Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

DRAFT TECHNICAL REPORT

WOLF (DÌGA) MANAGEMENT PROGRAM

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Photo: Dave Olesen

Tłı̨chǫ Ndek'àowo · Tłı̨chǫ Government · Kugluktuk Angoniatit Association Hunters and Trappers Organization · Wek'èezhìı Renewable Resources Board · Nunavut · Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

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Executive Summary

Tłı̨chǫ Government and the Government of the Northwest Territories (GNWT) are working together to implement management actions to reduce wolf (dìga) predation on the Bathurst (Kǫ̀k'èetı) and Bluenose-East (Sahtì) migratory barren-ground caribou (ekwǫ̀) herds because of ongoing conservation concerns related to significant ongoing population declines. The five-year program includes support for wolf harvesters to increase ground-based harvest of wolves, combined with a research, monitoring and assessment program.

The GNWT and Tłı̨chǫ Government provided measurable wolf-centered objectives to the Wek'èezhìi Renewable Resources Board (WRRB) in response to the WRRB's recommendation (#1-2020). However, establishing measurable wolf-centered objectives is confounded by the complexity in the seasonal and annual interaction of tundra wolves to caribou herds, and the influence of immigration of wolves from adjacent caribou herds in times of range overlap. Research and monitoring is important to help inform adaptive management of wolves, and objectives of the current research and monitoring program as well as a summary of progress for each wolf-centered objective are provided below.

1) **Research and Monitoring.** Understanding wolf population abundance, movement and interaction with caribou on the winter range of the Bathurst and Bluenose-East herds is required to inform management actions. One of the initial objectives for the wolf collaring program was to inform caribou herd affiliation, but those objectives have been updated to reflect the program's broader focus on understanding wolf ecology in line with a recommendation from the WRRB.

Wolf collaring. Nine GPS collars were placed on wolves captured on the range of the Bluenose-East and Bathurst barren-ground caribou herds during March and June 2023. Wolves encountered were in 7 packs and pack size ranged from 1-11 wolves with an average of 4 wolves (average = 4.3 wolves in 2022). Four males (3 adults and 1 juvenile) and five females (3 adults and 2 juveniles) were captured, sampled, and fitted with a GPS collar. Body condition scores ranged from 1-3 with an average of 1.9 (average = 2.6 in 2022). From 2020-2023, 48 collars have been deployed on wolves of which 36 have completed data acquisition and 12 are currently transmitting data. Collaring efforts will continue through March 2024. Opportunistic and concerted efforts to retrieve collars resulted in 10 collars being investigated: 2 were irretrievable, 5 were released and retrieved, 1 was collected from a natural mortality site, and 2 were no longer on the animal but the release mechanism was still intact.

Movement. Monitoring has shown that movement patterns of collared wolves are more complex than previously described in the scientific literature, with many individuals spending time on several different caribou wintering grounds and den sites not limited to the treeline. Analyses of cluster site investigations to estimate the kill rate of wolves on large ungulate prey are in progress.

Den investigations and camera deployments. An aerial survey for wolf dens was conducted from 25-31 May 2023 using a small-fixed wing aircraft on the Bathurst summer range. Five potential den sites were identified by observing wolves; however, only two dens near Gahcho Kue and Snap Lake mines were confirmed to be active by the capture crew in June. These two dens were visited from 21-23 August 2023 and confirmed to have three pups with one collared wolf and one pup with the other collared wolves. In 2012 (D. Cluff, GNWT-ECC unpublished data), a survey in the same study area found 22 active wolf dens and out of those dens, one den site was confirmed to have one pup in the follow-up survey of active dens in August. Nine potential den sites based on previous collar data were visited from 16 July-23 August 2023 and revealed one den with one collared wolf, a kill site, and one possible old den site. From 20-23 September 2023, cameras and autonomous sound recorders were deployed at four dens used by wolves in the previous year to assess pack size, litter size, and survival for the next year, should the den be reused.

Caribou winter distribution. Based on winter 2022/23 caribou satellite collar data, the Bathurst monthly range extents were almost completely overlapped (99.9-94.9%) by Beverly caribou from January to March 2023. Together, Beverly and Bluenose-East caribou winter ranges overlapped the Bathurst winter range modestly in November (41.7% and 0% in October) with increasing coverage through January (81.9%) and then decreasing through to May (16.5%), which is a higher percentage overlap than last year. The Bluenose-East monthly winter range extents in 2022/23 were overlapped in November (63.8%; 0% in October) by Bathurst and Beverly herds and the proportion of overlap ranged from 62.5% to 25.1% from December through to May. High winter overlap among adjacent caribou herds makes implementation of wolf management removals challenging with respect to targeting wolves associated with particular caribou herds, given the potentially reduced territoriality of wolves in the winter.

2) **Wolf Removal. The number of wolves removed annually through the five-year program was identified as a measurable wolf-centered objective.** The GNWT and Tłįchǫ Government continued to provide enhanced support for wolf harvesters and the traditional economy and closely monitored the ground-based harvest.

From January to April 2023, 142 wolves were harvested within the North Slave Enhanced Wolf Harvest Incentive Area (eWHIA) on the winter ranges of the Bathurst and Bluenose-East caribou herds. Hunting occurred primarily along the winter-road (36 wolves removed), around hunting camps set up by Tłįchǫ Government near Roundrock Lake (15 wolves), and by Inuit harvesters near Contwoyto and Yamba lakes (47 wolves). An additional 44 wolves were removed by guided non-resident hunters. A harvester workshop held in Yellowknife brought together harvesters to discuss wolf behaviour and harvest techniques and provide feedback on key aspects of the program. The number of wolves removed in the incentive area has varied across years: 85 were removed in 2019-2020, 135 were removed in 2020-2021, and 69 were removed in 2021-2022.

3) **Measures of Effort. Catch-per-unit-effort (CPUE) metrics for wolf removals were identified as a measurable wolf-centered objective**. Increased hunter-effort to find wolves may indicate that wolf numbers in an area are decreasing. Consequently, CPUE was calculated by measuring the effort of ground-based hunters (hunting days and distance travelled) per wolf removed and the hours flown per wolf sighted by survey crews.

