directly adjacent the six boreal caribou ranges, and the potential of those permit types to conflict with restoration goals intended to permanently close features to travel.

Ultimately, we focused our efforts as follows:

Subsurface tenures

> We identified active subsurface tenures associated with the oil and gas sector. We searched for active mineral tenures (mineral and placer claims and leases and active coal licences and leases) as well, but none occurred within our study area.

Surface dispositions

> We identified active surface dispositions for linear features associated with the oil and gas and forestry sectors because they were ubiquitous and by far the largest contributors of actively permitted linear features within the study area. We also included dispositions for linear features for municipalities and public utilities (e.g., powerlines, public roads and highways, railroads, etc.) as those are likely to remain permanently open for broad public use necessary for societal function. We also included polygonal features for privately owned land because it is unlikely private lands will be broadly sold off to support caribou conservation.

We did not include any polygonal dispositions for the myriad features associated with the oil and gas sector (e.g., well pads, facilities, etc.) because, while numerous, they are individually small, and their restoration is unlikely to influence travel patterns of wolves, the primary goal of linear feature restoration.

Review of all data available from the BC Data Catalogue was followed-up with a review of the Integrate Land and Resource Registry (ILRR) (https://www2.gov.bc.ca/gov/content/data/geographic-data-services/land-use/integrated-land-resource-registry) to ensure no active permits were missed in this analysis.

We did not include any polygonal permits related to timber harvest. In British Columbia, the permitting of forestry-related harvest activities occurs at a kind of interface between tenures and dispositions, as we have differentiated them above. Most activities that involve harvesting or clearing standing live or dead trees are permitted within a spatially explicit maximum extent, but harvest prescriptions do not manage each stem or dictate the location of all actions within permitted blocks. While it would be prudent to include planned, but not yet harvested blocks or other forestry permits that may resulted in altered habitats in this analysis, reporting of harvest blocks is variable. Unfortunately, disclosure of planned cut blocks is not a legal requirement in BC. Some planned blocks are reported, but overall little timber harvest activities occurs with the delineated boreal caribou ranges in BC. We reviewed a variety of data layers in the BC Data Catalogue related to harvest activities overseen by the Forest Tenure Branch, and reviewed data housed in The Reporting Silviculture Updates and Land Status Tracking System (RESULTS) database (https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/silviculture-reporting-results). Most of the harvest-related permits in the region either occurred outside or mostly outside of delineated ranges, or were already harvested and typically associated with an Occupant License to Cut (e.g., harvest to clear construction of a road or pipeline as were therefore accounted for elsewhere in our analyses). Most harvest permits do not confer rights that would preclude restoration activities geared toward lines closure, per se. Inclusion of harvest tenures within our study area would have done little to alter our interpretation of unrestorable linear features.

Lastly, it should be noted this effort does not include every permit or linear feature that could feasibly conflict with or preclude restoration. There were a range of active permits excluded from this analysis. Exclusions resulted for two reasons. First, some active permits were excluded to streamline analyses because they were uncommon in the study area and their inclusion would not have influenced findings at a regional scale or for the purposes of broad strategic planning. Locally and for individual restoration programs, some additional features may require consideration. For example, permits maintaining recreational or historic trails may warrant localized planning consideration. Second, some active permits were excluded because obvious conflicts with restoration goals were not codified in law, per se. For example, while registered traplines do not guarantee open access everywhere, historic trapping uses may require direct engagement to ensure restoration strategies and locations are permissible. Locally and for individual restoration programs, appropriate consultation activities may exclude portions of these kinds of permits for restoration.

Extent of active permits

Subsurface tenures: Petroleum & Natural Gas Tenures

Petroleum & Natural Gas Tenures (PNG tenures) serve as a first step to the broader oil and gas exploration and production cycle in BC. PNG tenures are issued by the Ministry of Energy, Mines and Low Carbon Innovation under authority of the Petroleum and Natural Gas Act. Tenures are intended as a temporary status meant to provide tenure holders a period of competition-free time to drill exploratory wells and confirm hydrocarbon resources. Awarded tenures confer the rights of exclusive exploration to a parcel of the subsurface for a set duration of time, but do not actually provide any rights to the surface or prevent access to the surface over conferred exploration rights by others. Any actual exploration-related activities or access to the land base atop awarded tenures, and any subsequent resource production-related activities that incur a surface disturbance require a different set of permissions and approvals issued by the BC Oil and Gas Commission under the authority of the Oil and Gas Activities Act (see surface dispositions).

The nuance of the regulatory mechanisms attached to PNG tenures and the interpretations of those mechanisms by FLNRO are important to the context of permitting restoration. On the one hand tenures estimate a surface extent over which disturbance to caribou habitat may be incurred. While some exploration activities and access needs can occur outside of a tenured area, exploratory wells are tied to tenures themselves. If exploration is successful and activity ultimately continues to commercial resource production, those subsequent activities will be clustered within a tenured block (though different permissions are likely to be issued and the original spatial extent of tenure blocks may shrink). On the other hand, tenures themselves do not actually guarantee any rights or access to, or use of the land atop tenures; nor do tenures prevent access by other parties.

Thus, tenured blocks of land occur in a grey area with respect to permitting restoration. Part of the permitting decision process for an SDM at FLNRO is to weigh the conservation benefit of restoration against potential future land uses that may remove or reduce the efficacy of delivered restoration. Within a tenured block there are likely past disturbances needing and available for restoration. While restoration of those features is legally permitted within active tenures (because a tenure holder has no surface rights or exclusive access rights), the presence of an active tenure also increases the odds of future disturbance. Because tenures delineate where habitat disturbance may but not necessarily will occur, it makes weighing restoration benefits against wasting conservation dollars very tricky. To further complicate that decision, PNG tenures are broken into a variety of tenure types based on land cover and ease of access, and the stage an exploration trajectory. Both the duration of issued tenures and the ability to renew and extend tenure periods varies tenure type. Once awarded, it is feasible a tenure can remain active for decades with no clear date of expiry and no easy way to track regulatory history. Thus, once on the books, a tenure, and its potential to constrain restoration, can remain active for many decades even if little or no actual exploration or production activity occurs.

Awarding of tenures follows a formal nomination and bidding process, the complexity of that process is largely outside the scope of this report. Importantly for restoration permitting, tenures can be awarded as a full package of subsurface formations or for a subset of specific formations only (e.g., as a “everything below ground” or as a “single slice” of the geologic history, respectively). Further, bids can be made by single companies or partnerships of multiple companies. Thus, a single patch of ground can overlay multiple tenures and or tenure rights shared by multiple individual companies.

Mapping active PNG tenures

Our goal for mapping active PNG Tenures was to delineate the spatial extent over which any subsurface tenure related to energy (hydrocarbon and geothermal) exploration and production have been issued and are currently active.

We first downloaded the spatial layer for Petroleum Title Polygons from the BC Data Catalogue (ultimately this layer is no longer directly available for a self-serve download and requires a direct request made to the Tenure and Geoscience Branch of the Ministry of Energy, Mines and Low Carbon Innovation). We next filtered out any non-active tenures in a Geographic Information System (GIS). Tenures listed in the downloaded layer exist at a variety of statuses including expired, cancelled, not issued, unsold, withdrawn, etc., related to the regulatory processes of tenure nomination, bidding, and awarding. Here, only currently active tenures were considered. Most retained tenures were PNG tenures, though other related tenure types including drilling licences and petroleum leases and parcels were also included because those types also confer rights for exploration activities that could influence restoration permitting.

Once filtered, we then clipped the active tenures to the outlines of the six caribou ranges and associated 16 cores currently recognized under the federal recovery strategy. We then tallied the number of individual active tenures for all geologic strata and the number of listed tenure holders for those active tenures for caribou ranges and calculated the proportion of caribou ranges and cores covered by active tenures. Note, there is some variation in range identification between federal delineations and ongoing caribou research in BC. All calculations here are relative to federal delineations of caribou ranges and cores recognized by the federal boreal woodland caribou recovery strategy.

Active tenures cover between 1.63% and 43.63% of the surface area within delineated caribou ranges (Figure 6, Table 2), and between 1.63% and 60.73% of delineated cores (Figure 7, Table 3). At the range scale the Prophet Range has the fewest number of tenures and tenure holders at seven and two, respectively, and the Chinchaga has the most at 1,806 and 66, respectively (Table 2).

Table 2. The number of active subsurface Petroleum and Natural Gas (PNG) tenures and tenure holders, and the total area covered by active tenure in the six delineated boreal caribou ranges in NE British Columbia.

Boreal Caribou Range	Range Area (km^2)	No. of PNG Tenures	No. of Companies with Ownership	Tenure Area (km^2)	Per cent of Range Allocated
Calendar	4972.93	350	13	1605.18	32.28
Chinchaga	13897.5	1806	66	5846.99	42.07
Maxhamish	7095.53	273	23	3096.09	43.63
Parker	751.62	9	2	33.18	4.41
Prophet	1193.03	7	2	19.4	1.63
Snake-Sahtaneh	11999.76	932	52	4520.01	37.67

Table 3. The total area covered by active subsurface Petroleum and Natural Gas (PNG) tenures in the sixteen delineated boreal caribou cores in NE British Columbia.

