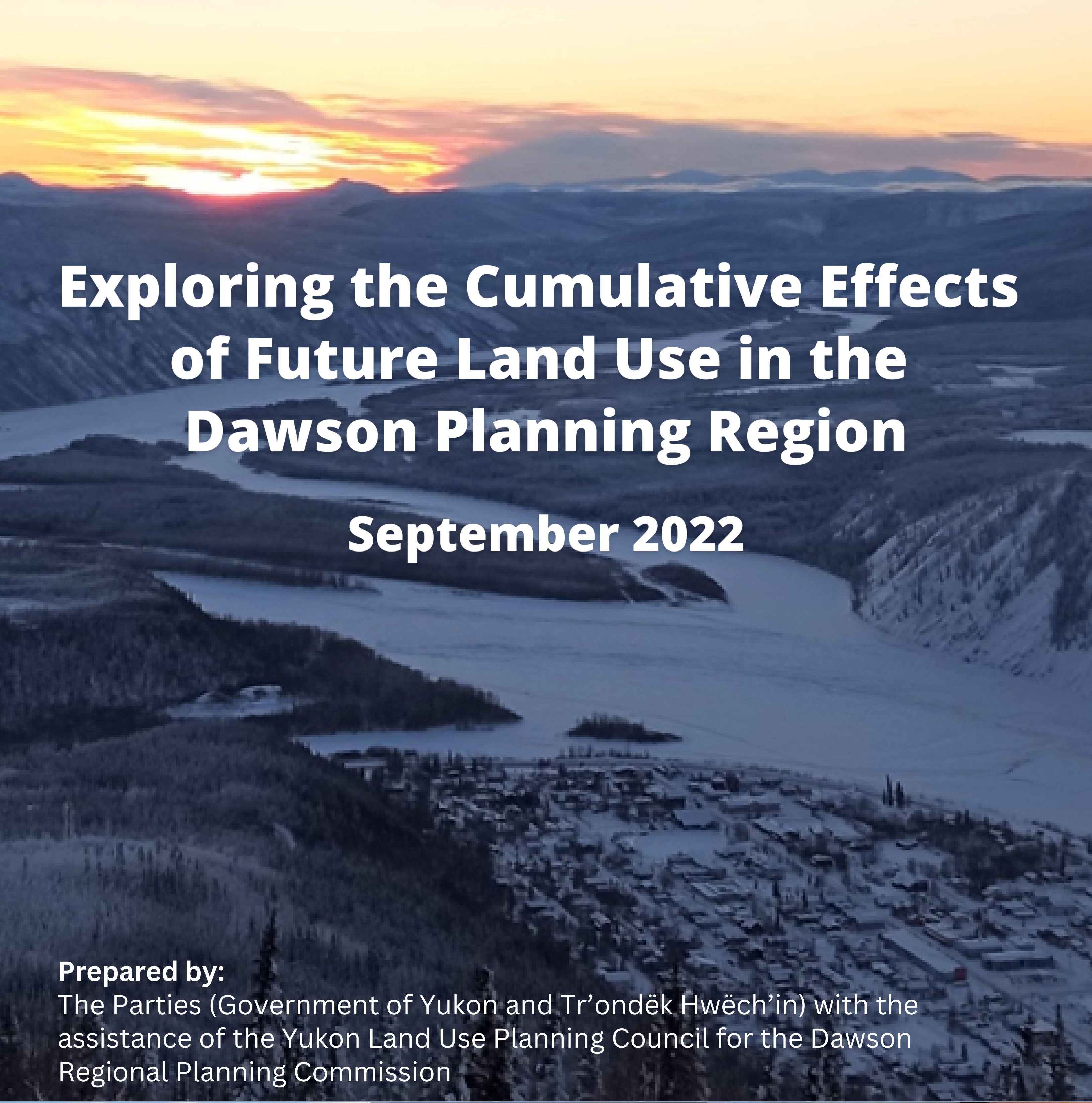

Exploring the Cumulative Effects of Future Land Use in the Dawson Planning Region

September 2022

Prepared by:
The Parties (Government of Yukon and Tr’ondëk Hwëch’in) with the assistance of the Yukon Land Use Planning Council for the Dawson Regional Planning Commission

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This report was produced for the Commission by the Parties (Tr'ondëk Hwëch'in and the Government of Yukon) and with the assistance of Yukon Land Use Planning Council (YLUPC), to support the Dawson Regional Planning Commission, and for endorsement by the Commission as per their Terms of Reference. This report is based on the best available information at the time of production (Spring 2022). Scenarios presented in this report are plausible futures, not predictions, and were used to inform the decision-making process.

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EXECUTIVE SUMMARY

Assessing and managing cumulative effects, the combined effects of past, present, and future human activities and natural changes on the landscape, is crucial to support informed decision-making regarding sustainable development in the Yukon. Land use planning is a key tool for managing cumulative effects. To assist the Dawson Regional Planning Commission with decision-making regarding cumulative effects, we developed a scenario analysis to support the Dawson regional land use planning process. This scenario analysis informs decision-making regarding future land use change in the region by presenting plausible future land use changes in a 20-year time horizon. We used quartz and placer mining as key sectors for land use change and developed high and low scenarios reflecting plausible futures.

We used the spring 2022 update of the Government of Yukon's surface disturbance database to inform the current status of two disturbance indicators: surface disturbance (percent of all human-caused disturbances within a landscape management unit (LMU)) and linear feature density (density of all trails, roads, and linear clearings expressed as km/km^2 within an LMU). We used ALCES, a modelling software designed to assess cumulative effects on the landscape, to spatially simulate land use change associated with placer and quartz sectors under the high and low scenarios in the Dawson regional planning area. We summarized the disturbance indicators in 2040 for both high and low scenarios by LMU.

We linked values to cumulative effects concerns and identified values-based indicators through working sessions for one ecological value, caribou, and one socio-cultural value, harvest, to inform the impacts of disturbance in a cumulative effects lens. We briefly summarized the existing cumulative effects information for each of these indicators but could not directly link the ALCES modelling to values.

We presented the information summarized in this report to the Commission to help inform their decision-making on cumulative effects in the Dawson regional planning process.

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SUPPLIMENTARY MATERIAL

Introduction

The Recommended Plan for the Dawson Region was developed by the Dawson Regional Planning Commission (henceforth the 'Commission') as per S11.4 of the Tr'ondëk Hwëch'in Final Agreement (THFA). The Recommended Plan includes recommendations for how to protect, manage and use the land, water and resources within a given area. It provides guidance for land and resource use decision-making and helps to achieve the kind of future people in the region want to see.

Cumulative effects are changes to the environment and/or society caused by the combined effects of past, present, and future human activities and natural changes on the landscape. Managing cumulative effects is important to ensure socio-economic, cultural and ecological values are maintained through sustainable development, as required under the THFA. The THFA defines sustainable development as "beneficial socio-economic change that does not undermine the ecological and social systems upon which communities and societies are dependent".

Assessing and managing cumulative effects is crucial to support informed decision-making regarding sustainable development in the Yukon. If cumulative effects are unmanaged, the seemingly small and incremental changes to the environment from development and increasing human land uses can compound, leading to decline of important values such as caribou and moose, as well as declines in socio-economic and cultural values including harvesting.

Regional land use planning is one way we can manage cumulative effects in the Yukon. This is achieved by outlining the management intent and values for the land and how they vary by landscape management unit (LMU). Scenario analyses allow us to envision multiple plausible future landscapes under different types of conditions to understand how these possible futures may change landscape condition, values, and inform decision-making.

Values used to inform cumulative effects management through land use planning should link to socio-cultural, socio-economic, and ecological processes. Priority values should be relevant to the Parties and stakeholders and have a demonstrated relationship to regulatory processes (Venier et al. 2021; Duinker et al. 2013). Indicators are a measurable signal to assess and track the condition of ecological, socio-cultural, or socio-economic values in response to landscape change.

To support incorporation of cumulative effects into the Recommended Plan, a cumulative effects working group (CEWG) was formed by the Parties' Senior Liaison Committee. The CEWG was comprised of representatives of both Parties, Tr'ondëk Hwëch'in and Government of Yukon as well as the Dawson planning team. The CEWG used values-based working sessions to identify values-based indicators relevant to regional land use planning and for use by the Commission.

We selected two priority values, one ecological (caribou) and one socio-cultural (harvest), to discuss cumulative effects concerns in the Dawson Planning Region based on their importance within this area. We used mining (quartz and placer) as representative socio-economic sectors to inform land use change through a scenario analysis by linking mining growth scenarios to surface disturbance and linear feature density.

This report provides a high-level qualitative discussion of potential effects from human-caused disturbance to the priority values: caribou and harvest. We did not consider climate change or wildfires; while these factors contribute to cumulative effects, they do not currently link to a regulatory process and are challenging to model at this spatial scale.

Scenario Analysis of Surface Disturbance

By relating the response of an ecological, socio-cultural, or socio-economic indicator to landscape change, we can use scenario analyses to evaluate practical options for land use planning. A scenario analysis is a fundamental component of cumulative effects assessment. Within a scenario analysis, various plausible descriptions of future land uses are used to understand the potential implications of future disturbance on the landscape. We used a specifically designed software program (ALCES, 2017) to carry out the cumulative effects scenario analyses.

We used scenario analysis to forecast high and low growth of the mining sectors (quartz and placer mining and mineral exploration) as these are the main drivers of human activity and landscape change in the Dawson planning area. We constructed development scenarios to assess the impact of high and low growth of these mining sectors based on surface disturbance indicators and 20-year scenarios (2020-2040) using ALCES software. We worked with Jeff Bond (Yukon Geological Survey) to develop the placer scenarios and Warwick Bullen (Yukon Geological Survey) to develop the quartz scenarios based on their knowledge of mineral potential and production of the region.

Tourism, agriculture, forestry, and oil and gas are also active sectors on this landscape. However, the overall footprint from these sectors is small, accounting for less than 0.1% of the surface disturbance within the Dawson planning region, so we omitted them from the scenario analysis. We did not include recovery of disturbances for any sector nor natural disturbances.

SURFACE DISTURBANCE AND LINEAR DENSITY

The Dawson Regional Planning Commission considered two indicators of human-caused disturbance to track changes in land use activity over time: **surface disturbance** and **linear feature density**.

Surface disturbance is the percentage of land physically disturbed by human activities (e.g., structures, clearings, quarries, etc.). It includes visible, human-caused disturbances that result in the physical disruption of land (soil or rock) or hydrology, or the clearing of trees and woody vegetation. It is a measure of human activity (e.g., mining) as well as a loss of habitat.

Surface disturbance does not include natural disturbances (i.e., fire), nor the surface area of linear features. This is different to the North Yukon and Peel Watershed plans which includes the surface area of linear features. Surface disturbance is expressed as percent of each LMU covered by human-caused disturbance.

Linear feature density is defined as the average length of all human-created linear features (roads, seismic lines, access trails, etc.), within an LMU. Linear feature density is expressed as km/km^2 and is an indicator of human activity and access, as well as landscape fragmentation and habitat integrity.