Harvester Questionnaires and CPUE. Harvesters returned 30 completed questionnaires, dated between 24 January and 13 April 2023, reflecting 86 wolves killed in the eWHIA (out of a total harvest of 98 wolves). From December 2022 to February 2023, in collaboration with hunters and trappers, revisions to the wolf harvester questionnaire design and delivery were completed, which improved survey completion and calculation of CPUE and response rates relative to the two previous years.

Effort by ground-based hunters. The Tłı̨chǫ Government's dìga harvest camp reported a greater number of wolves removed per hunting day (CPUE-day) in 2023 compared to 2022 and 2020, but less compared to 2021. The effort data reported by the winter road harvesters showed an increase in CPUE-day from 2020-2022, but a decrease in 2023. CPUE-day measurements for Kugluktuk harvesters, and on average across all three groups, showed an increase from 2020-2023, indicating an increase in the number of wolves harvested per day. The Tłı̨chǫ Government's dìga harvest camp reported number of wolves removed per kilometer travelled (CPUE-km) with a similar pattern as the CPUE-day. Similarly, Kugluktuk and winter road harvesters reported a higher CPUE-km in 2023 compared to 2022. On average, CPUE-km was highest in 2021 and 2023, was much lower in 2020 and was slightly less in 2022. Further statistical modelling is needed to determine what factors, such as weather, harvester experience, and hunting in groups versus alone, influence harvest success of wolves. Basic comparisons of CPUE do not take these factors as well as assumptions made when forms are not filled out completely into account.

Hours flown per wolf sighted. No wolves were sighted during the March 2023 caribou collar deployment and consequently observations of wolves have decreased when compared to previous years of coordinated collar deployment of both wolves and caribou (0.86 wolves per hour in 2022 and 1.82 wolves per hour in 2021). Sighting rates of wolves during March caribou composition surveys decreased from 2010-2020. From 2020-2023, sighting rates of wolves in areas of highly mixed caribou and Bluenose-East caribou only initially decreased and have slightly increased in the last year.

4) **Demographics and Health: Age structure of harvested wolves was identified as a measurable wolf-centered objective.** The GNWT has committed to monitor the health, condition and demographics of wolves harvested through the 5-year wolf management program. A sample of wolves removed from the program undergoes a full necropsy. To determine if the age composition of harvested wolves has shifted from an age structure of mostly adults to mostly young wolves (which may indicate a decrease in the wolf population), the age class of harvested wolves has been estimated and more accurate ages will be determined through cementum annuli analysis.

Demographics. Eighty-three (49 males and 34 females) wolves of 98 harvested in the incentive area in winter 2023 were necropsied for demographics and health analyses. Age structure (based on tooth cementum age) was significantly lower in 2021/2022 compared to 2020. Sample preparation and analysis of teeth for wolves harvested in 2023 is underway. A shift in age structure towards younger, immature animals is expected in a heavily harvested population. The number of pups being produced by females (litter size) has decreased significantly over the last three years. Noted for the first time in this program, 29.4% of females examined had uteri which appeared to be mature and/or in heat yet unbred/empty with no apparent implantations, fetuses, or placental scars, suggesting that animals are mature but non-breeding.

Health. We observed a significant declining trend in body condition as indicated by body condition score. This trend may be an indicator of declining health and/or condition in the wolf population. The proportion of stomachs that contained barren-ground caribou tissue was similar to last year: 50% in 2022 to 50.6% in 2023. The proportion of empty stomachs was greater this year compared to last: 26.1% of stomachs analyzed in 2022 and 32.5% in 2023.

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1 Introduction

The Bathurst (Kǫ̀k'èetı) and Bluenose-East (Sahtì) migratory barren-ground caribou (ekwǫ̀) herds have undergone significant declines, resulting in serious and continued conservation concerns shared among co-management partners across the respective annual herd ranges in the Northwest Territories (NWT) and Nunavut. The Bluenose-East population declined from an estimated 121,000 caribou in 2010 to 68,000 caribou in 2013 and 23,200 caribou in 2021. The most recent survey was done in 2023, estimating 39,500 individuals. Calving ground surveys conducted on the Bathurst herd in June 2006 and 2009 indicated significant declines in breeding females (Nishi et al. 2007, 2014), with population size declining from 128,172 (± 27,229 SE) caribou in 2006 to 31,980 (±10,853 SE) animals in 2009 (Adamczewski, et al., 2020) and 6,240 animals in 2021 (Adamczewski et al., 2022). The most recent Bathurst survey in 2022 resulted in a population estimate of 6,850 (Adamczewski, et al., 2023).

A range of management actions for these two caribou herds have been implemented across their ranges within the NWT, including actions within and outside of the Wek'èezhìı management area[1] established under the Tłıchǫ Agreement. Because of the ongoing conservation concern for these two caribou herds, the scope of management has extended beyond actions that initially emphasized implementing caribou harvest targets or total allowable harvests (WRRB 2010), along with other strategies focused on range disturbance and management of important habitat features (e.g. Bathurst Caribou Range Plan; see summaries in WRRB 2010, 2016a, 2016b, 2016c, 2016d, 2019a, 2019b). Management actions have been expanded to include reducing wolves (dìga) on the winter range of these two herds. Wolves are the primary predator of caribou; wolf predation can influence the abundance of large migratory populations of caribou especially during the decline phase of cyclic populations (Couturier et al., 1990; Messier et al., 1988) and when caribou are at low numbers (Bergerud, 1996; Messier et al., 1988).