Boreal Caribou Core	Core Area (km^2)	Tenure Area (km^2)	Per cent of Core Allocated
Calendar Range			
Calendar Core	4972.96	1605.20	32.28
Chinchanga Range			
Etthithun Core	780.18	404.40	51.83
Milligan Core	5196.19	3155.46	60.73
Maxhamish Range			
Capot-Blanc Core	875.68	450.30	51.42
Fortune Core	2662.41	1029.63	38.67
Kiwigana Core	1300.76	628.35	48.31
Parker Range			
Parker Core	751.62	33.18	4.42
Prophet Range			
Prophet Core	1193.03	19.41	1.63
Snake-Sahtaneh Range			
Clarke Core	2224.04	575.57	25.88
East Kotcho Core	318.03	227.32	71.48
Etsho Core	60.27	2.02	3.36
North Kotcho Core	748.38	328.69	43.92
Paradise Core	402.98	26.43	6.56
Shush Creek	282.48	107.24	37.96
Tsea Core	688.83	412.09	59.82
West Kotcho Core	361.81	94.17	26.03

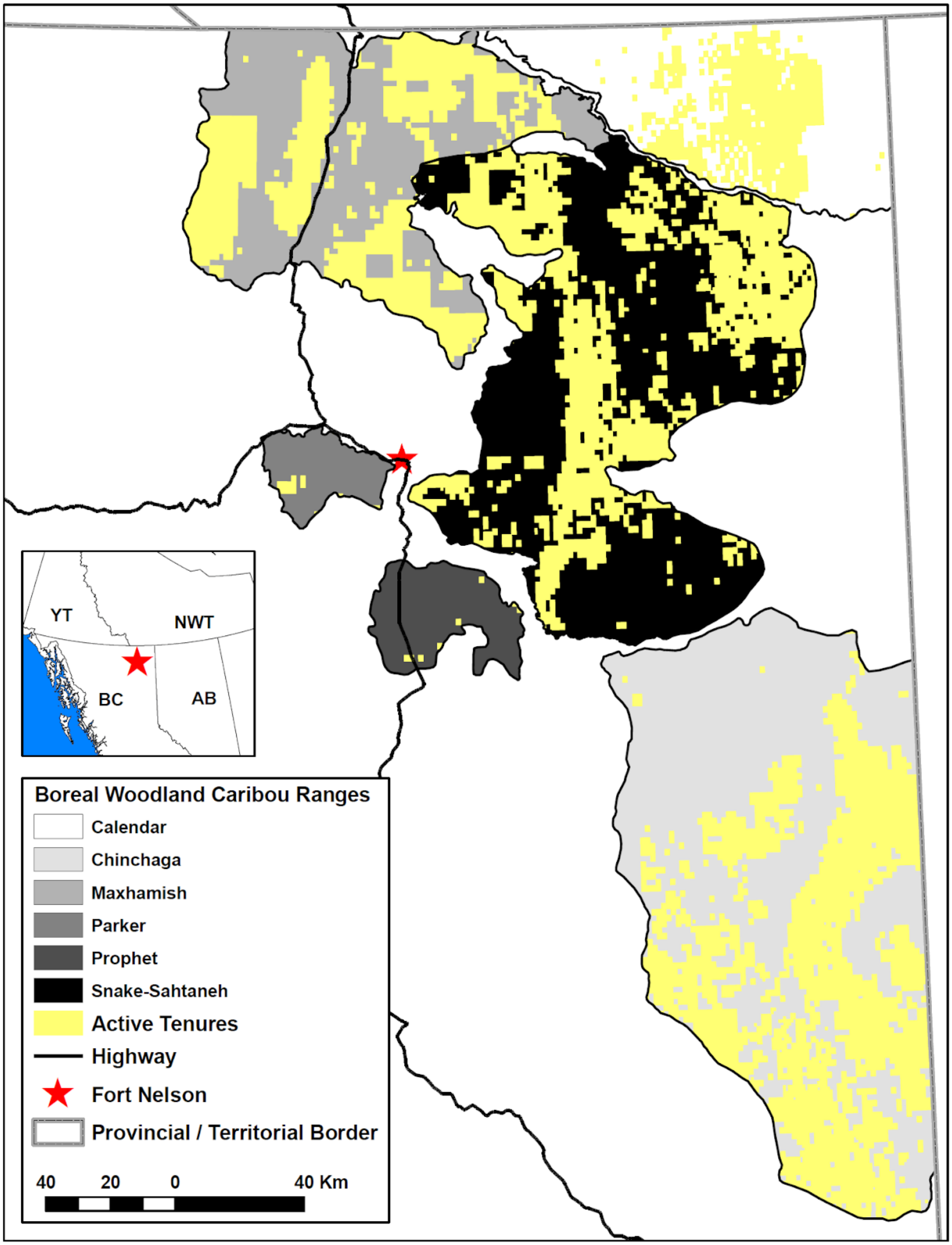


Figure 6. Active subsurface Petroleum and Natural Gas (PNG) tenures within the six delineated boreal woodland caribou ranges in NE British Columbia.

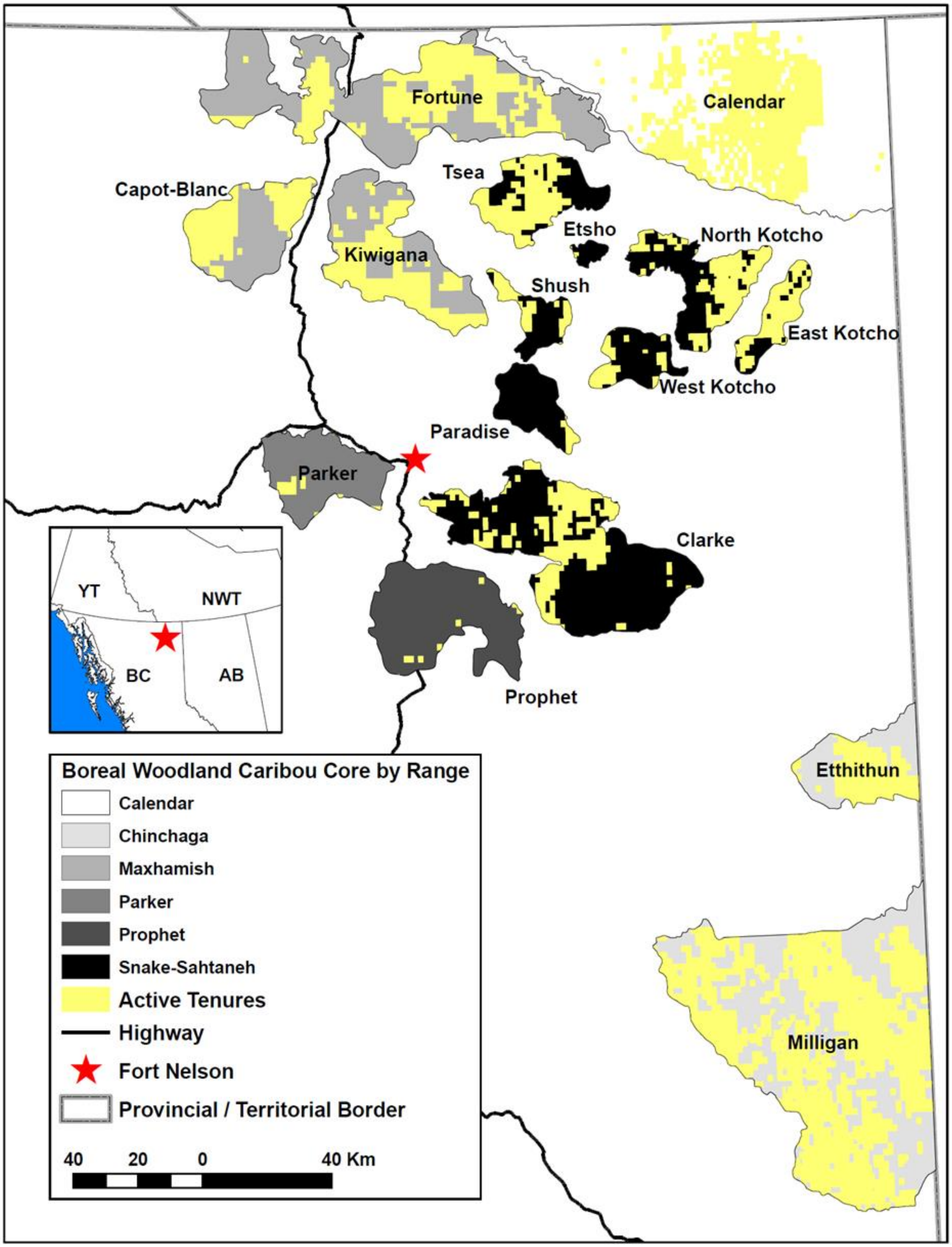


Figure 7. Active subsurface Petroleum and Natural Gas (PNG) tenures within the sixteen delineated boreal woodland caribou cores in NE British Columbia.

Surface dispositions: roads, pipelines, linear infrastructure, and private land

Compared to subsurface tenures, it was considerably more difficult to track, collate, and interpret surface dispositions. Those difficulties stemmed from layered complexities influenced by legislative and data tracking processes. While outside the scope of this report, understanding the basis for those complexities is important to understand the broader challenge involved with permitting restoration in BC.

Surface dispositions confer rights for land uses that incur an actual, physical, and spatially explicit disturbance on the surface of the land. Unlike tenures that provide rights to resources, surface dispositions provide the rights to actually access, explore for, produce, and otherwise use those tenured resources. In the case of natural resource-based land uses like oil and gas and forestry, surface dispositions confer rights to proponents to create, maintain, use, and operate features like roads, pipelines, well pads, and myriad other facilities atop a landscape.