Tracking surface disturbance and linear density is a method of estimating the amount of landscape change. These tracked disturbances can be used to monitor direct, as well as indirect effects on values resulting from human activity and land use. Human-caused disturbance and landscape change may have different effects on different values. These effects can be evaluated based on research, modelling, management objectives, or other considerations.

In 2021/22, the Government of Yukon updated the surface disturbance database for the entire Dawson planning region using SPOT 1.5m imagery collected in 2019 and 2020 (**Figure 1** – page 7) using the Surface Disturbance Mapping Standards Document (Powell et al. 2021). We used this information to summarize current surface disturbance indicators by LMU (**Table 2**).

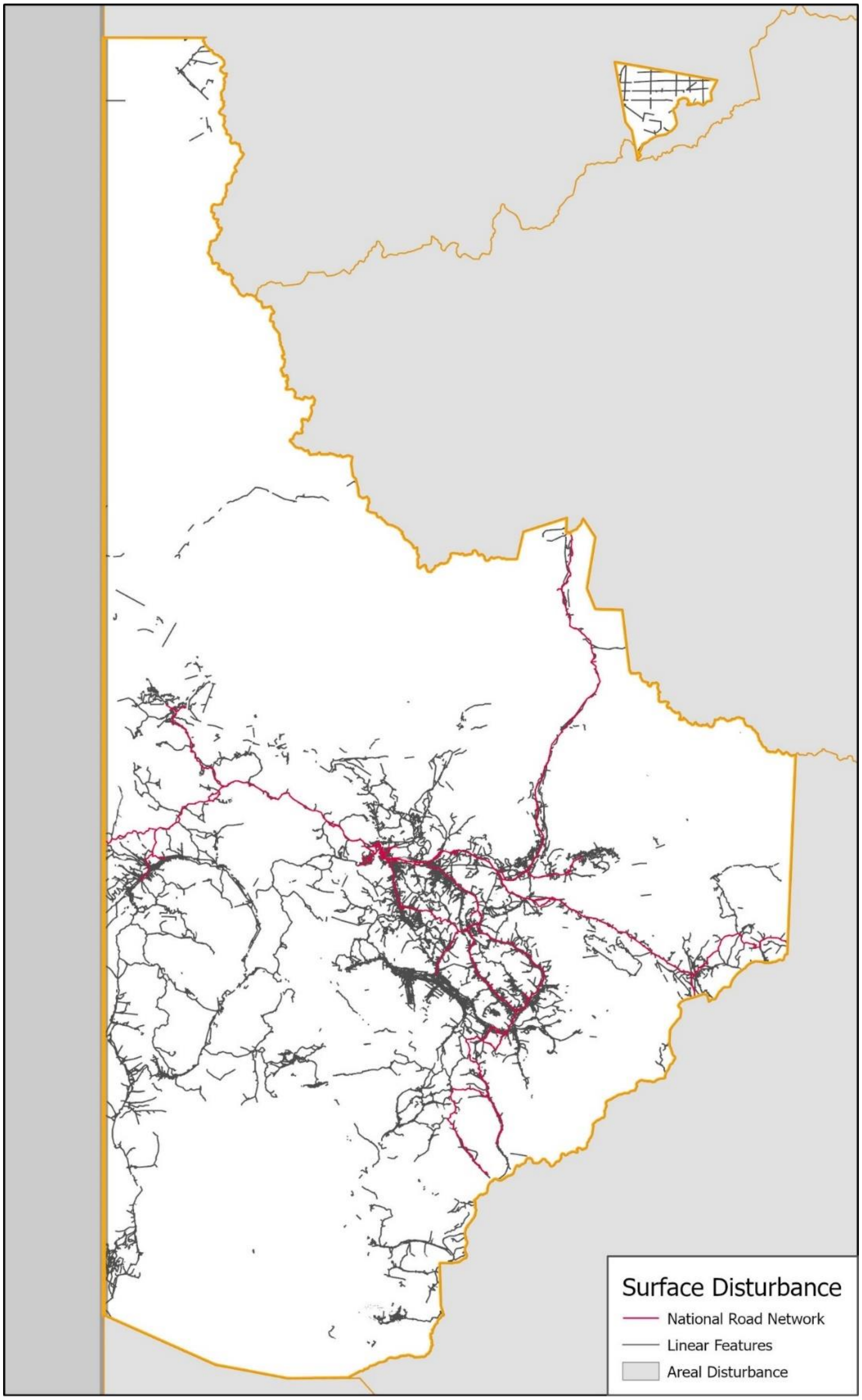

Figure 1 Most recent surface disturbance information for the Dawson planning region.
Mapped using SPOT 1.5m satellite imagery collected in 2019 and 2020. Features from the National Road Network are in red and all other disturbance features (areal and linear) are in grey.

DEVELOPMENT SCENARIOS

We explored two sectors that create land use change for this scenario analysis: placer and quartz (hard-rock) mining and mineral exploration. For both mining sectors, we included mineral exploration (including cutlines), future potential mine sites, and transportation (roads and trails) needs. We developed two 20-year scenarios with decadal growth for each sector: high and low growth. These scenarios explore plausible levels and locations of development. The quartz mining scenario is summarized in – page 10, and was based on expert advice on probable and potential mining and exploration location and extents. Both scenarios did not consider any legislative or regulatory changes, including a regional plan.

Table 1 Summary of quartz mining scenarios in the Dawson Planning Region over a 20 year time horizon using ALCES scenario modelling

Level of Activity	Summary
Low	• Construction of one mine (Brewery Creek) in next 5 years. • Two discovery / advanced exploration projects active per year over 20 years (2 * 20 = 40 project years of mineral exploration).
High	• 3 mines start (Brewery Creek, Coffee, and White Gold) in years 5-10 • 8 discovery/advanced exploration projects active per year 20 years (8*20 = 160 project-years of mineral exploration). • Northern Access Route required to support new mines.

Figure 2 provides overviews of the placer modeling scenarios. The low placer activity scenario represents a pace of development at 65% of the average gold production over the last decade and the average of the 5 lowest years in the last 4 decades. The high placer scenario represents an increase of almost double (1.9 times) the pace and scale of development over the last decade.

To determine a disturbance conversion rate for gold production we used mapped surface disturbance of the Indian River from two different time periods (2010 and 2016). We determined the change in surface disturbance over that time period and related that increase with the gold production reported. This resulted in a "disturbance conversion rate" of 13,300 oz. gold mined per km^2. This rate was used in both placer scenarios for the whole region. In the low activity scenario, 98% of placer mining was simulated adjacent to currently active placer areas. In the high activity scenario, 90% of placer mining was simulated adjacent to currently active placer areas. The remaining activity was simulated in new (currently unmined) areas in both scenarios.

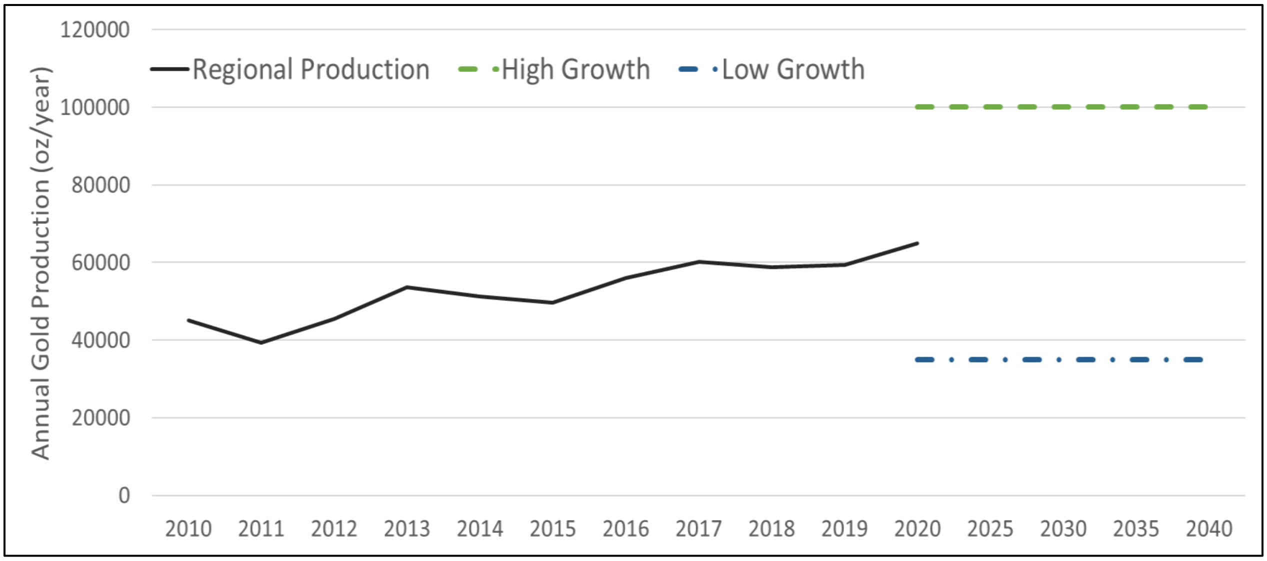

Figure 2 Annual gold production (oz. gold/year) in the Dawson Regional Planning area from 2010-2020.

The green and blue dashed lines represent the high and low growth scenarios used to represent the placer mining sector in ALCES development scenarios.

We summarized the accumulated future (20-year) footprints across the Dawson region, individually by sector (quartz and placer) and by growth scenario, and for each LMU to examine potential levels of surface disturbance (**Figure 3** – page 11, **Figure 4** – page 12 and **Table 2** – page 10).