Following the WRRB's (2016a, 2016b) recommendations on wolf management and completion of a wolf management feasibility assessment (WFATWG 2017), the Tłı̨chǫ Government (TG) and the Government of Northwest Territories, Department of Environment and Climate Change (GNWT-ECC) submitted a joint Proposal to the WRRB in January 2020. WRRB accepted the 2020 Joint Proposal as a pilot project and approved a revised joint management proposal with a technical report in August 2020 (Nishi et al., 2020). The WRRB conducted a Level 2 review of the Revised Joint Management Proposal and other evidence submitted to the public record. The WRRB (2021) concluded that wolf management is needed to support caribou recovery and made 20 recommendations that were accepted or varied by GNWT and Tłı̨chǫ Government (Appendix A).[2]

The goal of the five-year wolf (dìga) management program is to sufficiently reduce wolf (dìga) predation on the Bathurst and Bluenose-East herds to allow for an increase in calf and adult caribou (ekwǫ̀) survival rates to contribute to the stabilization and recovery of both herds. This report summarizes wolf management and monitoring activities undertaken by GNWT and Tłı̨chǫ Government during 2023. It provides an update to the

[1] Although this report is focussed in Wek'èezhìı, we also recognize the importance of co-management strategies and actions for Bathurst and Bluenose-East caribou that are also being implemented by other organizations across the herds' ranges including the Advisory Committee for Cooperation on Wildlife Management (2014, 2019), Délı̨nę ekwę́ Working Group (2016), Kugluktuk Angoniatit Association (2019), Łútsël K'é Dene First Nation (2020), Nunavut Wildlife Management Board (2020a, 2020b) and Sahtú Renewable Resources Board (2016).
[2] WRRB Reasons for Decision Final Report - 2020 Diga Management Proceeding.pdf

previous reports on wolf management activities in Wek'èezhìı during winter 2020 (Nishi et al., 2020), 2021 (Clark et al., 2021), and 2022 (Wilson et al., 2022) and is intended to fulfill the WRRB's recommendation (#20-2020) that an *"annual report be prepared by GNWT and TG and presented to the Board at a scheduled board meeting to allow for the discussion of adjustments in methodology based on the evidence, beginning fall 2021"*.

2 Research and Monitoring

2.1 Wolf Collaring

Understanding wolf population abundance, movement, and interaction with caribou on the winter range of the Bathurst and Bluenose-East herds is important to help inform management actions. The collaring program will help address the WRRB's recommendation (#11-2020) to: "continue the dìga collaring program, beginning in 2021, using a statistically rigorous design to measure dìga movements relative to the dìga-ekwǫ̀ spatial distribution, including reducing the uncertainties involved with assigning dìga to ekwǫ̀ herds." Since then, analyses (see Nishi et al., 2020, Clark et al., 2021, Wilson et al., 2022) have shown that it is not practical to assign wolves to a particular caribou herd. In December 2022, the WRRB recommended that research and monitoring efforts should be centered on understanding wolf ecology rather than herd affiliation. The objectives of the wolf collaring program are similar to previous years, but have been updated:

1. Improve our understanding of wolf movements within and between caribou herds
2. Understand individual wolf movement and behavior
3. Quantify diet through kill site investigations
4. Determine population trends through den surveys and pup counts
5. Assess pack size and litter size through camera deployments at den sites
6. Determine the fate, cause-specific mortality, and details of collar life through collar retrievals.

The capture and collaring of wolves adheres to GNWT Standard Operating Procedures for the handling of wolves to minimize trauma and stress to the animal and was conducted under animal handling protocol WCC# NWTWCC2022-014 approved by the GNWT Wildlife Care Committee and GNWT Wildlife Research Permit #WL501100[3].

2.1.1 March 2023 Capture and Handling

Between 8-13 March 2023, six wolves were collared within the NWT in an area that includes overlap of the Bluenose-East, Bathurst, and Beverly caribou winter ranges. An additional wolf was captured and handled but was released without a collar due to being a young wolf and two pack mates had already been collared, for a total of 7 wolves handled. Figure 1 shows the deployment locations and flight lines for 20.4 hours of flying.

[3] https://www.enr.gov.nt.ca/en/services/apply-research-observe-and-handle-wildlife-nwt/wildlife-care-committee

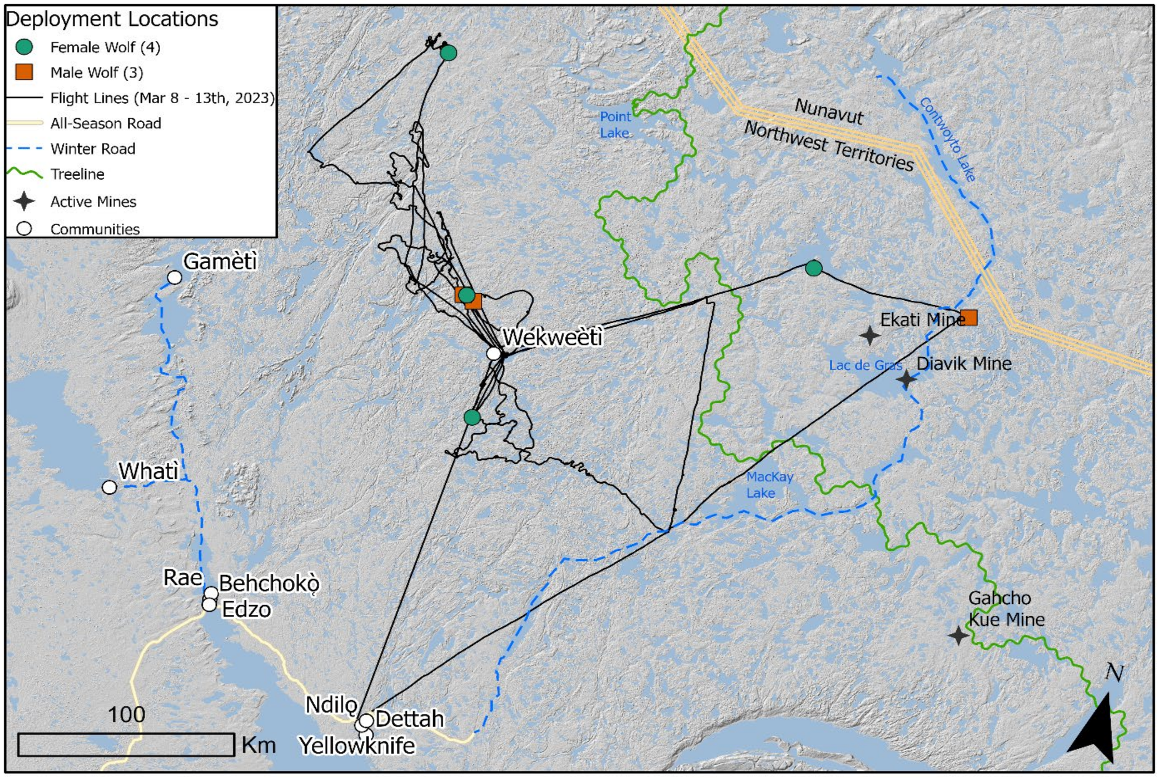

Figure 1. Flight lines and distribution of GPS/Iridium satellite collared wolves in March 2023.