Broadly speaking, the Lands Act underpins the issuance of rights attached to surface dispositions within caribou range in BC. Most of caribou range in BC occurs on public, or Crown, lands, and most Crown lands in BC are owned by the province. Under authority of the Lands Act, the province can confer non-Crown entities various legal rights to use and occupy Crown lands. Surface dispositions are issued for specified uses at specific locations, but the types of rights, the exclusivity of those rights and associated occupancy on the land they grant, and the duration over which issued rights and exclusivity are guaranteed vary by the type of disposition granted (see below for further detail).

In practice, the actual issuance and tracking of surface dispositions is complex for a variety of reasons. First, although the Lands Act is provincial, the legislative authority of the Lands Act to confer rights for dispositions is administered at the scale of the pertinent ministries and agencies tasked with managing a given land use. Often that administration occurs in conjunction with the pertinent agencies' own legislative Acts. For example, a forestry road intended to provide access to harvest permitted timber blocks would be applied for and provided a disposition through the Ministry of Forests, Lands, Natural Resource Operations and Rural Development under the Forest Act or Forest and Range Practices Act, while a road intended to provide access to construct and maintain a well pad would be applied for and provided a disposition through the BC Oil and Gas Commission under the Oil and Gas Activities Act. Because there is no single authority issuing dispositions, there is also no single ledger tracking all issued dispositions. In the example above, each road would be tracked in disparate datasets managed by independently by FLNRO and the OGC.

The second and third reasons issuance and tracking of surface dispositions is complex is related to disposition and disturbance feature lifecycles. Often the construction of a piece of infrastructure requires "daisy-chained" dispositions that may be tracked across different agencies. For example, construction of a pipeline may require the felling and clearing of timber in forested lands to open a right-of-way into which pipe is eventually buried. Initial harvest and subsequent land clearing could be managed by a Occupant Licence to Cut that is issued and tracked under Ministry of Forests, Lands, Natural Resource Operations and Rural Development, and then a Licence of Occupation under the Oil and Gas Commission, respectively. Eventual land use as a pipeline is likely to then be permitted as a surveyed right-of-way again issued and tracked by the OGC and by a regional land office. Similarly, once constructed, the intended use and or ownership of a permitted disposition may change. For example, a resource road may change ownership across companies or even industries. In both cases, a single disturbance feature may be represented by several different permits and those permits could be managed by entirely agencies and each permit could be managed by multiple agencies or offices.

Lastly, the creation of many footprint features associated with land uses in BC pre-date the creation of the current managing legislation and ministries for those land uses. For example, the earliest oil wells were drilled in northeast BC in the mid- 1940s, nearly 30 years before the 1970 BC Land Act established the contemporary notion of formally issuing dispositions and tenures to support industrial land uses. Similarly, many current disposition types have been managed and tracked by various agencies and management regimes over time as the management structure of the BC provincial government has evolved. Thus, many dispositions were never formally tracked or tracked by a variety of different databases, and their inclusion in current freely available, government databases remains a work in progress. In many instances private companies have stepped-in to track features available as licensed, for-profit data layers.

In sum, surface dispositions are splintered across multiple datasets managed by multiple agencies. At times, individual surface disturbance features are represented by duplicate and sometimes conflicting disposition records because they are tracked by multiple agencies and or require multiple permit issuances. Finally, many features are simply unaccounted for in formal, government databases that are freely available.

Mapping active surface dispositions

Our goal for mapping active surface dispositions was not to create a definitive, cleaned layer of the surface dispositions of interest representing the current owner or chronology of ownership and status. Rather, out goal was to cross reference information across pertinent spatial representations of disposition information to create as complete a layer as possible that accurately represents existing disposition types that would preclude permitting of restoration. Our focus was to identify active dispositions for linear features related to oil and gas exploration and production (roads and pipelines) and access to forestry operations (roads), linear features related to public infrastructure (highways and public roads, rail lines, transmission lines, and other public utilities), and polygons representing private land ownership have been issued and are currently active.

It is almost certain that some of the individual dispositions identified are not appropriately attributed, may not yet exist, or are about to expire and be removed. Further, some of these dispositions were never actually created (e.g., permitted, but not executed) or have naturally recovered on their own.

Layers and workflow

We downloaded a series of spatial data layers from the BC Data Catalogue and licenced layers from Geomatics Data Management Inc. (https://gdm-inc.com/) and then cleaned and edited those layers to compile individual layers for roads, pipelines, and miscellaneous linear features, and for private land.

We began with the data layer for Crown Tenures and selected for all features listed as electric power line, oil and gas pipeline, railway, roadway, sewer/effluent line, telecommunications line, or water line, and with the permit type of a Licence of Occupation (Section 39 of the Land Act), Lease (Section 22), or Right-of-Way (Section 40). Each of those permit types confer rights to the permit owner of exclusivity of use and ability to be kept in an open state for a long-term duration. In the case of ROWs, permits may be granted for “as long as required”. Each of those permit types are also linked chronologically wherein a given feature begins as a Licence of Occupation and as more permanent development is required can continue along a regulatory trajectory to a ROW. Selection of these permit types also allowed us to ignore the variety of other permits that are intended as more transitory and or do not provide for exclusivity of use by a single user or user group.

We further filtered selected features from the Crown Tenures layer into individual layers for roads, pipelines, and miscellaneous linear features.

To complete the road layer, we then added features from the BC Oil and Gas Commission (OGC) Road Segment Permits, Road ROW Permitted, and Petroleum Development Roads Pre 2006 layers and from the Forest Tenures (FTEN and FTS) Roads Section Lines, Roads Segment Lines, and Forest Road Segment Tenures. We included all features listed as active or permitted and excluded all features listed as retired or expired. Collectively, those features added in any remaining "resource roads". We then added all listed features from the BC Digital Road Atlas; the Surveyed Railways, Highways, and Roads (selecting only highways and roads for the roads layer and railways for the miscellaneous layer); the Tantalis Temporary Transport, and the PMBC Parcels (for features listed as a road). All features listed in those layers were considered active dispositions. We removed any duplicate feature or portion of a feature. Finally, we infilled any missing roads and road segments using the licensed GDM Resource Roads layer.

To complete the pipeline layer, we added features from OGC Pipeline Segments Permits, and Pipeline ROWs Permits that were listed as permitted or active. We also added all features listed as active, deactivated (no fluid flow for 18 consecutive months, but still active), or cap-and-cut abandoned from the licenced GDM Pipeline layer. From the perspective of permitting restoration, accounting for pipelines is unique for two reasons. First, the physical disturbance feature on a landscape requiring restoration is a right-of-way, but within that infrastructure may be several individual pipelines carrying different fluids, sometimes for different companies. To receive a permit to restoration that pipeline right-of-way, all individual pipelines would need to be abandoned and removed. Second, pipelines can be abandoned in Canada either by their removal from the ground, or by cutting and capping the pipe, but leaving the physical pipeline in the ground. Where pipeline is left in the ground liability is retained by the last disposition owner, so restoration may or may not be permissible. Across our study area, no single right-of-way containing multiple pipelines was open to restoration because at least one pipeline in the ROW was in active use. All abandoned pipelines in the study area were cap and capped and left in place, but < 5% of the total ROW distance of pipeline was abandoned.

The remaining linear features were clustered together in a miscellaneous layer. Private land was identified from the PCMB Parcels layer and cross-referenced in ParcelMap BC (https://ltsa.ca/products-services/parcelmap-bc/).

In all cases we removed duplicate features within a single layer type but retained multiple features within a single spatial footprint extent (e.g., multiple different pipelines with a ROW or a road and a pipeline with a shared or adjacent ROW). Our goal was not to create "the right" layer that provides all pertinent ownership information, but to provide a single, duplicate-free layer that accurately represents all linear infrastructure types.

Including a 500 m buffer applied to linear features, active dispositions cover between 16.16% and 49% of the surface area within delineated caribou ranges (Figure 8, Table 4). That is a significant amount of caribou range that is "off limits" to restoration.