Table 2 Current and future disturbance estimates by Landscape Management Units (LMU) as described in the Recommended Plan (June 2022)

*Current surface disturbance is summarized using most recent features of the May 2022 release of the surface disturbance database. Future disturbance was modeled using 20-year forecasts of ALCES scenarios outlined **Table 1** and **Figure 2**.*

Land Management Unit (# and name)	Linear Feature Density (km/km^2)			Surface Disturbance (%)		
	Current 2020*	High 2040	Low 2040	Current 2020*	High 2040	Low 2040
1 Tthetäwndëk (Tatonduk)	0.02	0.03	0.02	0.00	0.02	0.00
2 The Horseshoe	0.50	0.50	0.50	0.15	0.15	0.15
3 Chu Kon Dëk (Yukon River Corridor)	0.22	0.29	0.26	0.11	0.22	0.13
4 Tsey Dëk (Fifteenmile)	0.14	0.14	0.14	0.00	0.01	0.01
5 Ddhäl Ch'ël (Tombstone)	0.05	0.06	0.06	0.00	0.02	0.02
6 Tr'ondëk (Klondike)	0.32	0.33	0.33	0.27	0.28	0.28
7 Wehtr'e (Antimony)	0.02	0.06	0.03	0.00	0.06	0.02
8 Brewery Creek	0.30	0.35	0.30	0.55	1.46	1.43
9 Clear Creek	0.61	1.39	0.83	1.67	3.38	2.28
10 Tintina Trench	0.23	0.25	0.24	0.07	0.12	0.11
11 Goldfields	0.76	1.93	1.16	2.34	4.12	2.79
12 Tr'ondëk täk'it (Klondike Valley)	1.71	2.76	2.06	3.76	5.94	5.10
13 Ch'ënyàng (Dawson City)	2.56	2.78	2.56	13.66	14.58	14.04
14 Tay dëkdhät (Top of the World)	0.31	0.72	0.43	0.36	1.11	0.60
15 Khel Dëk (Sixty Mile)	0.36	1.02	0.59	0.75	1.55	1.01
16 Wëdzey nähuzhi (Matson Uplands)	0.29	0.29	0.29	0.01	0.03	0.02
17 Nän dhòhdäl (Upper Indian River Wetlands)	0.48	1.09	0.75	0.25	1.28	0.61
18 Ttthetryän dëk (Coffee Creek)	0.16	0.33	0.20	0.41	1.51	0.41
19 Tädzan Dëk (White River)	0.09	0.14	0.11	0.03	0.07	0.05
20 Łuk tthe k'ät (Scottie Creek Wetlands)	0.40	0.48	0.43	0.32	0.35	0.35
21 Wedzey Tay (Fortymile Caribou Corridor)	0.30	0.68	0.45	0.17	0.96	0.44

* mapped surface disturbance from SPOT 1.5m imagery collected in 2019 and 2020

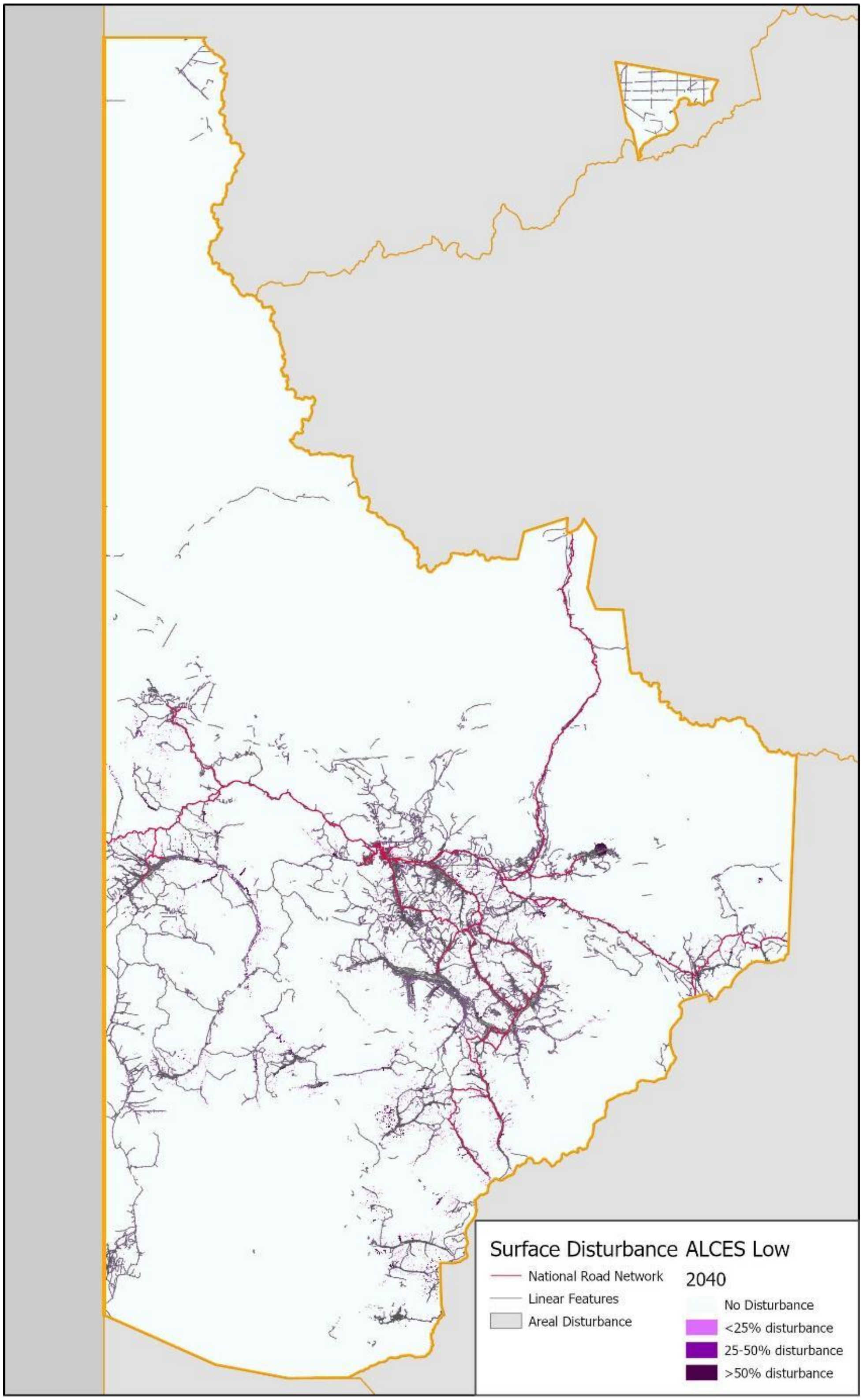

Figure 3 Visual representation of the ALCES low growth scenario in 2040.

Map demonstrating the existing disturbance and the low growth ALCES scenario for 2040. Features in grey are existing disturbance. Disturbance estimates are summarized in ***Table 2****.*

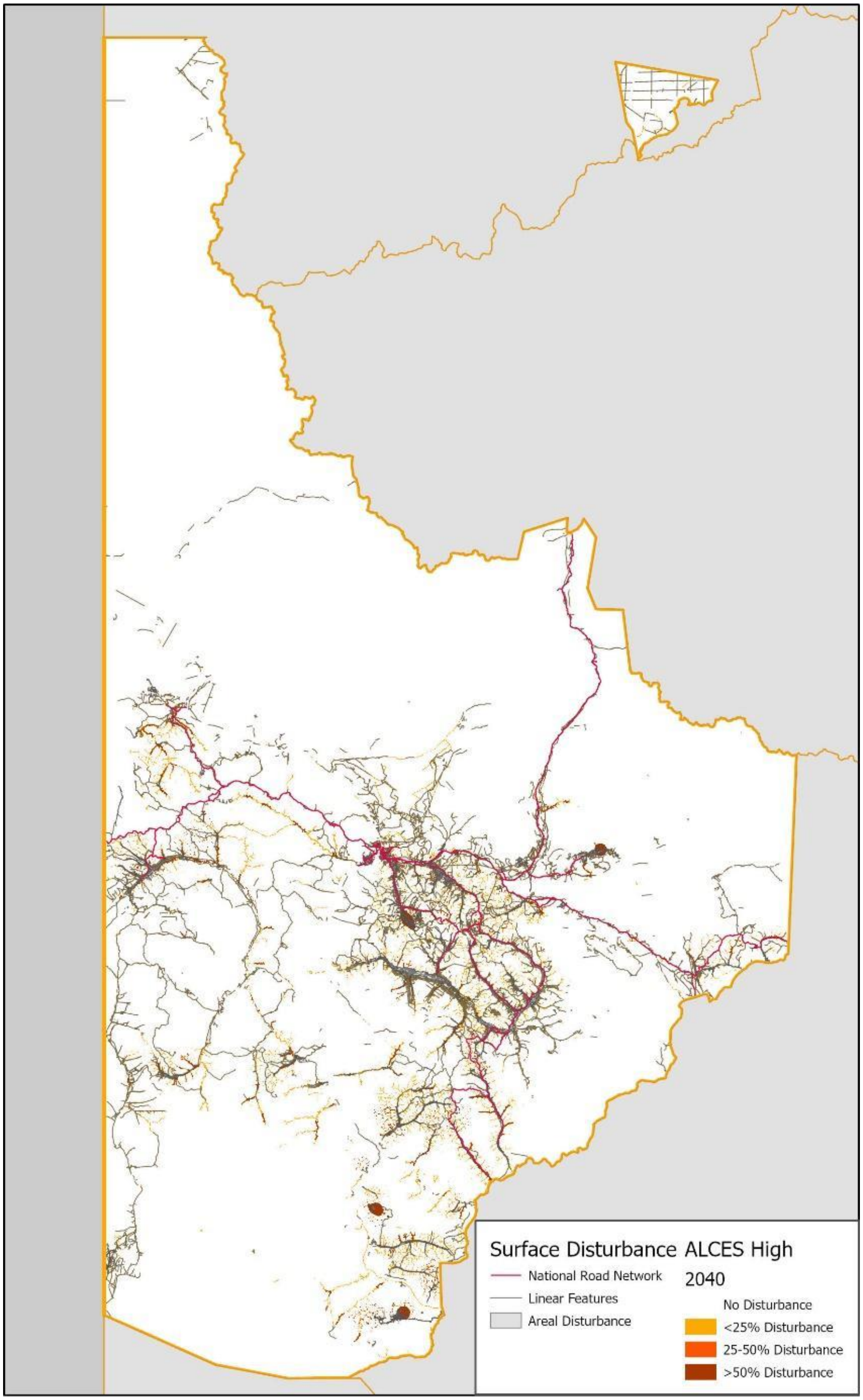

Figure 4 Visual representation of the ALCES high growth scenario in 2040.

Map demonstrating the existing surface disturbance and the high growth ALCES scenario for 2040. Features in grey are existing disturbance. Disturbance estimates are summarized in ***Table 2****.*

VALUES

INDICATORS, THRESHOLDS, AND ADAPTIVE MANAGEMENT

Indicators provide a measurable link between the environmental responses of values to stressors. Ideal indicators should be sensitive to environmental changes, relevant to the value, practical to evaluate, easily monitored, relevant to regulatory processes, responsive to cumulative effects, and have adequate current status or historical data (Venier et al. 2021).

Thresholds can be defined as a sudden or non-linear change in ecological, socio-cultural, or socio-economic values that follows an incremental increase in human activity (Johnson and Ray 2021). However, thresholds can also trigger a management action. Management thresholds are established through a combination of technical understanding of anticipated ecological impacts and a socially-defined level of acceptable change. A tiered threshold approach includes "precautionary", "cautionary" and "critical" levels and links to adaptive management processes to prevent a certain result or condition from occurring (**Figure 5**).