A team consisting of an experienced pilot, net-gunner, GNWT-ECC Wildlife Veterinarian and GNWT-ECC biologist carried out the capture and collar deployments. Wolves were captured using a net-gun followed by chemical immobilization (see section 2.1.3 for further details) following GNWT's Standard Operating Procedures[4], with chase times ranging from 8 to 55 seconds (Figure 2). One wolf required multiple net launches due to misses and the team landed to reload, resulting in a total chase time of 5.3 min. The average handling time was 35.6 ± 3.8 minutes, which included the time from net launch to full recovery from immobilization. Each wolf was ear tagged and fitted with a GPS collar (Telonics Model TGW-4577-4) designed to lay flush against the neck and contain both a cotton breakaway and a timed-release mechanism (Figure 3). The average total weight of the collars with the cotton breakaway addition was 854 ± 13 grams, which fell below the maximum estimated weight of the collar (880 grams) from Telonics, and was estimated to be 1.9% of the wolf weight when wolves were estimated to be 45 kilograms. The programmed time for release on the breakaway mechanism was 2.5 years after deployment. If the release mechanism fails, cotton inserts will eventually rot away and release the collar, ensuring that the animal will not wear a non-functioning collar throughout their lifetime. While an exact time for the cotton insert to rot off is unknown and is highly dependent on weather and movement, efforts were made to ensure the cotton inserts rot off within the wolf's lifetime (2-4 years after deployment).

[4] https://www.enr.gov.nt.ca/sites/enr/files/resources/wolf_handling_sop.pdf

Figure 2. Wolves were captured using a multi-modal net-gun and chemical immobilization approach and fitted with a Telonics GPS collar in March and June 2023. Photos taken by Ian Ellsworth, Trinity Tactical Consulting.

Complete sets of measurements (neck and chest circumference, body length, body weight, and body condition score) and biological samples (e.g., hair, blood, feces) were collected from five of seven animals handled and only priority samples (ear biopsy, hair, and blood) were collected from two animals that showed signs of high stress and hyperthermia. These samples are used to assess general health, condition, and age of captured wolves[5].

Figure 3. Wolves were fitted with Telonics (Model TGW-4577-4) GPS collars that were designed to lay flush against the neck and contain both a cotton breakaway and a timed-release mechanism (black box). Photos taken by Abbey Wilson, GNWT-ECC.

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[5] Photos are used to determine age and sex, while hair and blood are analyzed for genetics, reproductive status, and exposure to disease.

Table 1 shows the collaring details of wolves collared in March 2023. Of the 25 wolves encountered during the March collaring efforts, one yearling was located and captured as a solitary animal. The remaining wolves encountered were among four packs, with pack size ranging from 3-11 wolves (average pack size was 5 wolves). The composition of the captured and handled individuals was 4 females and 3 males. The four females were one juvenile (1-3 years old; non-breeders), two adults (3-5 years), and one older adult (6+ years based on heavier patterns of observed tooth wear and breakage). One captured male was estimated to be 1-2 years old and the remaining two males were estimated to be 3-5 years old. All animals were observed to be in good body condition, with scores ranging from 1-3 on a 0 (skinny) to 4 (fat) scale (average body condition was 2.1).

Prior to the start of collaring this winter, there were seven active wolf collars that had been deployed from 2020 to 2022. Due to the high rates of wolf mortality, individual dispersal from packs, and differences in movement behavior between male and female wolves observed in our previous collaring efforts, two wolves within each pack were collared this year. This effort resulted in collaring one new pack (two collars), a second collar added to two collared packs, and a second collar added to two packs (one each) with existing collars set to release in May 2023.

2.1.2 June 2023 Capture and Handling

Between 8-12 June 2023, three GPS collars were deployed on wolves within the Bathurst caribou summer range. Efforts were focused on potential den sites from GPS collar data, currently collared wolves, and five potential den sites identified in a survey the previous week (see section 2.3). Deployment locations and flight lines for 19.7 hours of flying are shown in Figure 4.