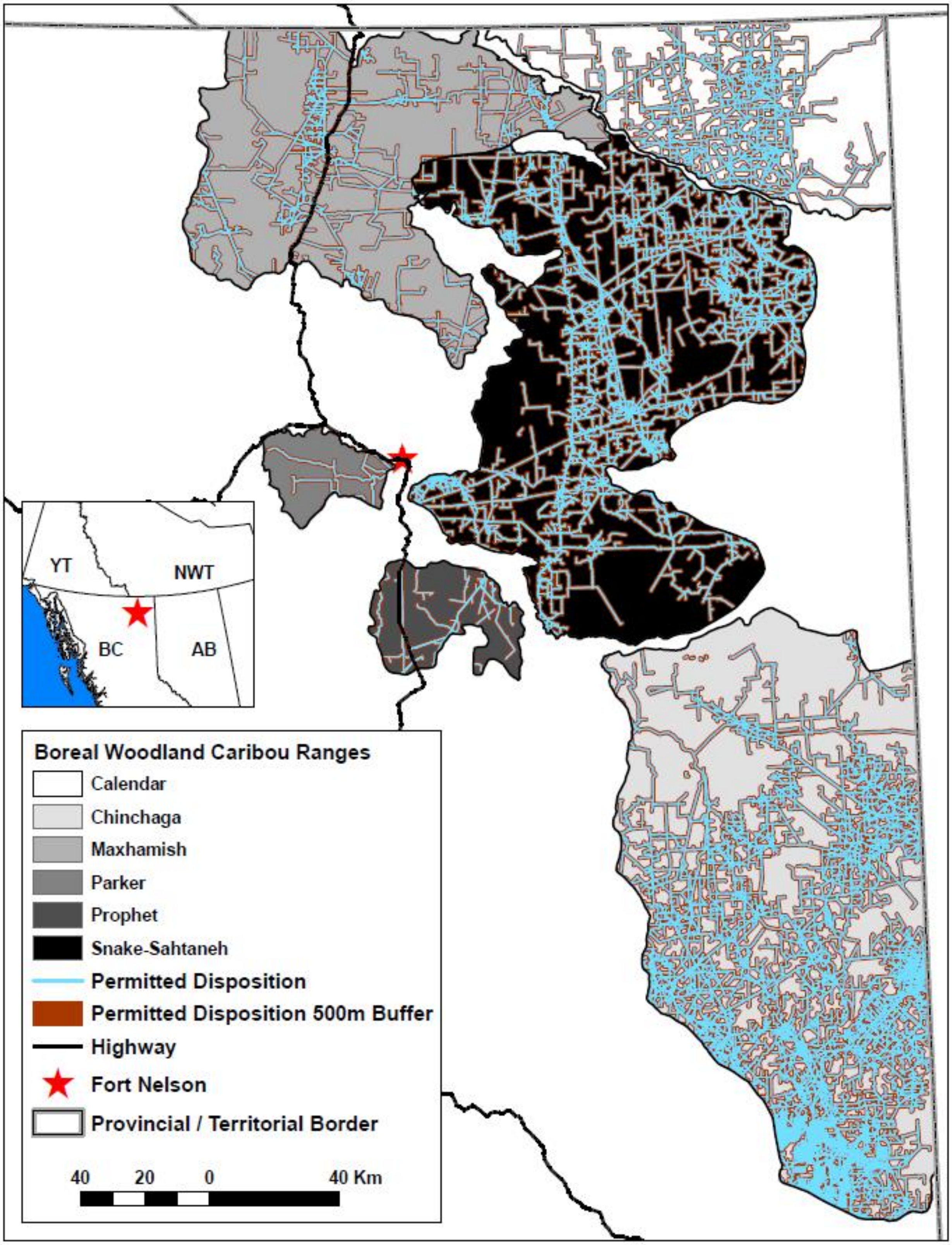


Figure 8. Active surface dispositions for resource roads, pipelines, and linear infrastructure, and private land holdings within the six delineated boreal woodland caribou ranges in NE British Columbia.

Table 4. The total area covered by active surface dispositions, differentiated by feature type, including resource roads, pipelines, and linear infrastructure, and private land holdings within the six delineated boreal woodland caribou ranges in NE British Columbia.

Boreal Caribou Ranges	Range Area (km^2)	Roads	Pipelines	Other Linear Features [a]	Private Land [b] (km^2)	Total Area with Surface Disposition (buffered by 500 m) [c]	Per cent of BWC Range covered by Surface Disposition
		Linear kilometers					
Calendar	4,972.93	2,171.14	1,023.29	0.00	0.00	1,797.47	36.15
Chinchaga	13,897.50	8,884.65	5,509.18	228.29	255.80	6937.47 [d]	49.92
Maxhamish	7,095.53	2,035.42	683.80	5.81	0.00	1,766.41	24.89
Parker	751.62	121.56	8.58	0.00	0.90	124.81 [e]	16.61
Prophet	1,193.03	316.44	110.58	0.91	0.00	303.68	25.45
Snake-Sahtaneh	11,999.76	5,596.37	3,806.13	202.91	6.63	4851.25 [f]	40.43

[a] Includes transmission lines, utilities, etc.

[b] Includes private landholdings and municipal lands earmarked for future development.

[c] Includes those portions of buffered extents from features that occur outside of delineated ranges.

[d] Addition of PMBC adds only additional 48.41 km^2; the rest is from linear features alone.

[e] Addition of PMBC adds only additional 3.59 km^2; the rest is from linear features alone.

[f] Addition of PMBC adds only additional 1.48 km^2; the rest is from linear features alone.

What is the ramification of active subsurface tenures and surface dispositions on restoration potential in delineated boreal woodland caribou ranges in BC?

The biggest issue associated with extensive coverage of active tenures and dispositions in caribou range is that "restorable" habitat is left quite fragmented. Although restoration is delivered at a small spatial scale – at and along a specific linear feature – the overarching goal for restoration is to restore habitat function by restoring large chunks of undisturbed habitat for caribou. Extensive ownership of subsurface tenures and an expansive network of surface dispositions in each of the six delineated boreal caribou ranges in BC means that even restoration of all current seismic lines translates to a high rate of "baked-in" habitat disturbance and highly fragmented habitat for caribou. Considering both currently active tenures and dispositions, between 80.19% and 39.83% of caribou range is "left" for restoration potential (Figure 9, Table 5).

Table 5. The total area covered by active subsurface tenures and surface dispositions, combined, and the relative amount of land "left" and available for active habitat restoration within the six delineated boreal woodland caribou ranges in NE British Columbia.

Boreal Caribou Ranges	Range Area (km^2)	Area under Tenure & Disposition (Combined; km^2)	Per cent of Range under Tenure & Disposition	Per cent of Range "left" available for restoration
Calendar	4,972.93	2,411.81	48.50	51.50
Chinchaga	13,897.50	8,361.95	60.17	39.83
Maxhamish	7,095.53	3,838.75	54.10	45.90
Parker	751.62	148.91	19.81	80.19
Prophet	1,193.03	308.79	25.88	74.12
Snake-Sahtaneh	11,999.76	6,653.85	55.45	44.55

What options are available to streamline restoration planning and improve efficacy in highly permitted landscapes?

Provincial and federal conservation goals for caribou strongly support habitat restoration as a primary strategy to support caribou populations. In highly permitted landscapes creative solutions are required to meet these strategic goals. As part of this project, we explored two complementary opportunities to permit restoration in otherwise "off-limits" areas.

Restoring seismic lines within active PNG Tenures

Petroleum and Natural Gas Tenures do not provide tenure holders with rights or guaranteed access to a land base atop an awarded tenure. Rather, tenures confer exclusive rights to apply under the Oil and Gas Activities Act to explore the subsurface geology within the tenure footprint. A tenure does not provide rights to the land surface, nor does it prohibit other surface activities from other proponents within a tenured footprint.

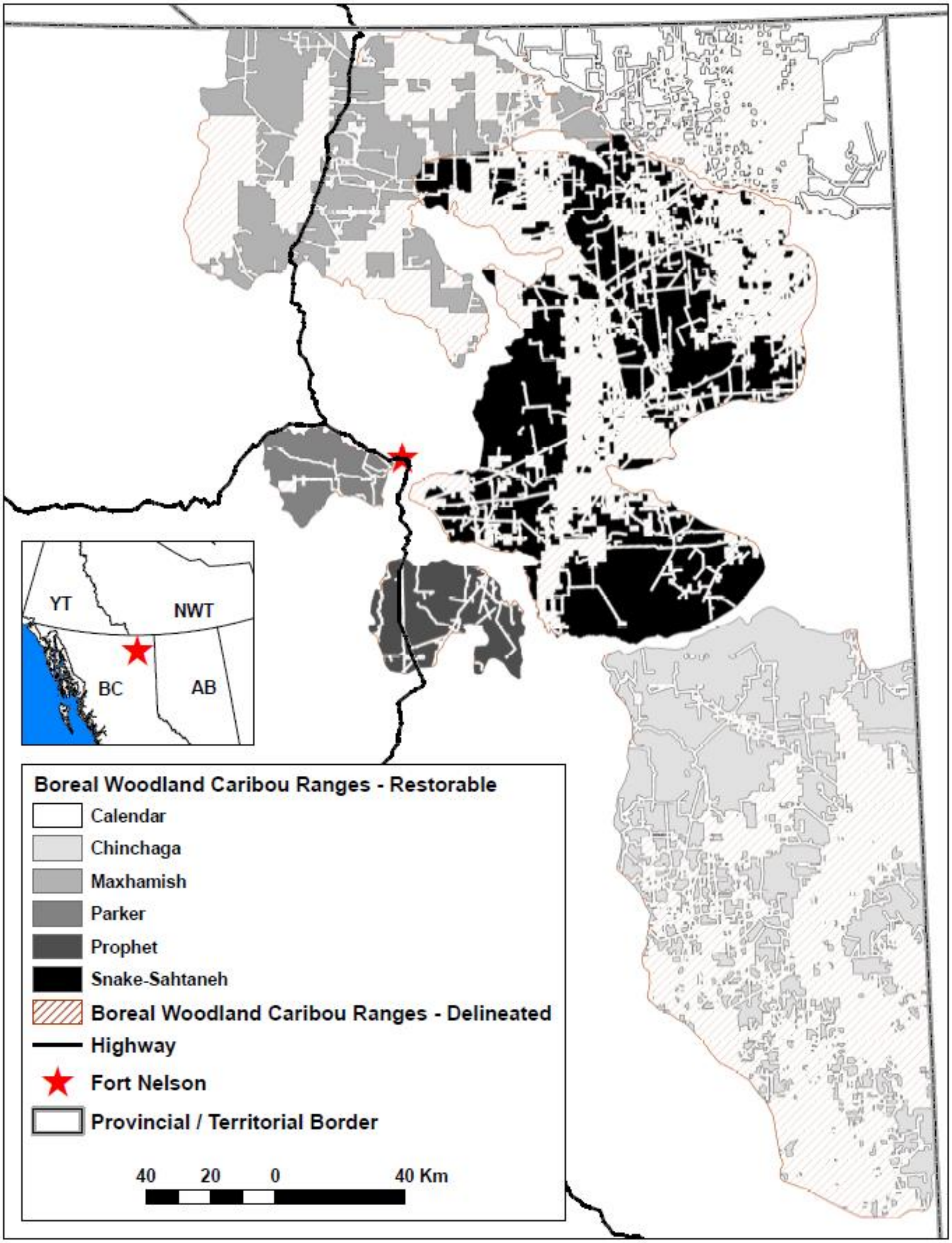


Figure 9. Distribution of the total amount of land "left over" and available for active habitat restoration after accounting for active subsurface PNG Tenures and active surface dispositions for resource roads, pipelines, and municipal linear features within the six delineated boreal woodland caribou ranges in NE British Columbia.