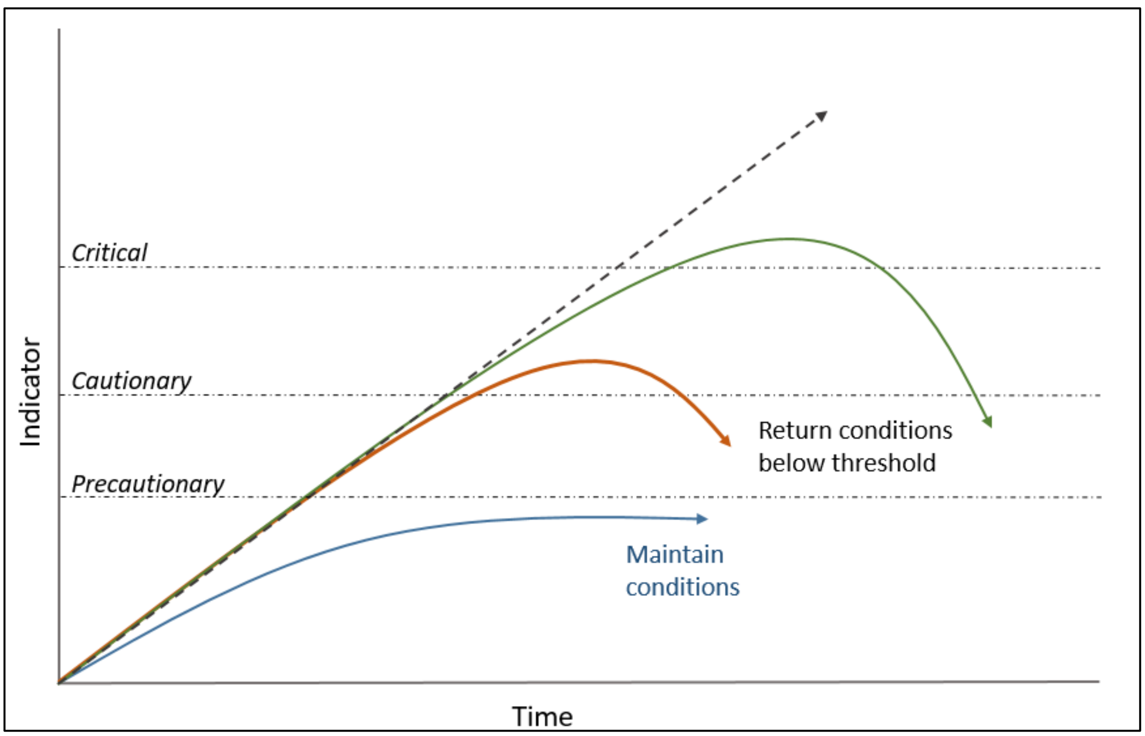

Figure 5 Conceptual relationship between disturbance indicators and thresholds

The Recommended Dawson Regional Land Use Plan suggests precautionary, cautionary, and critical thresholds for each land management unit. Generally, the goal is to maintain the indicator below a certain level if possible (blue line) or take action to return the indicator below the threshold (green and red lines). If thresholds are not implemented, disturbance may continue to increase (dashed line).

Thresholds are just one tool we have for managing cumulative effects. Surface disturbance and linear feature thresholds are challenging to tie directly to values, especially when averaged across an LMU. They provide broad guidance, but the location of the proposed disturbance can be just as important as the thresholds. For example, surface disturbance adjacent to existing disturbance may have less of an impact than in undisturbed areas, particularly if a new road is established. With respect to specific values, disturbance can have a greater negative impact on values, such as caribou, if it is in key areas such as calving, insect relief area, rutting, wintering areas, or within migratory routes.

The CEWG used the structure outlined in **Figure 6** to guide working sessions for caribou and harvest to link values to cumulative effects concerns and identify current and future possible cumulative effects indicators. The CEWG then prioritized indicators based on data availability, link to values, and ease of reporting. Values-based concerns, objectives, indicators are summarized in **Table SM1**.

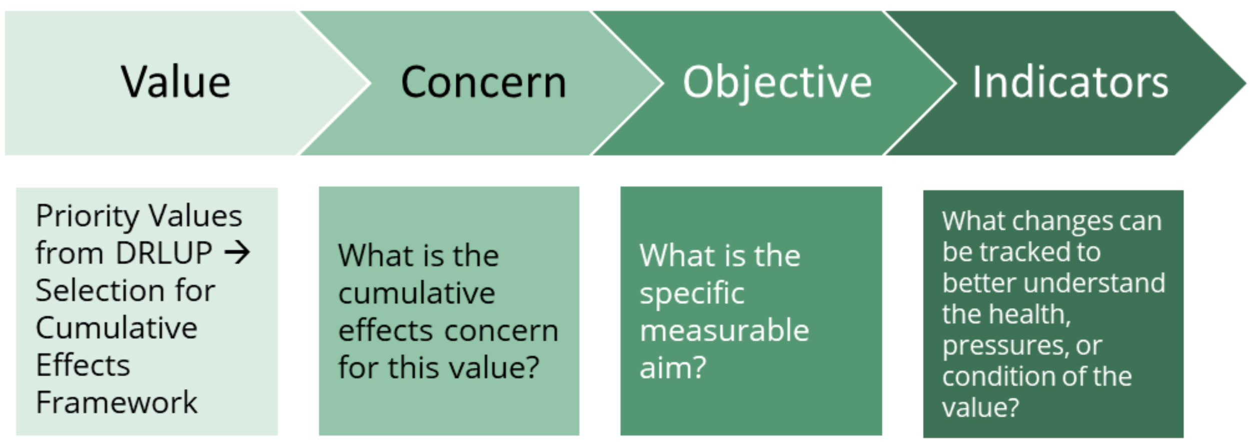

Figure 6 Components of the values-based indicator framework

Used in working sessions to identify linkages among values in the Dawson Regional Land Use Plan (DRLUP), cumulative effects, and monitoring. Adapted from the North Yukon Regional Land Use Plan (2009).

Ecological Value: Caribou

Caribou are a species of cultural, economic, and ecological importance in the Yukon. The Dawson planning region is home to three migratory and trans-boundary caribou herds (Porcupine, Fortymile, and Nelchina) and three Northern Mountain herds (Hart River, Clear Creek, and Klaza; **Figure 7** – page 15). All of these herds are subject to regulated harvest and are highly valued as not only a subsistence food source but also a species of great cultural and spiritual significance.

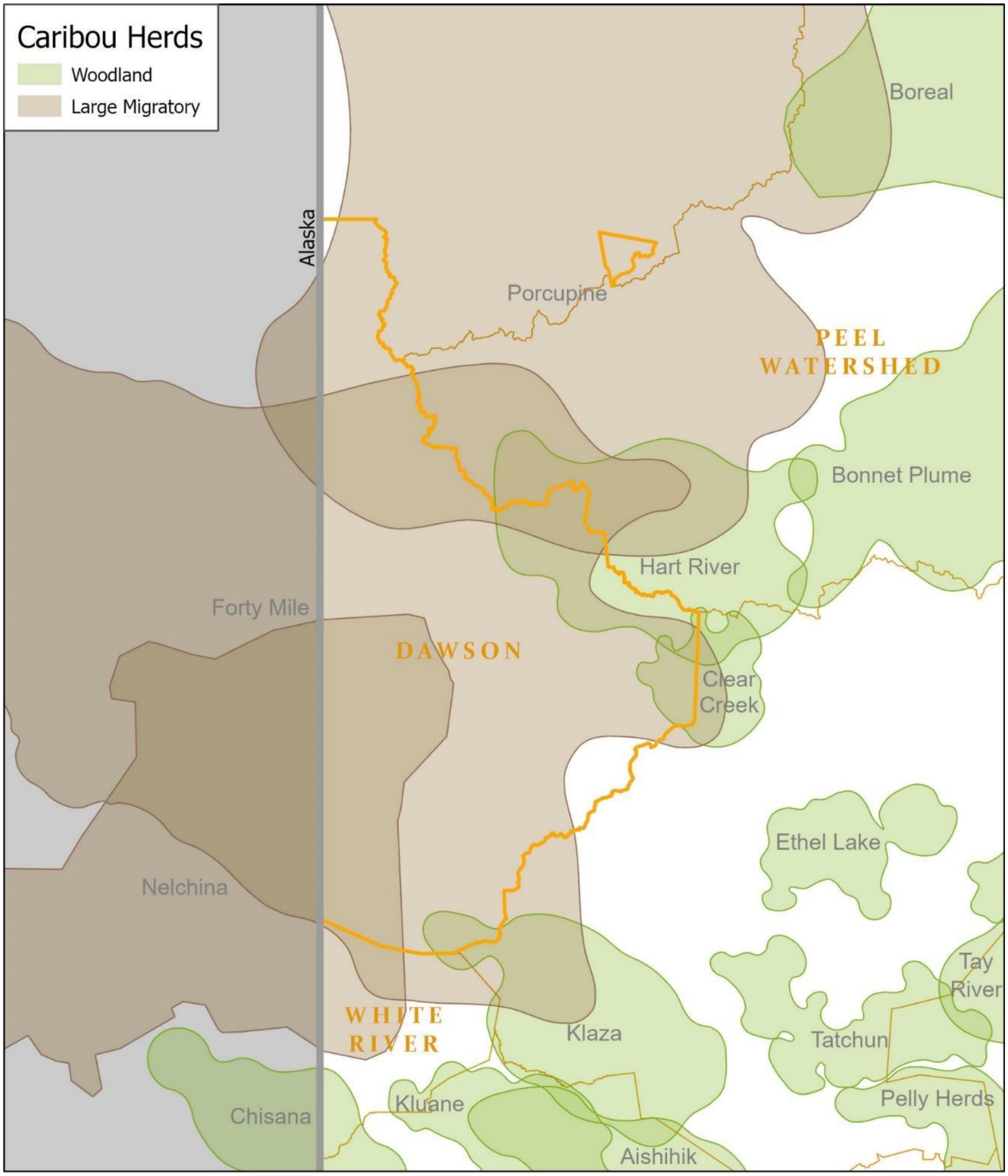

Figure 7 Migratory (brown) and Northern Mountain (green) caribou herds that overlap the Dawson planning region (orange).

The migratory herds are transboundary and managed with Alaska. The Northern Mountain herds overlap with other planning regions.

Northern Mountain caribou migrate between high elevation alpine/sub-alpine spring and summer ranges (used for calving and post-calving) and low elevation forested winter ranges. Migratory caribou occur at high abundances and as such require large expanses of habitat to meet their seasonal needs. While most Northern Mountain caribou populations are considered secure at this time, disturbance, displacement, habitat alteration, harvest and climate change driven effects have the potential to easily destabilize Northern Mountain caribou populations if not carefully managed (Environment Canada 2012). Northern Mountain caribou are listed as 'Special Concern' under the federal *Species at Risk Act* (SARA; Government of Canada 2009). The Porcupine caribou herd are under consideration to be listed as Threatened.

In Canada and elsewhere, migratory caribou are facing unprecedented levels of human disturbance, which have led to declines in barren-ground caribou populations beyond the range of natural variation (Parlee et al. 2018). Major issues facing migratory caribou at a global scale include barriers to movement between foraging areas and insect relief, and subsequently their cumulative effects (Nellemann and Cameron 1998, Johnson et al. 2020).