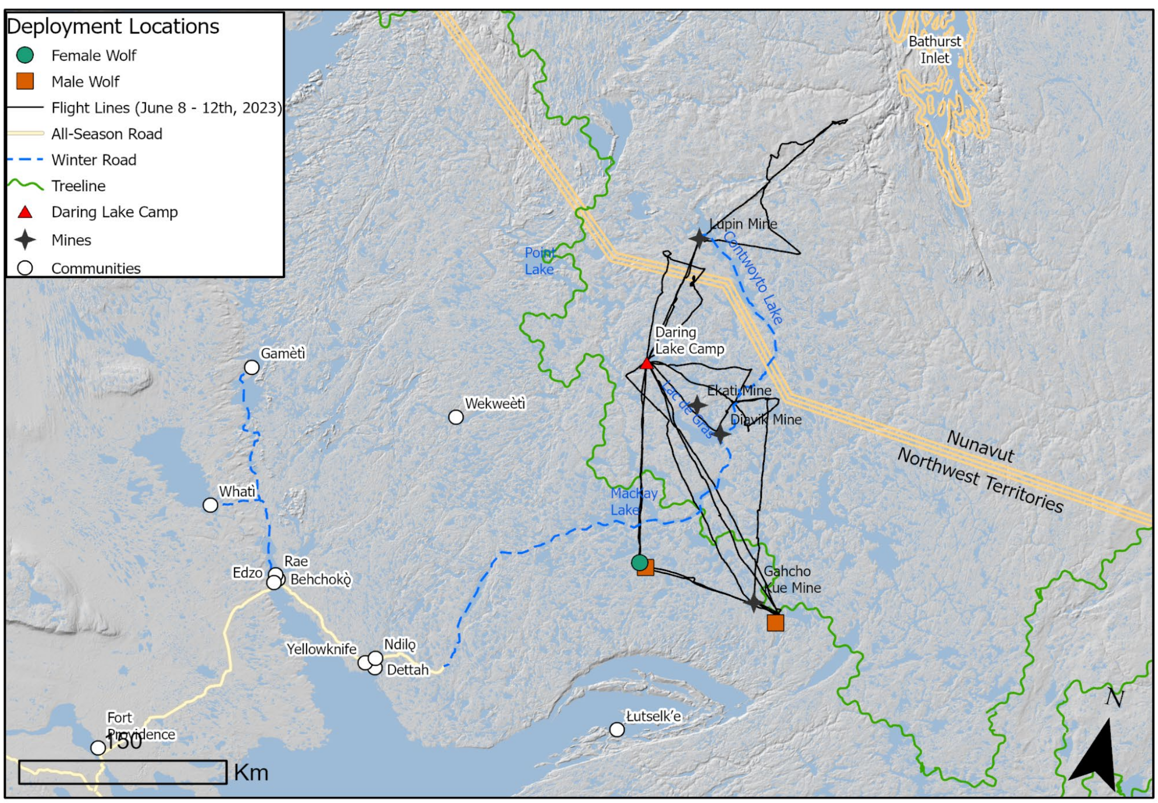

Figure 4. Flight lines and distribution of GPS/Iridium satellite collared wolves in June 2023. Efforts were based from Daring lake camp (red triangle).

Wolves were captured in June using the same methodology and capture team as the March effort. Given the lack of snow and occurrence of rocks, open water, and willows, additional time was required to capture the wolf in a safe location. Each collaring event consisted of multiple quick chases (<35 seconds) that were grouped into three chase events for each wolf ranging from 4 seconds to 3 minutes. Wolves were also given breaks (1-7 minutes) to allow for cooling and recovery. The average handling time was 31.3 ± 5.3 minutes, which included the time from net launch to full recovery from immobilization. Each wolf was ear tagged and fitted with a GPS collar similar to the March effort. Priority measurements (neck and chest circumference, body length, and body condition score) and biological samples (ear biopsy, hair, and blood) were collected from all three wolves. However, body weight and feces samples were not collected from any of the three wolves, as all showed signs of high stress and hyperthermia.

Table 1 shows the collaring details of wolves collared in June 2023. Of the three wolves encountered during the June collaring efforts, two individuals were identified at one den site and one individual at another den site. The composition of the captured and handled individuals was one female and two males. The one female was a juvenile (estimated to be 1-2 years old) and the two males were a juvenile (estimated to be 2-3 years old) and an adult (3-5 years old). All animals were observed to be in poor body condition, with scores ranging from 1-2 on a 0 (skinny) to 4 (fat) scale (average body condition was 1.3).

Table 1. Wolf collar deployments in March and June 2023.

Date	ID	Sex	Age Class	Fate (October 2023)
06/12/2023	WF-NS23-14	Male	Adult (3-5 yrs)	Active
06/09/2023	WF-NS23-22	Female	Juvenile (1)	Active
06/09/2023	WF-NS23-04	Male	Juvenile (2-3)	Premature collar removal[1]
03/13/2023	WF-NS23-03	Male	Adult (3-5 yrs)	Active
03/13/2023	WF-NS23-02	Female	Adult (3-5 yrs)	Harvested
03/11/2023	WF-NS23-12	Female	Old Adult (6+)	Active
03/09/2023	WF-NS23-08	Female	Adult (3-5 yrs)	Active
03/09/2023	WF-NS23-05	Male	Adult (3-5 yrs)	Active
03/08/2023	WF-NS23-01	Female	Yearling (1-2 yrs)	Active

[1]Collar was found on the ground with the release mechanism still intact and the cotton insert broken.

2.1.3 Chemical Immobilization and Monitoring

Ten (10) adult grey wolves were captured using a two-step approach that included physical capture followed by chemical immobilization with an injectable anesthetic. Wolves were caught by net-gun capture with manual restraint using a Y-pole and passive eye cover, followed by hand-injection of 0.5 mL of a commercially available reversible combination of Butorphanol (27.3 mg/ml), Azaperone (9.1 mg/ml), and Medetomidine (10.9 mg/ml) (BAMII; Chiron Compounding Pharmacy, Guelph, ON, Canada) in March and June 2023. Anesthesia was reversed with Atipamezole (1.1 mL, 25 mg/ml) and Naltrexone (0.5 ml, 50 mg/ml). Mean dosage volume of BAMII administered was 0.51 mL ± 0.03. Mean induction time was 5.55 ± 3.5 minutes and time to ambulation following reversal administration was 5.18 ± 2.83 minutes. Vital parameters measured were within expected limits: on average, oxygen saturation observed during handling was 87.35% ± 1.37, rectal temperature was 40.2°C ± 1.4, pulse rate was 102.0 beats per minute ± 22.0, and respiratory rate was 39.4 breaths per minute ± 17.5. All wolves recovered well, and survival was confirmed by observation of movement from fitted GPS collars. Six of ten (6/10) wolves had normal rectal temperatures at time of reversal and prior to release. Capture related injuries were observed on five animals, including a cutaneous laceration, laceration to the tongue/lip, broken nail, and a fractured tooth. One animal experienced a transient breakthrough event with re-sedation within 2 minutes. Biological samples and data were collected from all handled animals for health monitoring. Overall, this multi-modal approach proved to be a safe, rapidly effective, and reversible option for the capture, handling, and release of wolves, and supported the application of GPS collars, ear tags, and collection of a full suite of health data and samples.