After numerous discussions with staff from the Ministry of Energy, Mines, and Low Carbon Innovation and the Ministry of Forests, Lands, Natural Resources Operations and Rural Development we developed a plan to approach individual companies in a collaborative way identify seismic line restoration targets within active tenures, but away from likely future development plans. With written approval and consent directly obtained from active tenure holders, FLNRO was willing to permit restoration activities during winter operations in 2022. Part of that approach included reaching out directly to tenure holders and proponents with clear, written restoration requests for approval (Figure 10). Because individual tenures can be owned by multiple companies, requests must be made of all tenure holders.

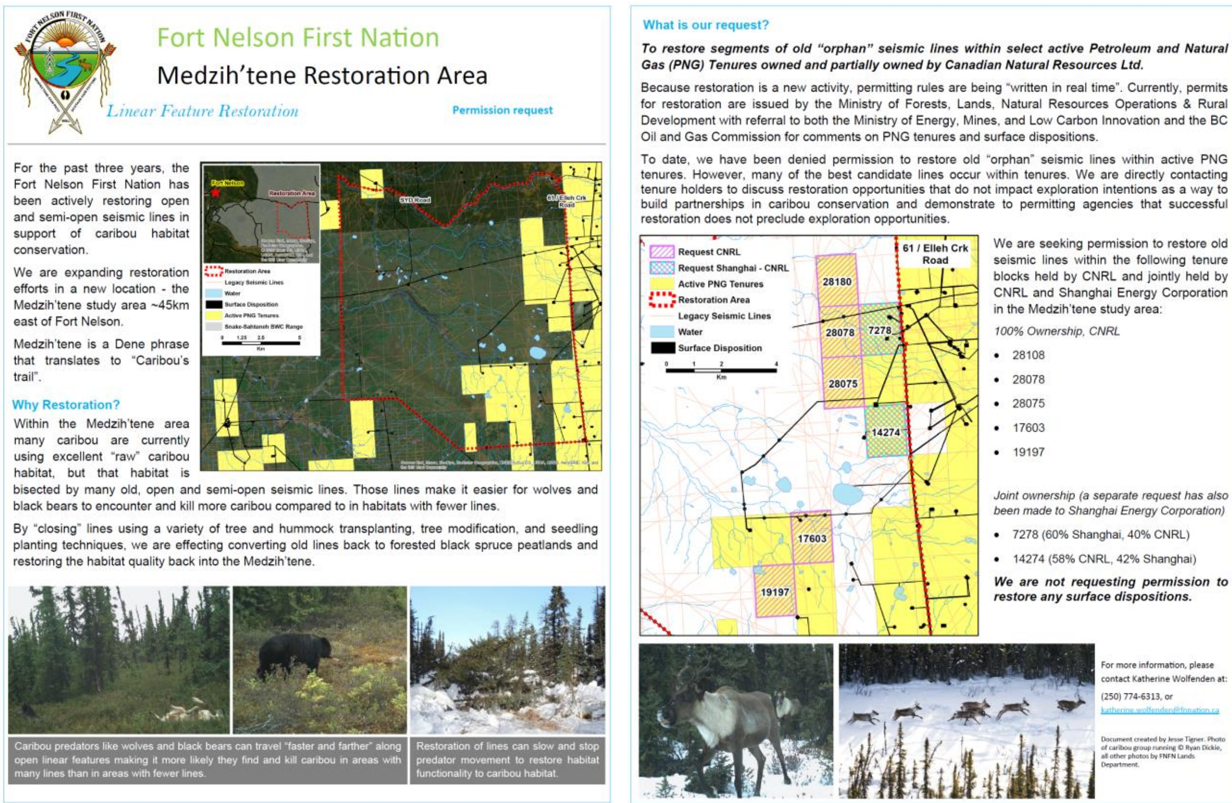


Figure 10. Request made to a PNG Tenure holder in the Snake-Sahtaneh boreal caribou range to restore individual seismic lines with an active tenure footprint.

This approach to work around operations and long-term development plans to "find restoration opportunities" is workable, but imperfect. A more permanent solution that targets accountability of meeting work requirements attached to awarded tenures and expeditiously expiring unused and under used tenures could likely better open opportunities for strategic and long-term restoration planning at broad landscape scales important for functional caribou habitat restoration.

Navigating surface dispositions to identify restoration targets

Navigating and classifying surface dispositions is a persistent and long-standing challenge in BC. Because permits and related spatial data are poorly tracked and managed, as described above, clearly and definitively understanding "disposition basics" like current ownership and status is extremely difficult. Clearly a common ledger of all features is required, but development of that kind of database is likely a massive undertaking that will require buy-in at Executive Director and ADM levels of Provincial Ministries and Agencies.

As part of this project, we met with the BC Oil and Gas Commission to share knowledge about the current state of disposition data and identify opportunities to proactively address issues. We focused our discussion around an example area of several wells and associated linear infrastructure under the purview of the OGC permitting processes. Our goals were to identify incumbent data issues and look for ways to "take dispositions off the books" to convert them to restoration candidates (See Appendix A). Though not all identified active surface dispositions for this project are under the OGC purview, most are.

Significant challenges persist to remedy disposition issues, however, positive progress was made to build a test case for working with specific disposition owners to restore specific unused features. Discussions are ongoing.

Part B – Test drone-based reconnaissance of current recovery status of linear features.

To assess the current recovery status of linear features in the Medzih'tene study area, we flew a number of lines to develop a workflow to assess whether a given line requires active restoration or not, and if needed, whether the line can be accessed to deliver treatment.

Our goal in this process is to identify a workable solution to scouting that can be at least as efficient as helicopter scouting, and can provide a more lasting and useful dataset. While helicopter time is expensive, a helicopter trip can yield excellent information about how much and what kinds of recovery exists along a line, and whether a line is logistically appropriate for treatment (e.g., is it too wet, etc.). However, those data are "fleeting" as they cannot be revisited beyond reviewing notes and memories of those who participated in scouting events. If feasible – and comparable on a cost and efficiency basis – the use of drones to scout lines could unlock more permanent and useful datasets including imagery and the associated post-processing products such as point clouds. These types of products could facilitate quantitative assessments of current line status, and could be used to objectively assess restoration success in the future.

Background

Drone imagery captures forest attributes in two main ways: through the imagery, and through point clouds. Imagery can be used to better understand traits regarding the forest that one might see visually, such as the delineation of where the forest is, the forest type and what tree species are present. Overlapping imagery from a drone can be used to build an orthomosaic, or a mosaiced image of the complete area based on the individual images. Point clouds are derived from the overlapping images using digital aerial photogrammetry (DAP). Both orthomosaics and DAP have been used to examine regenerating forests, and have successfully been used to delineate forest types and to determine regenerating tree heights. Specifically relating to our project, Chen et al. (2017) examined the regeneration on seismic lines in Alberta through the use of DAP drones.

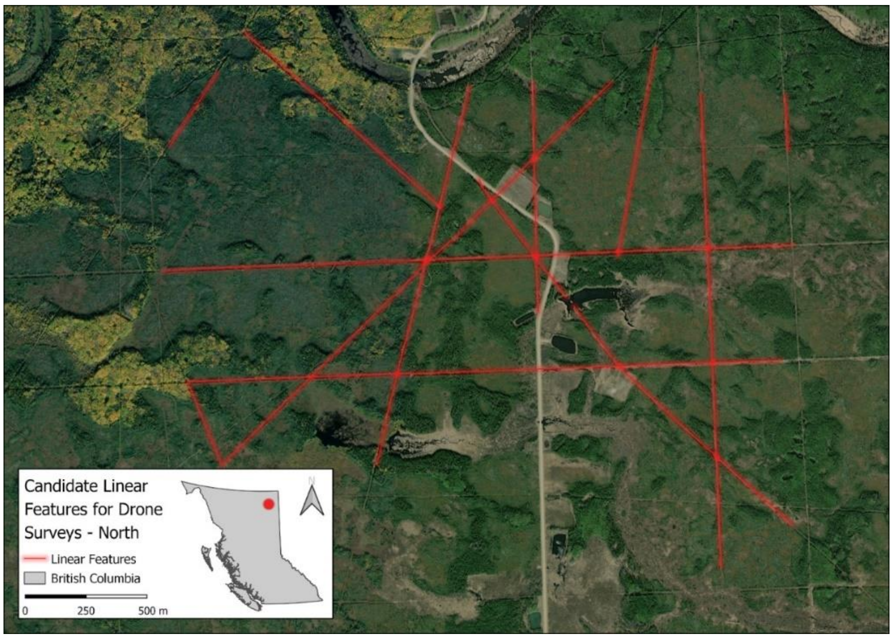
Despite the successful past studies demonstrating the utility of drones for assessing regenerating forests, drones have not been employed operationally to examine regeneration on seismic lines. As a result, there is no information available regarding the ideal drone flight and image capture parameters for our purpose.