Caribou are particularly sensitive to human activity on the landscape, especially land use change such as linear feature development. The most significant risk for many caribou herds is the development of linear features. Woodland caribou frequently avoid linear features at distances from 250m to 5km (Dyer et al. 2001, Hornseth and Rempel 2016), but migratory caribou have larger zones of influence of 18-30km (Johnson and Russell 2014, Boulanger et al. 2021). Variation depends on the herd, season, level of traffic, and type of linear feature (i.e., road vs. seismic line). Caribou do not always avoid linear features, as they ease travel and can offer higher quality forage (James and Stuart-Smith 2000; Johnson et al. 2015). However, caribou experience higher mortality risk when using linear features due to predation events, motor-vehicle collisions, and hunting (Ehlers et al. 2014, DeMars and Boutin 2018, McKay et al. 2021). Human disturbance results in habitat alteration, which increases moose habitat, and thus populations, and linear features increase wolf predation rates on both moose and caribou. In short, the primary reason for declines in caribou populations is cumulative effects of human disturbance (Serrouya et al. 2011; Dickie et al. 2017).

Researchers have identified a number of different linear feature thresholds for caribou, which suggests that thresholds differ by ecotype (e.g., migratory vs.

Northern Mountain) and are herd-specific. Currently there is a gap in our knowledge of the relationship between linear features and Northern Mountain caribou, particularly in the Yukon. However, we can look to other areas to inform this relationship. In Alaska, migratory caribou cow and calf densities declined when linear features approached densities of 0.3 km/km^2 (Nellemann and Cameron 1998). At the British Columbia-Alberta border, À la Pêche caribou herd (Southern Mountain ecotype) calving rates declined by 20% when linear features exceed 0.12 km/km^2 (COSEWIC 2014).

While this report focuses on the cumulative effects from human-caused surface disturbance and linear feature density, a thorough cumulative effects analysis on caribou must include consideration of wildfire and a changing climate. Interactions among resource extraction, natural disturbance, and climate stressors can result in complex and unexpected impacts on species. Habitat and population changes for caribou are complicated by potential interactions between resource development, vegetation dynamics, wildfire, and climate.

Fortymile Caribou Herd

The Fortymile caribou herd range has significant overlap with the Dawson Region. Caribou use portions of the Dawson Region in all seasons except during calving but include summer post-calving and early summer periods (McDonald and Cooley 2004). This herd has experienced dramatic population swings likely caused by overabundance, environmental change and, at times, overharvest. Historic population peaks likely numbered in the hundreds of thousands of caribou and ranged from Fairbanks to Lake Laberge. A recently completed harvest management plan for the herd (Fortymile Harvest Management Committee 2020) identified an objective to "*[p]romote and support management actions that allow for continued use and expansion into the herd's historic range*". To achieve this objective, careful management of habitat with a specific focus on disturbances in key habitats (such as migration corridors and summer ranges) is required.

Recent analysis conducted by Government of Yukon in partnership with researchers has found that caribou strongly avoid using habitats within 2 km of placer claims and mining disturbances during summer. Caribou response to those same disturbances continued to be significant but were not as strong during low activity times (i.e., at night or during winter), demonstrating that response to disturbed habitats was a factor in caribou use, but caribou response was much stronger when mines were likely most active. Caribou response to secondary roads (e.g., Top of World Highway, Goldfields primary roads) was similar (i.e., a 2 km avoidance that was stronger during daytime in summer). In addition, this analysis also identified that caribou minimized crossing secondary roads in all seasons, but smaller tertiary roads did not appear to impede movement (Mahoney et al. 2022).

Tertiary roads in some environments led to increased predation risk and functional habitat loss for caribou due to avoidance (Apps et al. 2013, Beauchesne et al. 2014). Results indicate that sufficient linear feature densities in an area may form a barrier to some caribou, and generally migratory caribou herds show only weak habituation to anthropogenic disturbance (Johnson et al. 2020, Johnson and Russell 2014). Although results from Mahoney et al. (2022) are clear that effects to caribou habitat use and movement are currently significant and adverse, it should be noted the distances of avoidance are likely very conservative. Data analysis in Mahoney et al. (2022) was completed prior to the 2020 surface disturbance mapping, so the precise size and distribution of active placer mines was unavailable, instead mining claims were used as a proxy for disturbance. As a result, the distances measured are likely an average distance and we expect response to distances by caribou to vary depending on the location of surface disturbance or linear feature density.

Recent research on the Fortymile caribou herd has also focused on the influence of available summer range on caribou density, as managers have been concerned the herd was approaching carrying capacity on their summer range (Fortymile Harvest Management Committee 2020). Since the most recent population estimate of ~84,000 caribou in 2017, the herd has undergone a decline with causes symptomatic of limitations affecting summer carrying capacity (Fortymile Harvest Management Committee *in prep*). As a result, maintaining current summer range is critical for this herd, meaning that any loss of summer range availability will result in a reduction in the size of the Fortymile caribou herd.

To meet the herd's harvest management plan objectives of continued use and expansion into historic range, human activity should be managed to allow for the full use of existing summer ranges in Yukon, including migration into and out of those ranges. Based on current research, the loss of either of these components will reduce in the herd's size and as a result, a reduction in herd distribution, which ultimately limits the ability of Yukoners to access this herd.

Clear Creek & Hart River Herds

Northern Mountain caribou are generally not well studied, and the relationship between Northern Mountain caribou and human disturbance is poorly understood in the Yukon. However, Polfus et al. (2011) examined the impacts of surface disturbance on the Taku River caribou herd in Northern British Columbia. In that study, caribou avoided disturbance at the landscape scale in both summer and winter. In both seasons, caribou avoided major roads at a distance of 2 km and minor roads at a distance of 1 km. In summer when human activity was higher, caribou avoided mines (placer and quartz combined) at a distance of 2 km and camps at a distance of 1.5 km, and in winter, when human presence was low, these features had a minimal impact on habitat use (Polfus et al. 2011).

Within the Dawson planning region, seasonal range use by the Clear Creek caribou herd has shifted northeast in response to increasing human activity and surface disturbance from seasonal range distributions described between 1997-2001 (**Figure 8**). During 1997-2001, the Clear Creek caribou herd frequently used the southern part of their range throughout the year. However, recent surveys and GPS tracking locations show that caribou largely avoid this area from calving through to the rutting season (**Figure 8**, page 20); local knowledge holders have also described this shift in range use. During the same period, there has been an increase in access, placer mining, and quartz exploration in this area. The Government of Yukon is currently completing a range assessment for this herd, which will provide guidance for land use planning and surface disturbance (anticipated completion spring 2023).

The Hart River herd occurs today in areas with minimal disturbance, with the bulk of that disturbance concentrated in and near the Dempster Highway. Disturbance includes recreation-based activities within Tombstone Territorial Park and adjacent areas. Some quartz exploration activities have historically occurred within the herd's range with some becoming active again in 2021 following implementation of the Peel Land Use Plan. Historically, a small mine operation was also present near the core of the winter range between the west and main stems of the Hart River. The mine was accessed through the West Hart winter road. No analysis examining the influence of these features on caribou distribution and habitat use has been completed. Trends in caribou GPS collar data collected since 2015 indicate caribou make limited use of habitats immediately adjacent to the Dempster Highway and some areas of high human recreation use in Tombstone Territorial Park that were historically used by the herd (i.e., Grizzly Lake) (M. Suitor, Government of Yukon, unpublished data). Most of this recreational activity occurs during the summer months, however the GPS collar data suggests general avoidance of these previously used areas.

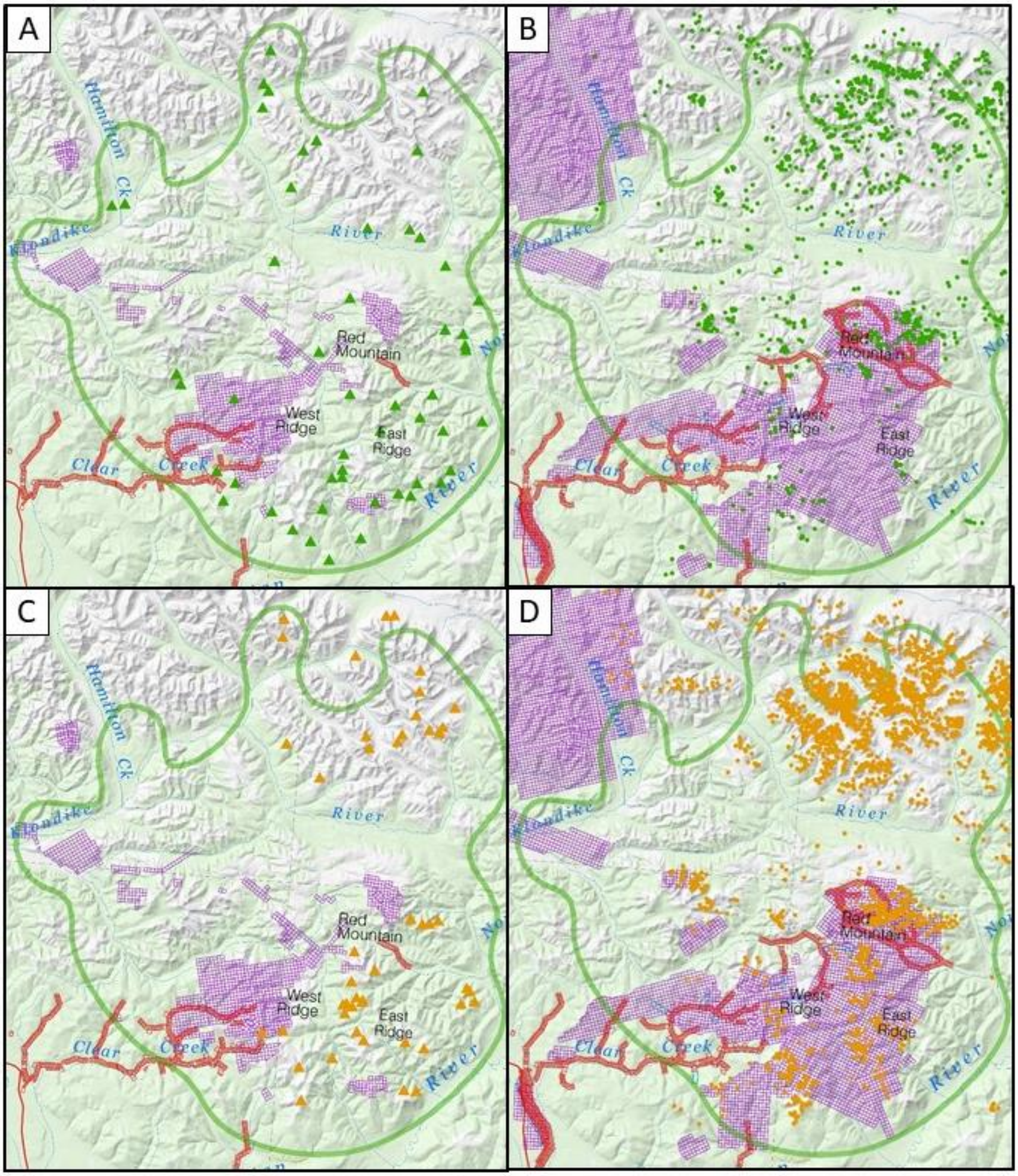

Figure 8 Clear Creek caribou herd seasonal range distributions

A) Calving locations (from VHF collars, green triangles) in 1997-2001 and quartz and placer mining claims (purple and red squares, respectively) from 1998.