2.1.4 Collar Retrieval

Stationary and released collars have been retrieved opportunistically throughout the program. This year, collars were retrieved during capture and handling efforts in June. During the June effort, one released collar was retrieved, and two stationary collars were investigated. One stationary collar was not found (suspected to be in water) and the other was retrieved from a deceased wolf, assumed to have died from natural causes in 2021 as the carcass was found with no signs of human interaction (i.e., skull and skeleton intact, collar release mechanism was intact, whole carcass was not taken or skinned). However, we cannot rule out the possibility that it was shot and died after the fact. The collar, ear tag, hair, skull, and bones were collected from the site for ageing and health screening. Additionally, a concerted effort for collar retrieval was made from July to September through a fixed-wing aircraft contract. Seven collars were investigated; six of which were retrievable. Of the six collars retrieved, one still had the release mechanism intact (deployed without a cotton insert) and the other one had the release mechanism intact but the cotton insert was broken. At this point in the program, 25% percent of the collars are active, 21% are to be investigated (released and need to be retrieved or stationary and need to be investigated), 34% were collected from a mortality (harvest or natural), and 27% have been investigated (retrieved or determined to be irretrievable; Table 2). Three collars are currently released in Nunavut, and ECC will work with the Government of Nunavut to retrieve these collars, investigate potential mortalities, and collect samples when possible.

Table 2. Status of wolf collars from 2019 to October 2023.

Wolf fate (2019-Oct 2023)	Number (%) of collars
Active	12 (25%)
Released (to be retrieved)	2 (4%)
Stationary (to be investigated)	8 (17%)
Harvested	6 (13%)
Mortality + assumed mortality[1]	10 (21%)
Released and retrieved[2]	10 (21%)
Irretrievable	3 (6%)
TOTAL	51 (100%)

[1]Assumed mortality for 2 collars, as the mortality signal was received and classified as a stationary collar, but needs to be investigated.
[2]Two collars were removed and found on the ground, but the release mechanism was still intact for both collars. The cotton insert was broken on one collar. Three collars were retrieved, but no details provided.

2.1.5 Discussion

When combining both capture efforts (March and June), wolves encountered were in 7 packs and pack size ranged from 1-11 wolves with an average of 4.0 wolves, which is similar to the average of 4.3 wolves in 2022. During the March effort, body condition scores ranged from 1-3 with an average of 2.1, which is lower than the average of 2.6 during March collaring efforts in 2022. As of October 2023, 48 wolves have been collared over the preceding three years; 19 of the collared wolves have died, 5 collars are currently stationary and need to be investigated, 2 collars (from 2021 and 2020) have been released on schedule and need to be retrieved, and 12 collars are currently active and transmitting data (Tables 1 and 3), 7 of which were deployed in 2023. Prior to the start of collaring in March 2023, there was one active wolf collar that had been deployed in 2020, five active collars deployed in 2021, and one active collar deployed in 2022. In combination with population surveys, den site investigations, and health screenings, this capture and handling program is intended to enhance monitoring efforts and improve our understanding of wolf movements within and between caribou herds on the central barrens. Additional capture and handling efforts will take place in March 2024 to attempt for a total of 30 active collars on wolves.

Table 3. Collar deployments and status from 2020-2023, as of October 2023.

Deployed		Capture/Handling Mortalities	Post-Capture Mortalities	Stationary status (Oct 2023)	Total Active Collars (Oct 2023)
2020	13	3	2	0	1
2021	19	0	9	4	3
2022	7	0	4	1	1
2023	9	0	1	0	7
Total	48	3	16	5	12

2.2 Wolf Movement patterns

Grey wolves are known to be range resident predators that defend territories and rely on prey species within these territories (Mech & Boitani, 2003). The tundra grey wolf is a unique ecotype that has been shown to abandon established ranges around denning sites for portions of the annual cycle presumably to follow the main prey species in the area, barren-ground caribou, through the winter season (Musiani et al., 2007; Walton et al., 2001). Studies investigating tundra grey wolf den site selection on the Bathurst barren-ground caribou range have shown a trend for individuals to den near the treeline, and early and late summer prey distribution were the best predictors of den site (Heard & Williams, 1992; Klaczek, 2015). Klaczek (2015) also explored den site selection in relation to Bathurst caribou range contraction and concluded that tundra grey wolves did not shift den site selection towards the calving grounds.

In 2022, Caslys Consulting Ltd. conducted an analysis of wolf movement patterns relative to barren-ground caribou movements using collar data from individuals of both species from March 2020 to June 2022. These analyses were conducted on annual and seasonal temporal scales, and were informative in grouping wolves into movement groups (north-south, east-west, and stationary) and relating these movements to caribou movements (Caslys Consulting Ltd., 2022). These analyses showed that space use and movement patterns were variable across individuals over the three-year period. However, there was a high degree of consistency in annual movement patterns within individuals. Seasonally, wolves displayed clustered movements and space-use for both the spring and calving time periods. Identifying these movement patterns was a first step towards understanding the spatial distribution of potential wolf-caribou interactions.

We aim to further assess whether spatial-temporal patterns in wolf movements are associated with changes in numerical abundance of Bathurst and Bluenose-East caribou herds along with dynamic patterns of winter range overlap with the much larger Beverly herd. Building on the analysis of Caslys Consulting Ltd (2022), Abernethy (in prep) assessed wolf movement at a finer temporal scale (location by location). The specific objectives of this analysis were to:

- Identify range resident vs non range resident wolf behavior throughout each wolf satellite collar deployment and;
- Explore the temporal and spatial patterns of range resident vs non-range resident behavior patterns.

Range resident movement is defined as movement with a central mean tendency, while non range resident movement lacks the central mean tendency. Here, central mean tendency refers to the propensity for data points to cluster around a middle value (i.e., linear movements do not have clusters). Range resident movement is movement within a concentrated area (often referred to as a range or territory) with apparent boundaries. Geographic patterns in the distribution of tundra grey wolf ranges (periods of range resident behavior) were also explored.

2.2.1 Datasets

This analysis was conducted on the wolf telemetry data collected from March 2020 to the end of March 2023. Data from collared wolves with less than seven days of tracking were excluded, and data from two collared wolves were truncated due to gaps in coverage. In total, data from thirty-eight collared wolves were analyzed (18 females, 20 males); see Table 4 for deployment metadata. Data obtained after March 2023 was not included as this was the cutoff date for data to be used for this thesis research. As previously described, various sampling rates were used across these deployments (see Wilson et al., 2022). However, methodologies used here are insensitive to sampling differences, so data was not subsampled/standardized across deployments.

Table 4. Metadata for GPS collar data collected from wolves captured and handled from 2020-2022.