Our Project

The goal of our project is to identify if scouting linear features through drone based imagery is at least as effective and cost efficient as helicopter scouting. In order to test this, we planned and conducted a series of drone flights to capture aerial photos of various seismic lines in the study area. Our goals here included testing various combinations of flight elevation, speed, and flight path overlap to evaluate the relationships between processed imagery products and raw data collection speed in the field. Collecting imagery at higher elevations, at a greater flight speed, and / or with less overlap, results in a much greater ground sampling distance and therefore a less detailed orthomosaics and point clouds. Specifically, we are trying to estimate how quickly we can collect a useful dataset. Additionally, as we are interested in comparing the utility of drone based information collection to our current method of assessing seismic lines, we were also interested in the costs associated with collecting this dataset.

Selection of Potential Lines

We first identified areas of interest in the previously identified Medzih'tene Restoration Area. We selected two main areas with a high density of seismic lines within 1 kilometre of the road (Figure 11). We selected these areas as they are likely treatable based on our previous work.



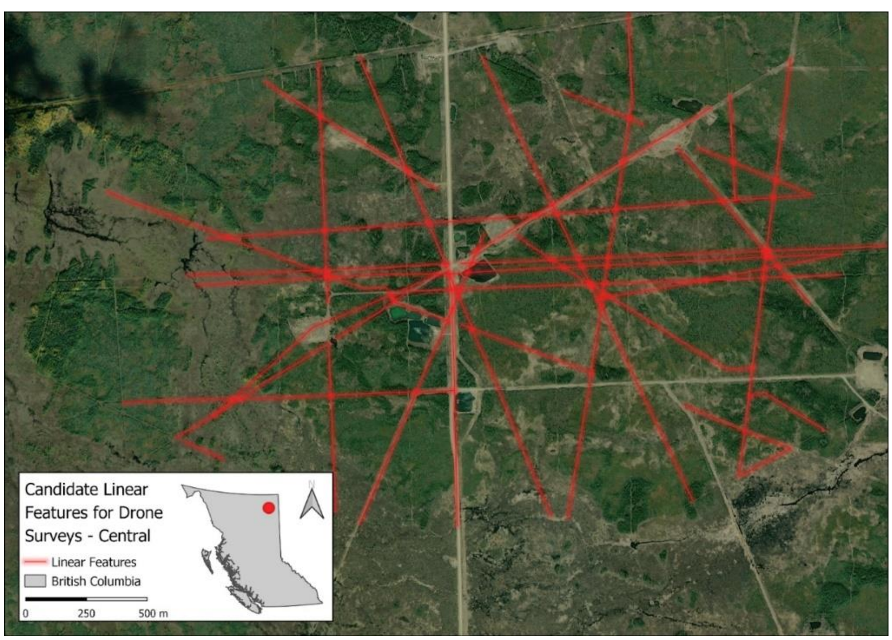


Figure 11. Candidate linear features for drone surveys in Medzih'tene. Red lines indicate portions of the seismic lines that fall within ~1 kilometre of the road.

Flight Planning

We examined the utility of four different flight planning applications for our purposes: Pix4D Capture, UgCS, DroneDeploy, and ArduPilot. The apps range in utility and capabilities. We selected the Pix4D app; it had a relatively straightforward interface while still providing the functionality we needed. The app allows you to cache maps in the device memory, so flight plans can be set up in the office and stored for flights out of cell / data range in the field. The only downside to this app, is that the app does not allow uploading of imagery, maps, or shapes so all planning has to occur within the app itself using the app's spatial data.

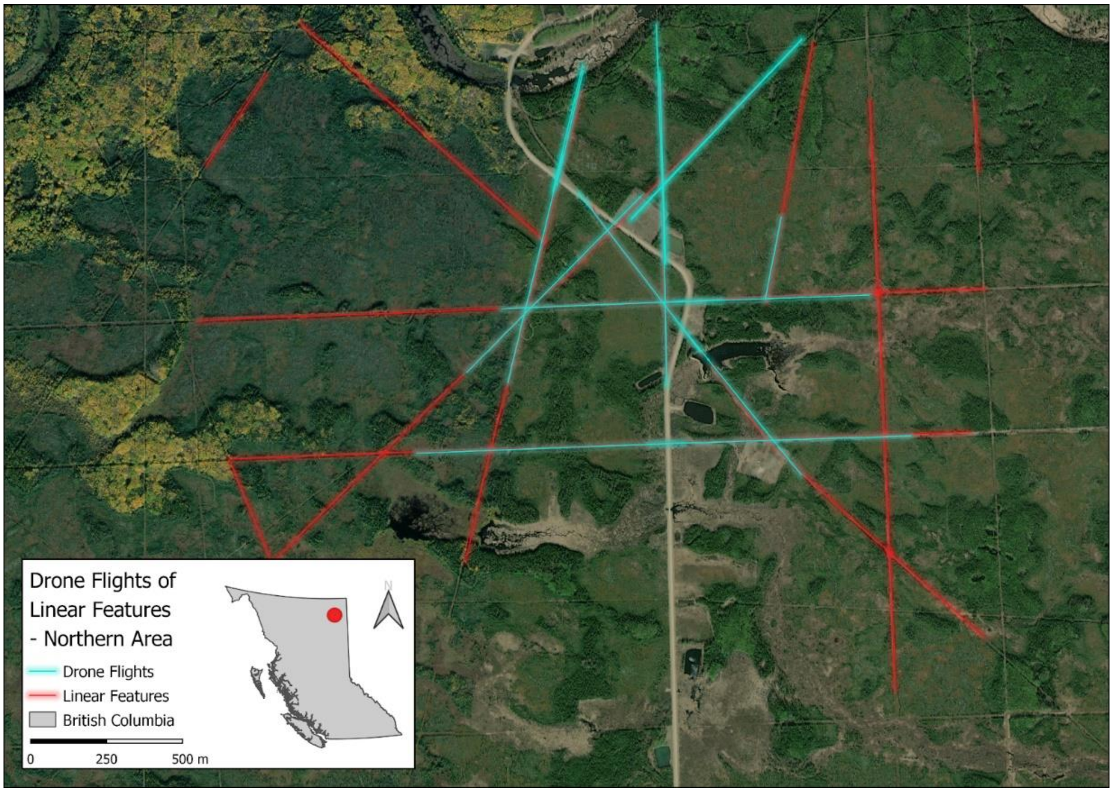
Day one of field work was spent trialling the different parameters for flight planning within Pix4DCapture and collecting trial imagery. After examining the imagery, we decided that a max flight height of 120 m above ground level (AGL) was appropriate for capturing the details of seismic lines in the imagery while maximising the visible area. (Flight above this height in Canada required permission from Transport Canada, and although we put in an application, we did not receive permission to fly higher in time for the drone work).

Drone Flights

We flew 26 flights over a number of seismic lines – and other linear features – in two locations within the study area (Figure 12 and 13). All flights were flown with a DJI Mavic 2 Pro drone on September 14, 16 and 17 in 2021. We selected this time of year as the deciduous tree leaves had changed colour, making them more obvious in the imagery. Of the 26 flights, three flights were repeated due to an error on our part, and one flight was repeated as a trial of different flight parameters. 25 flights were flown at 120 m AGL with a 90% along-track overlap and a 90% across-track overlap. The repeated flight with different parameters was flown at 60 m AGL with a 90% along-track overlap and a 80% across-track overlap. We originally intended to fly a greater subset of flights with different parameters in order to compare the resulting products. Flight times and the downtime in between flights (due to drone battery limitations and wind speeds) limited our capacity to fly more flights with different parameters. Instead, we opted to collect imagery with a high amount of overlap, with the intention of down-sampling / reducing the data set artificially in order to test different parameters. The majority of the flight paths covered rectangular areas within 500 m of the road, as differently shaped polygonal flight paths took much longer to fly. Flight paths fell within approximately 500 m from the road as drone regulations in Canada require that the drone is within sight at all times. Flight times ranged from 5 min to 45 min and covered areas between 6,555 m^2 and 114,257 m^2.

In total, 25,476 m of linear features were captured by the drone imagery, and drone flights covered approximately 850,000 m^2.

Figure 12. Launching the drone from the road.