B) Calving locations (GPS collars, green dots) and mining claims in 2018.

C) Summer locations (from VHF collars, orange triangles) in 1997-2001 and quartz and placer mining claims from 1998.

D) Summer locations (GPS collars, orange dots) and mining claims in 2018.

Porcupine Caribou Herd

Porcupine caribou occur throughout the northern portion of the Dawson Region. Disturbances in this region are generally limited to the Dempster Highway and associated facilities; however historic oil and gas disturbances activities (i.e., seismic lines and historic trails) do occur in the Eagle Plains, Kandik and Tatonduk basins. The Eagle Plains area has active oil and gas activities, but these are outside the Dawson Region. Disturbances within the herd's range are limited to the above features as well as communities in Alaska, Yukon, and Northwest Territories. Previous analysis of the Porcupine caribou herd has demonstrated an avoidance response by the herd to historic and maintained disturbances, despite most features being 30-50 years since creation and having limited current use (Johnson and Russell 2014). Other work on migratory caribou herds has demonstrated a strong response to disturbance during migration and within seasonal ranges in response to industrial activities (Wilson et al. 2016, Johnson et al. 2020, Boulanger et al. 2021). The collapse in abundance within large migratory populations of ungulates has in part been tied to impediments to migration (Berger et al. 2004, Bolger et al. 2007, Kauffman et al. 2021).

Values-based cumulative effects concerns & priority indicators

The working sessions on values-based indicators for caribou identified the following priority concerns regarding cumulative effects on all caribou herds. Cumulative effects negatively impact:

- Spring, summer & fall caribou migration
- Winter range
- Summer range
- Herd demographics

Based on these concerns and related management objectives, we identified the following priority indicators:

- Persistent use of summer/fall migration pathways
- Quantity of effective summer & winter habitat
- Surface disturbance (assessed in seasonal range, migration pathways, etc.)
- Wildfire disturbance
- Area of lichen cover
- Distribution of caribou

A comprehensive summary of the working session including the caribou cumulative effects concerns, management objectives, and indicators are in **SM1**.

Socio-cultural value: Harvest

Harvest encompasses a range of important activities, such as hunting, trapping, fishing, and harvesting plants, berries, and medicines. However, harvesting is not solely about providing food or related to harvested materials. For Tr'ondëk Hwëch'in, the ability to engage in harvesting activities and maintain harvesting rights has much broader meaning:

> *"Harvesting is also a time for re-connecting with the land and its environment, bonding with family, and sharing teachings through oral knowledge and history. Various activities on the land are about the perseverance of culture and heritage, and an integral part of understanding traditional economy and traditional land use management practices."*
> *(Tr'ondëk Hwëch'in Government 2018)*

Given the importance of harvest to both diet and culture, many Tr'ondëk Hwëch'in citizens perceive the increasing land use as having a negative effect their ability to harvest. One citizen explained this impact when discussing a site where she and her family used for hunting before placer claims were developed in the same valley:

> *"You know, we had been camping for years over in California Creek. We'd go there [to] hunt and camp for two, three weeks at a time in hunting season; and in the summer, we'd go for weekends or the long weekend and just camp. It's just a little valley, like this, you know; but it's perfect. And then not too long ago, back there they gave some [...] to a placer miner or whatever. And all he did was rip the whole place apart. That hillside, oh, it was just terrible, terrible! He just ruined that land, ruined it good"*
> ***(Angie Joseph-Rear, Tr'ondëk Hwëch'in Natural Resources Department 2019)***

Additionally, several Tr'ondëk Hwëch'in citizens have raised concerns over the quality of the harvest in recent years:

> *"Our people are recognizing that traditional foods taste differently today. Our people are noticing that plants and animal patterns are shifting. Our people mourn the loss of our fresh creeks and our caribou herds."*
> ***(Tr'ondëk Hwëch'in Implementation 2022)***

More generally, negative harvest outcomes have been linked to the cumulative effects in research conducted with other Indigenous peoples in British Columbia, the Yukon, and the Northwest Territories. In British Columbia, researchers identified several influencing factors that contribute to the decreased use of traditional resources, including:

- Changing knowledge systems due to religious conversion and residential schools
- Loss of indigenous languages
- Loss of time and opportunity for harvesting due to increased participation in the wage economy
- Increasingly urbanized indigenous populations
- Loss of access to traditional resources
- Restrictive management practices for sustaining resources; and
- Industrialization (Turner and Turner, 2008).

In the Inuvialuit Settlement Region, the cumulative effects of climate change and human activity (e.g., oil and gas exploration) have negatively affected travel routes, access to harvesting areas, wildlife dynamics, and the quality of meat and pelts (Tyson, 2015).

The ability of harvesters (including subsistence and licensed harvesters) to engage in harvesting activities relies on a range of different factors. For example, a local knowledge study conducted by the Dawson District Renewable Resource Council (DDRRC) from 2017-2020 noted an increasing trend of extreme weather events creating challenges for local harvesters while travelling on the land (DDRRC 2020). Other factors could be socio-economic in nature (e.g., sufficient time, access to financial resources to pay for fuel or equipment, a partner to go with), ecological (e.g., the health and abundance of what is being harvested), or a combination of multiple factors.

Access is a central issue for harvesters. Roads and trails provide access to important harvesting areas, but the impact can be positive or negative, depending on the context. Creating access to a variety of different harvesting areas that are easily accessible and support healthy and abundant animal or plant populations is important, especially if local harvesters lack the time and resources to access more remote harvesting areas. However, where an increase in access leads to the concentration of additional pressures, such as mining, the cumulative effects of these pressures may directly or indirectly displace local harvesters. For example, increased concentration of traffic, other hunters, or mining may discourage local harvesters from accessing what was previously an important area, indicating an area has exceeded a socially accepted level of change (Staples 2022).

An increase in access and surface disturbance can lead to declines or displacement in harvested species, leading to concerns about food security. Local subsistence hunters may have to travel further to hunt or relying on other food sources instead of harvested ones (Staples 2022). In addition, resource extraction may also lead to diminished use of the land for hunting and cultural activities, and reduced consumption of traditional foods (Myette and Riva 2021).

The relationship between surface and linear disturbances and impacts to harvest is complex. Unlike a caribou herd, for example, there is no specific number that can be used to estimate potential impacts of increased traffic or increased linear density on harvesters. However, monitoring indicators that provide insight into how surface disturbances may be influencing harvesters, whether there are changes in their opportunities or abilities to harvest, and other sources of pressure that influence harvest is critical to inform land use decision-making.

Moose

Moose are abundant throughout the planning region and are of ecological, cultural, and economic value. While they were not considered explicitly as a value in this report, they are an important food source for many residents of Dawson City and other Yukon residents that come to hunt in the region, so we include a brief summary under the value of harvest. Hunting and consumption of moose meat remains an integral subsistence activity for many Tr'ondëk Hwëch'in citizens. Moose harvesting also provides an avenue for strengthening knowledge and intergenerational relationships with the land. Since we did not consider moose as a value in and of itself, we instead summarized the following information recognizing that moose are an important species for harvest, a priority socio-cultural value. A working session for harvest identified several indicators for moose.

Moose require a variety of habitats with seasonal habitat use reflecting a trade-off between shelter, forage, ease of travel, and predation risk (Morrison and Wong 2013). Riparian areas are important summer habitats for cow moose with calves while cow moose appear to prefer to have their calves on river islands. Riparian areas in the southern half of the Dawson Region are heavily used for placer mining activities and road construction, and the impact of this surface disturbance on moose remains largely unknown. For example, willow revegetated placer areas are used by moose, but this habitat alteration could impact changes in calf survival and nutrition.

Previous research has shown that resource roads can displace moose and lead to functional habitat loss due to disturbance and habitat removal. Previous studies from across North America have shown that moose avoid recently disturbed areas (Street et al. 2015) and that resource roads displace moose. Linear features also increase the amount of habitat fragmentation, predation risk by wolves, and decrease the size of refuge habitat. When linear features are spread out across the landscape instead of being concentrated in specific areas, this impact is more severe as areas without access become less common (McCulley et al. 2017, Laurian et al. 2000). In areas experiencing high harvest rates, access should be carefully managed to avoid significant impacts to local moose populations.

In the Yukon, the sustainability of moose harvest and human caused mortality is assessed at the scale of Moose Management Units (MMUs) p. Within the planning region south of the Ogilvie Mountains, MMUs include Dawson West, Dawson Goldfields, Lower Stewart River-White Gold, and Ogilvie Foothills (**Figure** 9 – page 26). The 2017 survey of Dawson West indicated the population increased in abundance compared to the 1989 survey of this MMU (M. Suitor, personal communication). The Goldfields MMU has been regularly monitored over the last several decades. Harvest in this MMU is above recommended levels, but the population size appears stable. The Lower Stewart River-White Gold MMU was surveyed in November 2021 and recent harvest rates are believed to be near sustainable harvest rates (final results are still pending). Within and north of the Ogilvie Mountains, MMUs tend to be very large due to low density and highly migratory moose populations. To date, no moose abundance surveys have been completed, however most habitats are intact, and harvest is limited.