Animal ID	Sex	Start Date	End Date	Duration Days	Number of locations
Exclusively range resident					
WF-NS20-23	Female	2020-04-29	2022-05-17	748	1675
WF-NS20-29	Female	2020-03-13	2022-05-14	792	1868
WF-NS21-20	Male	2021-03-29	2021-07-20	113	363
Range resident with short trips					
WF-NS20-01	Male	2020-04-26	2022-01-07	621	1990
WF-NS20-12	Male	2020-03-18	2020-07-29	133	514
WF-NS20-18	Male	2020-03-19	2020-07-26	129	505
WF-NS20-22	Female	2020-04-26	2020-09-26	153	373
WF-NS21-03	Male	2021-03-23	2021-06-06	75	261
WF-NS21-07	Male	2021-03-27	2021-11-07	225	674
WF-NS21-14	Female	2021-03-18	2023-03-22*	734	2349
WF-NS21-17	Male	2021-04-01	2021-09-26	178	498
WF-NS22-18	Female	2022-03-12	2022-07-31	141	747
Range resident with short and long trips					
WF-NS20-02	Female	2020-04-27	2022-07-09	803	2475
WF-NS20-21	Female	2020-04-01	2022-05-09	768	1889
WF-NS20-27	Male	2020-03-16	2022-05-16	791	1960
WF-NS20-30	Male	2020-03-17	2021-05-28	437	1128
WF-NS21-04	Male	2021-04-01	2022-03-16	349	1140
WF-NS21-08	Female	2021-03-16	2023-03-22*	736	2373
WF-NS21-10	Male	2021-03-16	2023-03-22*	736	2415
WF-NS21-15	Female	2021-03-24	2022-04-24	396	1258
WF-NS21-16	Male	2021-03-25	2022-04-23	394	1308
WF-NS21-24	Female	2021-04-01	2023-03-23	721	1634
WF-NS21-25	Female	2021-03-28	2022-04-27	395	941
WF-NS21-28	Male	2021-03-31	2023-03-23	722	1659
WF-NS21-32	Female	2021-03-22	2022-05-29	433	1380
WF-NS21-33	Female	2021-03-28	2022-02-17	326	1025
WF-NS21-34	Male	2021-03-27	2022-03-25	363	1171
WF-NS22-08	Female	2022-03-15	2023-03-23	373	2169
Inconclusive - no range identified					
WF-NS20-13	Female	2020-03-17	2020-03-28	11	44
WF-NS20-19	Male	2020-03-19	2020-04-18	30	121
WF-NS20-26	Male	2020-03-19	2020-09-17	182	499
WF-NS21-06	Female	2021-03-16	2021-06-05	81	286
WF-NS21-11	Male	2021-03-19	2021-06-04	77	275
WF-NS22-05	Female	2022-03-10	2022-05-02	53	416
WF-NS22-07	Male	2022-03-16	2022-05-31	76	481
WF-NS22-11	Male	2022-03-17	2022-03-25	8	72
WF-NS22-14	Male	2022-03-16	2022-04-14	29	230
WF-NS22-15	Female	2022-03-10	2022-04-01	22	172

* Date of data query - deployment ongoing at time of query

2.2.2 Methods: Segmentations

Visual inspection of the wolf telemetry data indicated significant variation among wolves in space use patterns. Examples could be seen of 1) wolves remaining range resident within a visually identified range throughout the year, 2) wolves being range resident for various portions of the year while making several shorter trips outside the visually evident range at various times of year, 3) range resident behaviour paired with short and long trip movements where visually identified ranges were abandoned during the winter season, and 4) movement with no range resident movement. A meaningful temporal stratification was not possible due to the complexity and variation of the non-range resident wolf behaviour.

Therefore, the locations making up each wolf dataset were stratified by movement pattern. This was achieved by iterating through the dataset location by location while also looking at the movement paths connecting successive locations: the stratification decision was achieved by spatial comparisons of the point of interest against the spatial patterns within the dataset as a whole. Range resident locations were defined spatially as those locations within the visually identified concentration of locations surrounding one or more identifiable den sites. Den sites were identified as concentrations of locations within a constricted area with movement paths radiating in all directions, indicating movement coming and going from the den. Locations that were part of forays outside the spatial concentration of locations surrounding a den site but lasted less than seven days were not considered a change in the range resident pattern. Locations that were part of trips outside the range were identified as either short or long trips. The start and end of each trip were identified as the locations immediately following and preceding return to either an identified den site or instance of overlapping successive locations within the range indicating a break in movement. Locations that were part of trips outside the range lasting 7 to 59 days were described as short trips, while trips 60 days or longer were described as long trips. Several tracks of shorter duration showed no instances of range resident movement in which case all locations were categorized as short trips. The final step was to assign a wolf year, defined as March 1st thru to the end of February the following year, to each portion of the track to facilitate the modeling of annual range distributions. The three observed movement patterns (range resident, short trips, and long trips) were then grouped into four different movement profiles (exclusively Range resident, range resident with short trips, range resident with short and long trips, and inconclusive with no range resident behaviour observed). Visual inspection and manual stratification of each wolf track was conducted within the ESRI ArcPro software and then imported into the R program for statistical analysis.

2.2.3 Methods: Range size and distribution

Range distributions were computed for all periods of range residency pooled throughout a wolf year. Ranges were calculated using the continuous-time movement modeling (ctmm) analytical framework facilitated by the ctmm R package within the R environment for statistical computing (Calabrese et al., 2016; Fleming et al., 2014a, 2014b, 2015a, 2017, 2018, 2019; Fleming & Calabrese, 2017; Noonan, Fleming, et al., 2019; Noonan, Tucker, et al., 2019). Each range distribution was categorized as annual vs partial based on how much of the year the individual was monitored, using a threshold of 334 days (~94% of a full year). This threshold was set to provide adequate annual coverage while accounting for the reality that wolves were collared throughout March; thus, deployment lengths for the first year of monitoring could not exceed 334 days. Partial ranges, where animals were not monitored for more than 334 days, were calculated for periods of range residency that did not have a full deployment year of monitoring, and thus were referred to as partial ranges. These partial ranges were excluded from discussions of range size but included for analysis of geospatial trends in range resident behaviour. Annual range distributions are presented as mean ± standard deviation in kilometers.