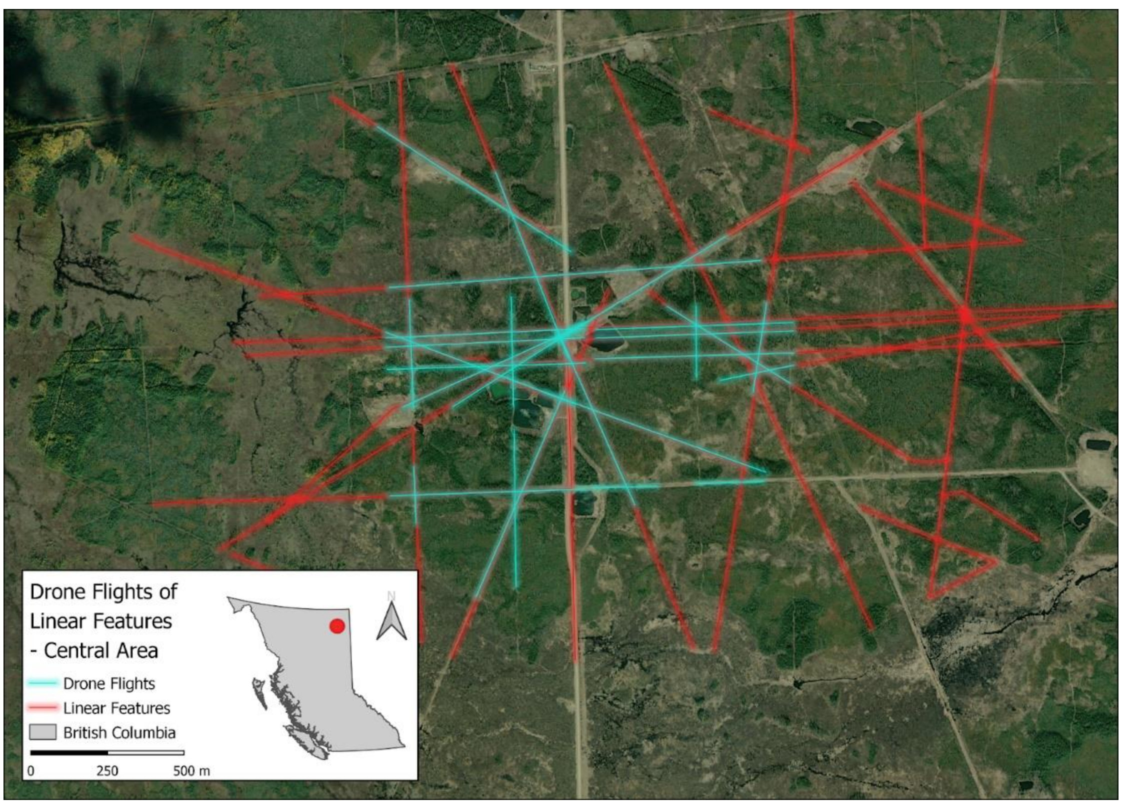


Figure 13. Drone surveys flight lines in Medzih'tene. Blue lines indicate the linear features flown by a drone. Red lines indicate portions of the seismic lines that fall within ~1 kilometre of the road.

Ground Control Points

Prior to collecting the drone imagery, we established two to three ground control points per flight plan. Ground control points (GCP) were marked with two large spray painted Xs (Figure 14), and GPS points were taken. The intention of collecting these was to enable us to improve post-processing accuracy by tying the imagery to the xyz coordinates. Specifically, GCP will improve the quality of DAP point cloud data.

Figure 14. Spray painting a ground control point.

Ultimately, we did not end up using the GCPs in image processing due to time constraints, and the reality that establishing GCPs is not operationally feasible. Placing GCPs takes a long time as a field crew must walk out to place each of them. In order for drone imagery to be operational useful, data collection must be efficient.

Image Processing

We processed the data using photogrammetry to convert the individual images from each drone flight into single, seamless air photos (an orthomosaic) and point clouds. To process the imagery, we used the image processing software Pix4D. Image processing took a long time; the total image processing time was 154 hours, 6 minutes and 38 seconds. The average processing time for the imagery from one drone flight was 5 hours, 55 minutes and 38 seconds. Processing time varied dramatically with the number of images captured per flight. For example, flight 14-3 with 68 photos took approximately 1 hour, while flight 16-11 with 700 photos took approximately 24 hours to process.

Next, we downsampled the data by removing all the imagery from the repeated passes within a drone flight. This artificially reduced the amount of overlap between photos down to 90% along-track and 0% across-track. The reduction in the number of images used for the processing of the imagery into orthomosaics and point clouds dramatically reduced the processing time. However, this method of downsampling was not ideal as the software failed to process a few of the flights due to a lack of data. It is unclear if the flights would have processed properly if we had originally collected the data with 90% along-track and 0% across-track overlap. Considering that in most cases, orthomosaics and point-clouds were properly generated with this overlap, it would be possible to collect data with only one pass of a linear feature.

Orthomosaics

To assess the orthomosaics for details on the treatability of the linear features surveyed by the drone, we marked the orthomosaics with notes. The person in our group most experienced with assessing the landscape for treatability by helicopter, looked at pdfs of the orthomosaics and marked down comments on the feasibility of treatment. She noted f eatures that would make treating the linear features impossible (e.g., water or wet areas, bushy areas or natural regeneration) or features that indicate the area is good for treatment.

Helicopter Scouting

To assess the treatability conclusions from the orthomosaics, we scouted the same lines by helicopter. The helicopter scouting involved flying along the lines and marking with GPS waypoints features on the landscape that relate to treatability (e.g., wet, bushy, treat, leave, ...). The helicopter scouting took place on November 2, 2021. The helicopter flight paths can be seen in figure 15, as can the location of the notes collected. This is the standard approach that we currently use to assess an area for treatability.

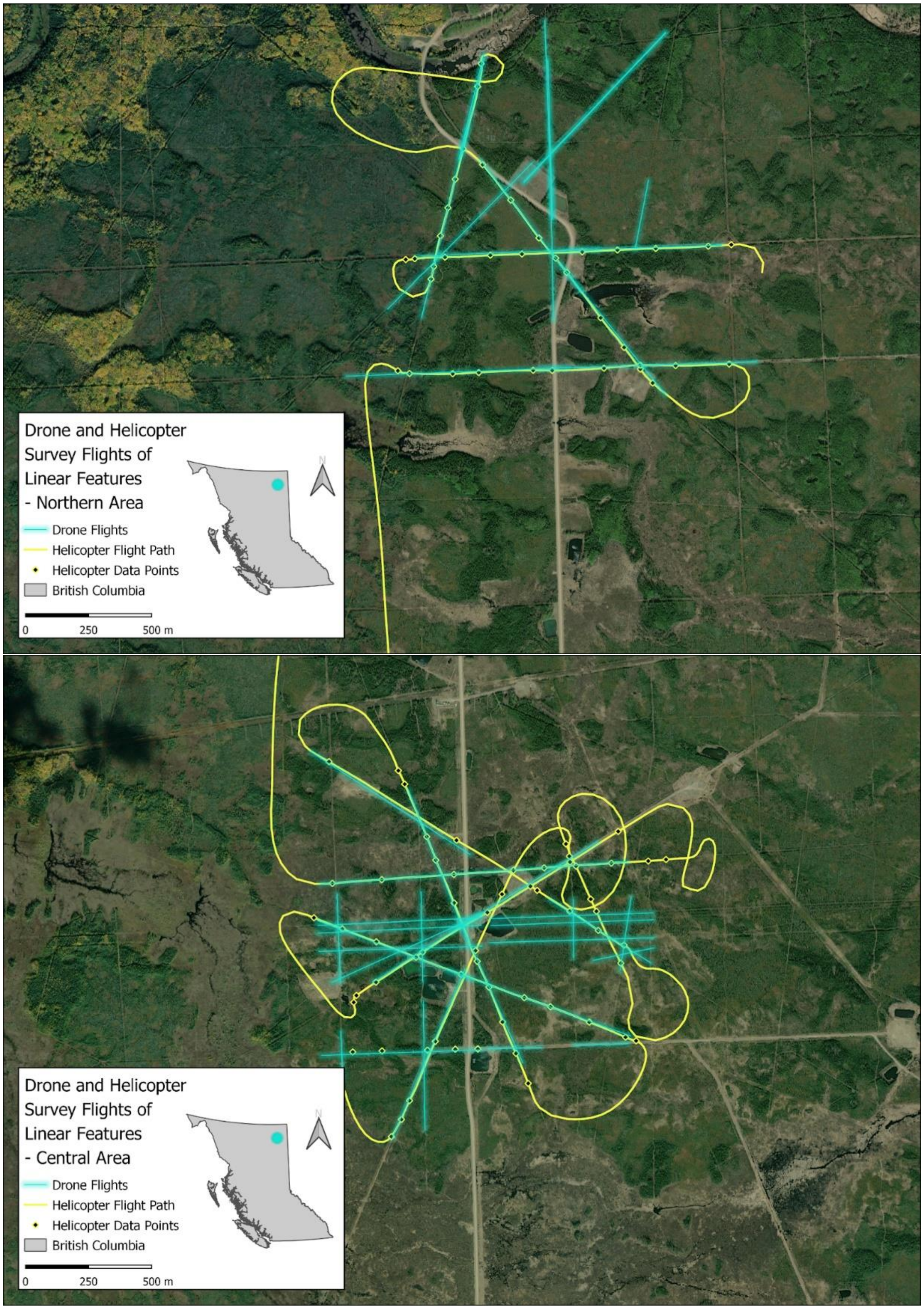


Figure 15. Helicopter and drone surveys flight lines in Medzih'tene. Blue lines indicate the linear features flown by a drone, the yellow line indicates the helicopter flight path.