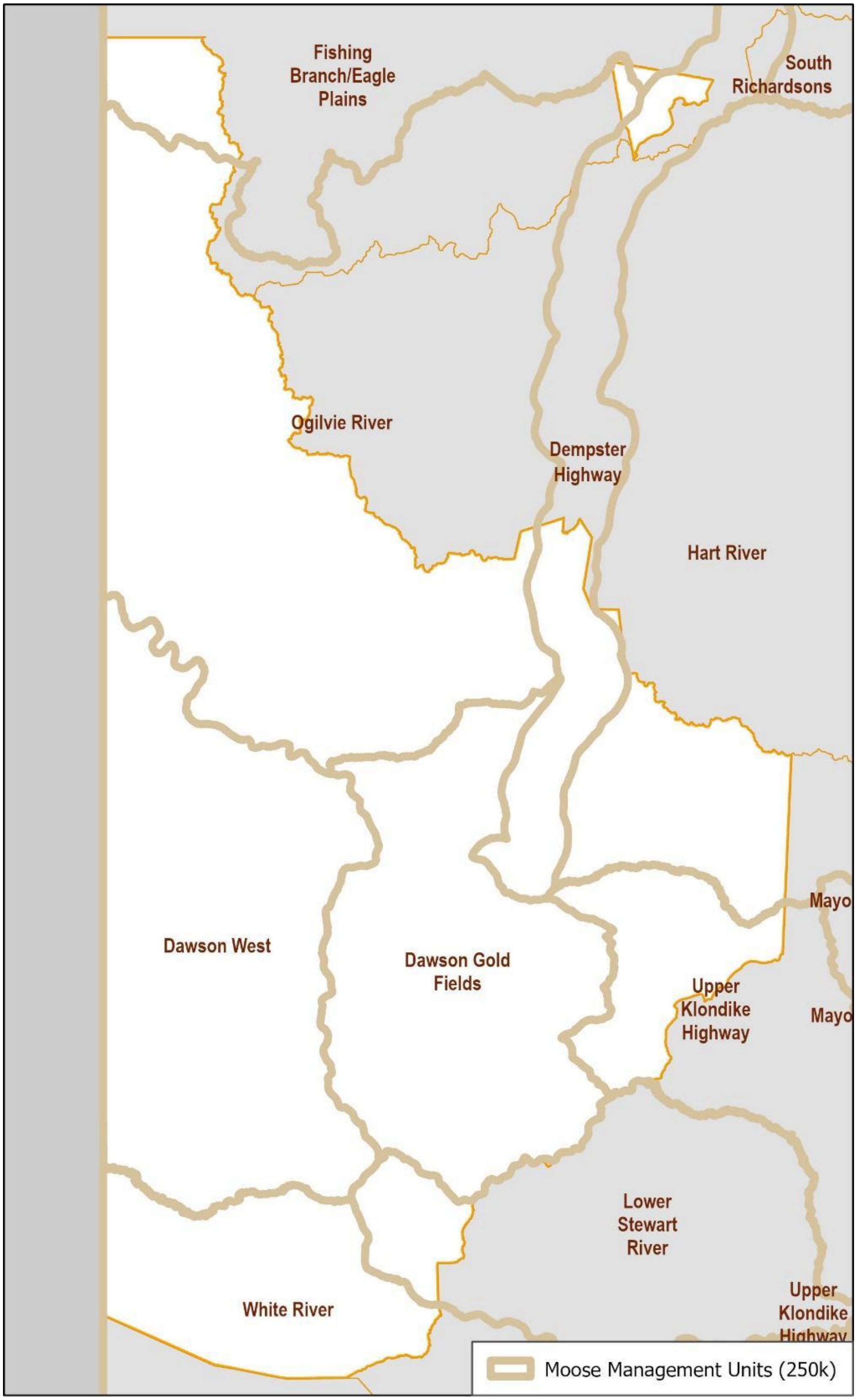

Figure 9 Moose Management Units (MMUs) that overlap the Dawson Regional Planning area

Values-based cumulative effects concerns & priority indicators

The working sessions on values-based indicators for harvest identified the following priority concerns regarding cumulative effects. Cumulative effects can negatively impact:

- The ability of harvesters to access important harvesting areas
- The ability of harvesters to meet subsistence needs
- The quality of harvested foods and related materials
- The health and abundance of moose, caribou, and furbearer populations, as well as berries and plants
- The ability of Tr'ondëk Hwëch'in to meaningfully exercise harvesting rights

Based on these concerns and management objectives outlined in the Draft Plan (2021) as well as other species management plans, we focussed on identifying priority indicators for caribou and moose populations, including the following:

- Traffic patterns in important harvesting areas (caribou and moose)
- Changes to total amount of huntable area (moose)
- Changing trends in numbers and demographics (sex ratio, cow: calf ratios, age) (moose, caribou)
- Reported ability to meet subsistence harvest needs and, if not met, a rationale for why (moose, caribou)

A comprehensive summary of the working session including the harvest cumulative effects concerns, management objectives, and indicators are in Table SM1.6-8.

Conformity Checks

Conformity checks connect chapters 11 (Land Use Planning) and 12 (Development Assessment) of the Tr'ondëk Hwëch'in Final Agreement through project assessments, by linking regulatory processes to land use plans. Project conformity with a regional land use plan is determined by comparing a proposed project's activities with the prescribed management intent of a specific LMU and/or determining if disturbance thresholds within an LMU will be reached or exceeded.

Conformity checks are an important part of the development assessment and review process; new projects are evaluated for conformity to land use plans to ensure disturbance thresholds within LMUs are not crossed. To determine conformity with disturbance thresholds, the proposed amount of human activity (e.g., trails, roads, clearings, quarries, etc.) is added to existing surface disturbance estimates within an LMU. If the combined disturbance does not exceed the critical threshold, the project conforms to the land use plan. If the combined disturbance exceeds the critical threshold, the project is flagged for 'non-conformity' and Parties to the plan are notified. This does not prevent a project from proceeding through the assessment process, although it does trigger specific management actions by the Parties, as recommended in the land use plan.

At present, conformity checks are only conducted on individual projects and do not consider multiple projects in the same area. While any one project may not exceed disturbance thresholds, the seemingly small and incremental changes to disturbance from multiple projects could exceed thresholds. For the North Yukon and Peel land use plans, conformity checks are completed by the Yukon Land Use Planning Council. However, given the large number of projects assessed annually in the Dawson planning region, there may be insufficient resources available to complete conformity checks. However, recent disturbance data is available for that region, making full conformity checks theoretically possible.

Currently, the Government of Yukon compiles surface disturbance information through an intensive manual digitizing process, which is reliant on expensive satellite imagery and skilled external contractors. This effectively means tracked surface disturbance is several years old. This delay, coupled with the time lag between assessment, permitting and creation of disturbance, could mean that surface disturbance thresholds will be exceeded before the Parties are notified through conformity checks. The Commission has recommended that a more sophisticated disturbance tracking system is necessary.

FUTURE CONSIDERATIONS

In this report, we provide an overview of the cumulative effects of disturbance from the mining sector and their potential impacts on the values of caribou and harvest. We used scenarios to forecast the physical footprint of the placer and quartz mining sectors but did not directly link these forecasts to anticipated impacts on the priority values. The DRPC recommended that the Parties continue to collaborate on cumulative effects to address other priorities and support the Dawson Regional Land Use Planning process through implementation, including surface disturbance tracking.

We were unable to address socio-economic values in this report due to limited resources and data availability. Economic impact indicators such as total investment, regional employment and income, and fiscal benefits, provide a good foundation for monitoring the effects of industry investment over time. The DRPC recommended that the Parties continue to work to inform economic and socio-economic indicators by linking values, like housing and wellness, to cumulative effects.

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GLOSSARY

Adaptive management – a strategy or decision-making tool for continually improving management in the face of uncertainty; "learning by doing".

Critical Threshold - A point at which some activity represents an intolerable risk to an ecological or socio-cultural value.

Cumulative Effects – changes in the environment and/or society that result from multiple interactions among human activities and natural processes in combination with other past, present and future activities.

Cumulative Effects Assessment – a systematic process of identifying, analyzing, and evaluating the cumulative effects of a proposed project.

Cumulative Effects Framework – brings together different tools and strategies available to address cumulative effects management objectives.

Cumulative Effects Management – the identification and implementation of measures to control, minimize or prevent the negative consequences of cumulative effects. This means taking a holistic view of the region by looking at the overall impacts of all activities on the landscape.

Ecological Threshold - the point at which there is an abrupt change in an ecosystem quality, property or phenomenon, or where small changes in an environmental driver produce large responses in the ecosystem

Effective Habitat Restoration – the practice of reclaiming and restoring surface disturbance (e.g., mineral exploration, mine sites, roads) by active human intervention and action. Effective restoration requires an explicit reclamation objective or policy, preferably an unambiguous one that is clearly articulated so that the success of meeting the objective can be verified through monitoring.

Effects Monitoring - Studies explicitly designed to link the impacts of stressors (or industries and mitigations) to impacts on ecological, socio-cultural, or socio-economic values through regular tracking of values-based indicators. These studies are necessary to identify potential effects caused by stressors.

Indicator – A measurable signal used to assess and track the condition of ecological, socio-cultural or socio-economic values (e.g., caribou population size).

Linear Feature Density - the total length of all human-created linear features (roads, seismic lines, access trails, etc.) in a given area (km/km^2). Linear feature density can be used as an indicator of fragmentation—the division of larger areas of habitat into smaller areas. Increasing levels of access may result from linear feature development, potentially leading to greater harvest of wildlife and fish, higher predation rates, and a change in how people and wildlife use the land.

Scenario Analysis – A fundamental component of cumulative effects assessment where plausible but structurally different descriptions of future land uses are used to understand the implications of future disturbance on the landscape.

Senior Liaison Committee – Made up of representatives from both Parties, the mandate of the Senior Liaison Committee (SLC) is to provide coordinated, senior level, governmental input, advice and support to Dawson Regional Planning Commission as may be required to address issues in the preparation of the plan.

Surface Disturbance - The amount of land physically disturbed by human activities in a given area, reported as a percentage. Such features as structures, gravel quarries, clearings, well sites, and farms all create physical *footprints* on the land. These footprints have a direct impact on habitat and can be tracked over time.

Thresholds –the point where small changes in a stressor or combination of stressors may produce large responses in the ecosystem, used to trigger a management action. Thresholds are informed by a combination of technical understanding and a socially defined level of acceptable change. A tiered threshold approach can often be used which includes “cautionary” and “critical” levels to prevent a certain result or condition to occur.

Value: Caribou (Fortymile)

Concerns	Objectives	Possible indicators
SUMMER MIGRATION (June 15-August 15)		
1. Cumulative effects negatively impact **summer** migration pathways	1.1. Maintain migration pathways (connectivity)	1.1.1. Persistent use of migration pathways
		1.1.2. Connectivity of migration pathways
		1.1.3. Linear feature density and surface disturbance
		1.1.4. Wildfire disturbance
		1.1.5. Proportion of the herd that is delayed in migration due to disturbance and climate impacts
		1.1.6 Proportion of herd that migrates into the Yukon
	1.2 Maintain ability to harvest during summer migration (see Harvest)	*Moved to harvest value*
FALL MIGRATION (Sept 15-November 30)		
2. Cumulative effects negatively impacts **fall** migration	2.1 Maintain migration pathways (connectivity)	2.1.1. Persistent use of migration pathways
		2.1.2. Maintain connectivity of migration pathways (by minimizing climate impacts and disturbance)
		2.1.3. Linear feature density and surface disturbance
		2.1.4. Wildfire disturbance
		2.1.5. Proportion of the herd that is delayed in migration due to climate impacts and disturbance
		2.1.6. Maintain habitat quality and quantity during migration.
		2.1.7. Proportion of the herd that stays in the Yukon

Value: Caribou (Fortymile)

Concerns	Objectives	Possible indicators
WINTER RANGE		
3. Cumulative effects negatively impact **winter** range	3.1 Maintain lichen/forage availability	3.1.1. Percent of lichen cover
		3.1.2. Percent of cumulative disturbance
		3.1.3. Climate impacts including precipitation, drying, vegetation/shrub encroachment (willow) in sub-alpine/alpine habitats
	3.2. Increase effective habitat (e.g., improve connectivity within and among patches, reduce behavioural avoidance)	3.2.1. Amount of anthropogenically disturbed habitat effectively restored
		3.2.2. Quantity and connectivity of effective winter habitat
		3.2.3. Relative use of available habitat
		3.2.4. Patterns and intensity of human activity
		3.2.5. Location and quantity of high quality habitat within fire risk zones (ie. Refuge habitat).
SUMMER RANGE		
4. Cumulative effects negatively impact **summer** range	4.1. Increase effective habitat (e.g., improve connectivity within and among patches, reduce behavioural avoidance)	4.1.1. Amount of habitat effectively restored (anthropogenic)
		4.1.2. Quantity and connectivity of effective summer habitat.
		4.1.3. Relative use of available habitat
		4.1.4. Patterns and intensity of human activity (not just footprint)
		4.1.5. Location and quantity of high quality habitat within high fire risk zones (ie. Refuge habitat).
	4.2. Maintain Forage quality	4.2.1. Quality of summer forage
	4.3. Maintaining no net loss of summer range	4.3.1. Management action of 4.1.2. Quantity of effective summer habitat.
HERD SIZE		
5. Cumulative effects negatively impact herds	5.1. Maintain demographic rates	5.1.1. Herd size
		5.1.2. Cow-calf ratios; recruitment rates

Value: Caribou (Northern Mountain: Clear Creek and Hart River Herds)

Concerns	Objectives	Possible indicators
SPRING MIGRATION (April/May)		
1. Cumulative effects negatively impact **summer (April/May)** migration pathways	1.1. Maintain migration pathways (connectivity)	1.1.1. Persistent use of migration pathways
		1.1.2. Connectivity of migration pathways
		1.1.3. Linear feature density and surface disturbance
		1.1.4. Wildfire disturbance
		1.1.5. Proportion of the herd that is not delayed in migration due to disturbance and climate impacts
	1.2 Maintain access to critical habitat for calving (Peel Watershed)	1.2.1. Connectivity of migration pathways
		1.2.2. Linear feature density and surface disturbance
		1.2.3. Wildfire disturbance
		1.2.4. Cow-calf ratios; calf counts
		1.2.5. Recruitment rates
FALL RUT (Mid Sept-Mid October)		
2. Cumulative effects negatively impacts **fall rut**	2.1. Maintain habitat quantity	2.1.1. Quantity of effective habitat
		2.1.2. Surface disturbance & linear feature density
		2.1.3. Connectivity among patches
	2.2. Maintain forage quality	2.2.1. Quality of fall forage
	2.3. Maintain functional and effective habitat	2.3.1. Distribution of caribou
		2.3.2. Caribou use of available habitat
		2.3.3. Patterns and intensity of human activity (not just footprint)
		2.3.4. Connectivity among patches
		2.3.5. Surface disturbance & linear feature density
	2.4. Maintain effective breeding activity	2.4.1. Caribou behaviour not altered
		2.4.2. Timing of rut
WINTER RANGE		
	3.1 Maintain lichen/forage availability	3.1.1. Percent of lichen cover
		3.1.2. Linear feature density and surface disturbance
		3.1.3. Wildfire disturbance
		3.1.4. Climate impacts including precipitation, drying, shrub encroachment in sub-alpine/alpine habitats

Value: Caribou (Northern Mountain: Clear Creek and Hart River Herds)

Concerns	Objectives	Possible indicators
3. Cumulative effects negatively impact **winter** range	3.2. Maintain effective habitat	3.2.1. Amount of habitat effectively restored
		3.2.2. Quantity and connectivity of effective winter habitat
		3.2.3. Relative use of available habitat
		3.2.4. Patterns and intensity of human activity (not just footprint)
		3.2.5. Location and quantity of high quality habitat within fire risk zones (ie. Refuge habitat).
		3.2.6. Linear feature density and surface disturbance
SUMMER RANGE (Calving/May to end of August)		
4. Cumulative effects negatively impact **summer** range	4.1. Maintain habitat quality and quantity for calving, post-calving & summer range (May to end of Aug)	4.1.1. Quantity of effective summer habitat.
		4.1.2. Linear feature density and surface disturbance
		4.1.3. Relative use of available habitat
		4.1.4. Patterns and intensity of human activity (not just footprint)
		4.1.5. Location and quantity of high quality habitat within high fire risk zones (ie. Refuge habitat).
	4.2. Maintain Forage quality	4.2.1. Quality of summer forage
	4.3. Maintain functional and effective habitat	4.3.1. Distribution of caribou
		4.3.2. Caribou use of available habitat
		4.3.3. Patterns and intensity of human activity (not just footprint)
		4.3.4. Connectivity among patches
		4.3.5. Surface disturbance & linear feature density
HERD		
5. Cumulative effects negatively impact herds	5.1. Maintain demographic rates	5.1.1. Maintain herd sizes
		5.1.2. Maintain cow-calf ratios; recruitment rates

Value: Caribou (Porcupine)

Concerns	Objectives	Possible indicators
SUMMER MIGRATION (April/May)		
1. Cumulative effects negatively impact fall (Sept 15-Nov 30) migration pathways	1.1. Maintain migration pathways (connectivity)	1.1.1. Persistent use of migration pathways
		1.1.2. Connectivity of migration pathways
		1.1.3. Linear feature density and surface disturbance
		1.1.4. Wildfire disturbance
		1.1.5. Proportion of the herd that is not delayed in migration due to disturbance and climate impacts
		1.1.6. Habitat during migration
WINTER RANGE		
2. Cumulative effects negatively impact winter range	2.1 Maintain lichen/forage availability	2.1.1. Percent of lichen cover
		2.1.2. Linear feature density and surface disturbance
		2.1.3. Wildfire disturbance
		2.1.4. Climate impacts including precipitation, drying, vegetation/shrub encroachment (willow) in sub-alpine/alpine habitats
	2.2. Maintain effective habitat	2.2.1. Amount of habitat effectively restored
		2.2.2. Quantity of effective winter habitat
		2.2.3. Connectivity of effective winter habitat
		2.2.4. Relative use of available habitat
		2.2.5. Patterns and intensity of human activity
		2.2.6. Location and quantity of high quality habitat within fire risk zones (ie. Refuge habitat).
		2.2.7. Linear feature density and surface disturbance
HERD		
3. Cumulative effects negatively impact herds	3.1. Maintain demographic rates	3.1.1. Maintain herd sizes
		3.1.2. Maintain cow-calf ratios and recruitment rates

Value: Harvest

Concerns	Objectives	Possible indicators
1. Cumulative effects negatively impacting the ability of local harvesters to access important harvesting areas for moose	1.1 Maintain road access for local harvesters to important harvesting areas during key harvesting times	1.1.1. Traffic patterns in important harvesting areas
		1.1.2. Reported changes to harvest location and rationale for change (moose)
		1.1.3. Changes to spatial element of road access (e.g., moving road from one side of a valley to another, mining access road changes)
	1.2 Monitor river activity that affects access to important harvesting areas	1.2.1. Reported changes to harvest location and rationale for change (moose)
		1.2.2. Boat traffic (tourism, industrial use, licensed hunters)
	1.3 Maintain legal huntable areas for local harvesters	1.3.1. Changes to total amount of huntable area
		1.3.2. Level of satisfaction with access to harvested foods (moose)
2. Cumulative effects negatively impacting the ability of local harvesters to access important harvesting areas for caribou	2.1 Maintain access for local harvesters to important harvesting areas at important harvesting times	2.1.1. Reported changes to harvest area and rationale for change (caribou)
		2.1.2. Maintain minimum access for caribou to important, high quality habitats
		2.1.3. Shift in caribou distribution
		2.1.4. Loss in effectiveness of habitat
		2.1.5. Level of satisfaction with access to harvested foods (caribou)
3. Cumulative effects negatively impacting moose populations	3.1 Maintain sustainable moose population	3.1.1. Changing trends in numbers and demographics (sex ratio, cow:calf ratios, age)
		3.1.2. Observed number of moose and moose activity (e.g., tracks)
		3.1.3. Observed health of moose
	3.2 Maintain ability to meet subsistence harvest needs for present and future generations	3.2.1. Reported ability to meet needs and rationale for why needs have not been met
		3.2.2. Reported sharing of harvested foods (moose)
		3.2.3. Participation of the next generation in harvest activities (e.g., knowledge of harvest, number of youth participating in on the land camps, number of days youth spend harvesting)
		3.2.4. Amount of moose consumed relative to all subsistence needs

Value: Harvest

Concerns	Objectives	Possible indicators
		3.2.5. Level of satisfaction with availability of moose
	3.3 Maintain quality of harvested foods	3.3.1. Level of satisfaction with quality of moose and rationale for dissatisfaction
		3.3.2. Contaminants in moose
4. Cumulative effects negatively impacting caribou populations	4.1 Maintain sustainable caribou population	4.1.1. Changing trends in numbers and demographics (sex ratio, cow:calf ratios, age)
		4.1.2. Observed number of caribou and caribou activity (e.g., tracks)
		4.1.3. Observed health of caribou
		4.1.4. Loss in effectiveness of caribou habitat
	4.2 Maintain ability to meet subsistence harvest needs for present and future generations	4.2.1. Reported ability to meet needs and rationale for why needs have not been met (caribou)
		4.2.2. Reported sharing of harvested foods (caribou)
		4.2.3. Participation of the next generation in harvest activities (e.g., knowledge of harvest, number of youth participating in on the land camps, number of days youth spend harvesting)
		4.2.4. Amount of caribou consumed relative to all subsistence needs
		4.2.5 Level of satisfaction with availability of caribou
	4.3 Maintain quality of harvested foods	4.3.1. Level of satisfaction with quality of caribou and rationale for dissatisfaction
		4.3.2. Contaminants in caribou
5. Cumulative effects impacting furbearer populations	5.1 Maintain sustainable furbearer population	5.1.1. Changes in trends to numbers and demographics (sex ratio, age)
		5.1.2. Observed number of furbearers/activity (e.g., tracks)
		5.1.3. Reported quality of trapper experience, trapper satisfaction
	5.2 Maintain ability to meet socio-economic needs within a traditional economy, for current and future generations	5.2.1. Reported ability to meet socio-economic needs and rationale for why needs have not been met
		5.2.2. Sale and use of trapped furs
		5.2.3. Participation of the next generation in harvest activities (e.g., involvement in trapping activities or camps)
		5.2.4. Reported quality of trapper experience & satisfaction

Value: Harvest

Concerns	Objectives	Possible indicators
	5.3 Maintain quality of furs	5.3.1. Reported quality of furs
6. Cumulative effects impacting berries	6.1 Maintain ability to meet subsistence harvest needs (community, family, future generations)	6.1.1. Abundance, size of harvested berries
		6.1.2. Reported ability to meet needs and rationale for why needs have not been met
		6.1.3. Reported sharing of harvested foods (berries)
		6.1.4. Participation of the next generation in harvest activities (e.g., knowledge of TH laws re: harvesting, number of youth participating in on the land camps, number of days youth spend harvesting)
	6.2 Maintain quality of harvested foods	6.2.1. Level of satisfaction with quality of harvested foods and rationale for dissatisfaction (berries)
7. Cumulative effects impacting the ability of TH to meaningfully exercise harvesting rights	7.1 Achieve meaningful exercise of harvesting rights	*Most other indicators apply*
		7.1.1. Landscape change or familiarity with landscape
		7.1.2. Transference of knowledge related to harvesting
		7.1.3. Percentage of TH citizens engaged in harvesting activities
		7.1.4. TH Stewardship obligations
	7.2 Ensure amount of effort to meet subsistence needs is sustainable (e.g., affordable, time-wise, equipment)	7.2.1. Percentage of TH citizens engaged in harvesting activities
		7.2.2. Changes to TH harvester effort and rationale for change