Comparing Drone Based Surveys with Helicopter Surveys

The drone based survey (orthomosaics) and the helicopter survey data were compared by examining and summarising the notes. Conclusions regarding the treatment of the linear features were drawn, then these conclusions were compared to determine if there was agreement. See table B-1 for a summary of the comments and the conclusion drawn from each survey method, and for whether there was general agreement between the two survey methods. In general, the notes recorded on the orthomosaics were much more detailed than those of the helicopter flight.

Overall, there was strong agreement between the two methods of survey. The exceptions to this were primarily due to the amount of water on the linear feature: the amount of water features or wet areas marked on the helicopter flights was higher than those marked in the drone based surveys. The reason for this may be due to the difference in timing between when the drone imagery was collected (September 2021) and when the helicopter survey was conducted (November 2021). It is possible that when the helicopter survey was flown there was more water on the landscape. However, it is also possible that this difference is a result of viewing the landscape while moving (as is the case with the helicopter survey) compared to viewing a stationary image (the orthomosaics), visible water may be more easily identified while in motion because of the "shimmer" from reflected sunlight.

Comparing Orthomosaics with Different Overlap

We compared the notes from the orthomosaics of the simulated 90% along-track and 0% across-track overlap flights with those from the 90% along-track and 90% across-track overlap flights (Table B-2). Although the orthomosaics were significantly more noisy and difficult to interpret for the flights with 0% across-track overlap – they were often blurry and distorted – the conclusions regarding the treatment of the lines was 100% consistent with the orthomosaics from the 90% across-track overlap flights.

Conclusions

Drone based imagery continues to hold potential for the assessment of linear features for treatability, however there are significant operational limitations at this time. The data and conclusions drawn from the drone imagery is comparable to the information gained from helicopter survey flights, and does provide a concrete data source that can be revisited if needed. Ideally, we could use the point-cloud data to examine the structural makeup of vegetation on the linear features surveyed, but this was outside of the scope of our project. Potentially a future project could examine the utility of the point-clouds we generated through this project and determine if additional useful information can be gleaned.

Currently, the operational limitations of drone based surveys should not be ignored and are currently substantial enough to limit the utility of drones for FNFN in our current restoration workflow. It took significantly longer to collect the imagery and process it than it did to scout the lines by helicopter, and it was more expensive when you factor in drone equipment and licensing, and processing time. If drones are to be used in the future by FNFN, we would need to either invest in more drone equipment (such as more batteries and / or a higher capacity drone) and obtain permission to fly the drone out visual range, or we would need to hire a company specialising in drone operations. The processing of the imagery also required substantial computer processing power and would likely be more efficient with better computers.

Overall, the current survey method that FNFN employs to assess the regeneration status and treatability of linear features is more efficient than drone based surveys. Helicopter surveys enable us to survey a large number of linear features very quickly, enabling us to properly plan for restoration treatments. The key way in which drones can assist with restoration right now, is during treatment. Drones can help with planning and can specifically inform decision making in the moment. Drones can be flown ahead (down a line) to provide more information regarding the line status. This type of scouting assists with on the ground decision making and can be done while in the field scouting from the ground or during restoration treatments.

Table B-1. A comparison of the information gained from the orthomosaics and helicopter scouting flights.

Flight Number	Orthomosaic Comments	Orthomosaic Conclusion	Helicopter Scouting Comments	Helicopter Scouting Conclusion	Agreement?
14-1 / 14-5	~225 m segment worth treating.	Treat if accessible from another line.	Line not flown.	N/A	N/A
14-2 / 14-6	~225 m segment and another ~250 m intersecting segment worth treating.	Treat if accessible from another line.	Line not flown.	N/A	N/A
14-3 / 14-7	Only ~120 m of treatable line, then there is water and natural regeneration.	Treatable section is small (probably not worth it).	Beginning of the line is treatable, then there is water and natural regeneration.	Treatable section is small (probably not worth it).	Yes
14-4	~500 m of treatable line with one short area that is untreatable.	Treatable, with offshoot segments of other lines also treatable.	Segments with big trees interspersed with bushy sections.	Not worth treating.	No
16-1	Lines are treatable (~500 m segment with offshoots adding to ~400 m more) except for where they intersect the 61 road.	Treatable.	Main line is treatable. North intersection with the 61 road is bushy.	Treatable.	Yes
16-2	A few small treatable areas, but mostly grown in.	Not worth treating.	Would not treat the south section. (Line not completely flown.)	N/A	N/A
16-3	Lines are treatable, except for where they intersect the 61 road.	Treat, but the line segment is small.	Treatable sections.	Treat, but the line segment is small.	Yes
16-4	The first ~ 290 m are treatable, then it is too grown in. Other line offshoots near the treatable	Treatable but stop when it gets bushy.	The first ~425 m of the line are treatable, then	Treatable.	Similar but different segment lengths considered

	end are also treatable (~170 m and ~200 m).		it is too grown in.		treatable – might result in a different prescription.
16-5	Lines are treatable (~325 m and ~270 m) with a small patch at the beginning that is untreatable.	Treat.	Bushy and wet at ~325 m from the 61 road.	Not worth treating.	No
16-6	Small segments of treatable line with bushy and wet patches.	Not worth treating.	Would not treat. Bushy and there is a pond.	Not worth treating.	Yes
16-7	Small segment untreatable, including the intersection with the 61 road. ~800 m treatable.	Treat.	A bushy segment, and wet at the road, but treatable.	Treat.	Yes
16-8	Treatable in patches, but looks like an access road and is wet in patches.	Treatable but likely an access road.	Wet and likely an access road.	Not worth treating.	No, more wet areas in the helicopter flight.
16-9	Good to treat if it wasn't an access road.	Not treatable.	Access road, not treatable.	Not treatable.	Yes
16-10	Do not treat.	Not worth treating.	Not treatable – marsh.	Not treatable.	Yes.
16-11	~ 500 m of treatable line (near the road). The other line segments are all untreatable with the exception of an ~180 m segment (also near the road) and ~300 m of treatable line that would need to be accessed from another line.	Treat (only one of the lines).	Bushy and wet. (Not all lines flown.)	Not treatable.	Yes (agreement on the lines assessed by the helicopter – not all flown).
16-12	Line is naturally open; leave the whole thing.	Not worth treating.	Wet and marshy, very open.	Not worth treating.	Yes
16-13	Small treatable segment.	Not worth treating (segment is too small and likely an access road).	Not treatable and too wet.	Not worth treating.	Yes
16-14	All of the line segments are treatable. (~1900 m total of	Treatable.	Lines not all flown. The line	Not worth treating.	No (not all lines flown)

	intersecting lines.) Note that it was difficult to see in this imagery as the tree shadows are so big.		flown is not treatable, wet and bushy.		
17-1	Line is treatable (with the exception of the connection to the 61 road), some acknowledgement that it might be wet.	Treatable.	Primarily bushy and too wet.	Not worth treating.	No, this is due to more wet areas in the helicopter flight.
17-2	Segments of ~160 m, ~120 m, ~200 m treatable but interspersed with upland areas and wet areas.	Not treatable as treatable segments are inaccessible.	Bushy, big timber and wet.	Not treatable.	Yes
17-3	~200 m and ~60 m segments treatable.	Treatable section is small (probably not worth it).	Small segment is treatable, the rest is open and marshy or bushy.	Treatable section is small (probably not worth it).	Yes
17-5	~230 m segment on the main line is treatable (after a little bit of brush at the 61 road). Additional ~370 m of off-shoots are also treatable.	Treatable.	Treat until it gets too marshy.	Treatable.	Yes

Table B-2. Comparison between the conclusions drawn from the 90% along-track 90% across-track orthomosaics and the 90% along-track 0% across-track orthomosaics.

Flight Number	90% Along-track, 90% Across-track Orthomosaic	90% Along-track, 0% Across-track Orthomosaic	Agreement
14-2 / 14-6	Treat if accessible from another line.	Treat if accessible from another line.	Yes
14-3	Treatable section is small (probably not worth it).	Treatable section is small (probably not worth it).	Yes
14-4	Treatable, with offshoot segments of other lines also treatable.	Treatable with a small section that might not be treatable.	Yes
14-5	Treat if accessible from another line.	Treat if accessible from another line.	Yes
16-1	Treatable.	Treatable.	Yes
16-2	Not worth treating.	Treatable areas interspersed with untreatable areas. Not worth treating.	Yes
16-3	Treat, but the line segment is small.	Treatable with offshoot also treatable, but it's a small segment.	Yes
16-4	Treatable but stop when it gets bushy.	Treatable until it gets overgrown.	Yes
16-6	Not worth treating.	Small segment treatable, not worth treating.	Yes
16-7	Treat.	Treatable.	Yes
16-8	Treatable but likely an access road.	Great to treat, but likely an access road.	Yes
16-9	Not treatable.	Not treatable, access.	Yes
16-10	Not worth treating.	Not treatable. Image quite blurry.	Yes
16-11	Treat (only one of the lines).	Treat, image a bit blurry.	Yes
16-12	Not worth treating.	Not worth treating - natural openings.	Yes
16-13	Not worth treating (segment is too small and likely an access road).	Treatable if not access.	Yes
17-1	Treatable.	Treatable.	Yes
17-2	Not treatable as treatable segments are inaccessible.	Only very small treatable segments.	Yes
17-5	Treatable.	Treatable until naturally open.	Yes

Appendix A

Discussions with the OGC about navigating issues and opportunities associated with restoration potential of active surface dispositions.

Email outlining the scope of the encountered problem.

Supporting documentation.