The workflow for the creation of range distributions proceeded in the following order; variogram analysis to confirm range residency, model fitting of the continuous time movement models which account for range residency, and then computation of the autocorrelated Kernel density estimates (aKDEs) conditioned on the data and best fitting movement model. This ctmm analytical approach is superior to traditional Kernel density estimation (KDE) as it optimizes the bandwidth to account for spatial and temporal autocorrelation within the data which have been shown to negatively bias range estimates (Fleming & Calabrese, 2017). The 95% contour of the aKDE with 95% confidence intervals are then created and areas computed in square kilometres using the Canadian Albers Equal Area projection.

Distance to treeline was calculated for each annual and partial range and measured as the closest distance between the boundary of each range and the treeline. The Kyoto treeline, defined as continuous forest with a canopy cover of at least 25 percent and a height of 5m (pers comm., Tom Lakusta, Manager, Forest Resources, Forest Management Division, Hay River, NWT) was used. This was chosen as an acceptable representation of the gradual transition from the forest to the tundra biome and more conservative than other treeline representations that capture the northern extent of tree growth. It is important to define the treeline used as there are multiple definitions of treeline in academic research. For example, treeline could be defined as the most northern extent of tree growth (Heard and Williams, 1992).

2.2.4 Results: Segmentation

Manual behavioral stratification of 38 deployments resulted in 4 categories of movement profiles – (1) 100% range resident (n=3; female=2, male=1), (2) range resident with short trips (n=9: female=3, male=6), (3) range resident with short and long trips (n=16; female=9, male=7), and (4) inconclusive (n=10 wolves) due to lack of established range and abbreviated deployments (Table 4, Figure 5). All movement patterns (range resident, short trips, and long trips) occurred throughout the annual cycle and study area (Figures 5-9). Wolves that took longer trips spent a mean of 40% ± 18% of the year in a range resident state compared to wolves that only took short trips that spent a mean of 66% ± 22% of the year in a range resident state (Figure 6).

Patterns in time and space use were evident for both non range resident and range resident wolf activity (Figures 7-9). Wolf activity was concentrated at lower latitudes in December through February, then moved northward to various degrees throughout April through September and returned to lower latitudes starting in October (Figures 7-9). For further clarification, Figure 8 shows only non-range resident movement while Figure 9 shows only range resident movement. All three behavioral patterns were observed on the calving grounds of the Bluenose-East, Bathurst, and Beverly caribou April thru October. Short trips were more prevalent in spring through fall (April-September), and long trips over the winter (October-March).

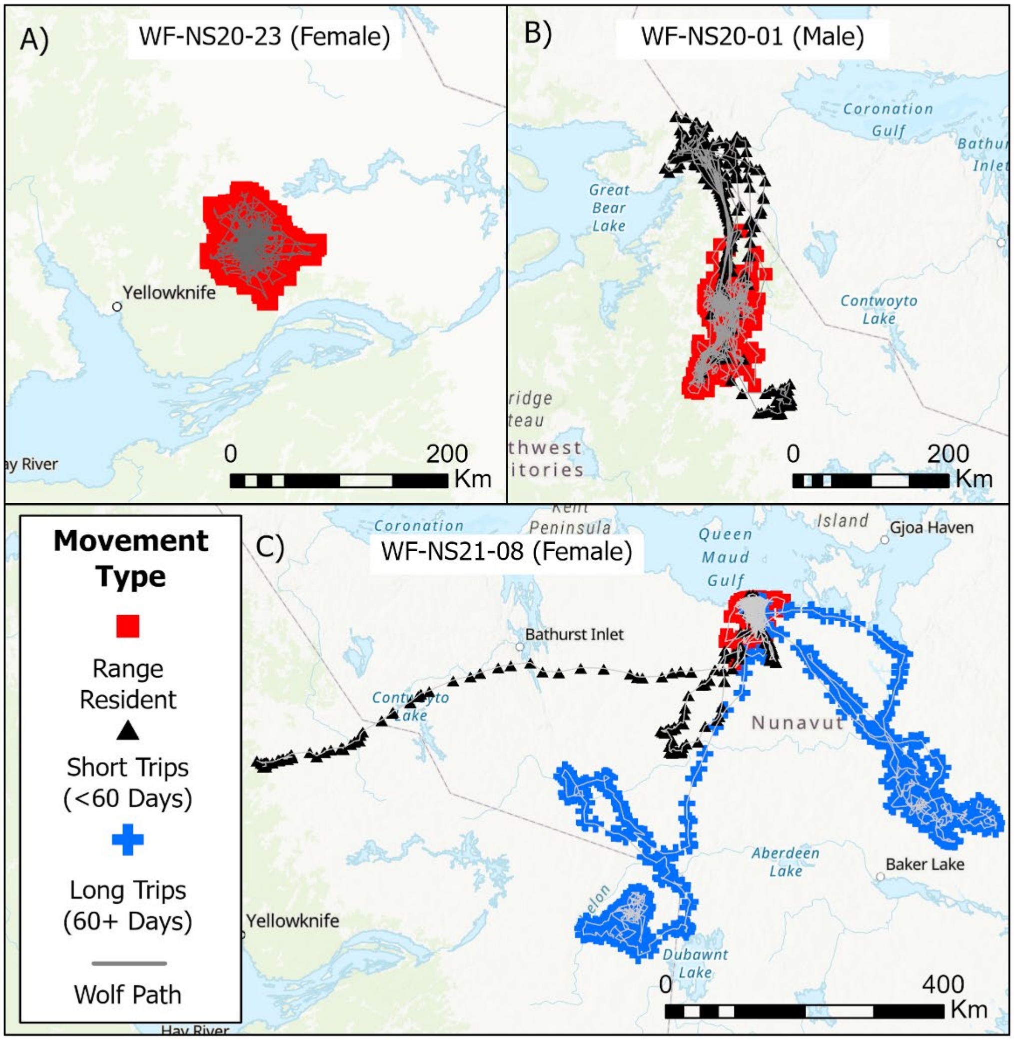

Figure 5. Representative maps of the 3 main movement patterns. A) exclusively range resident, B) range resident with short trips, C) range resident with short and long trips.

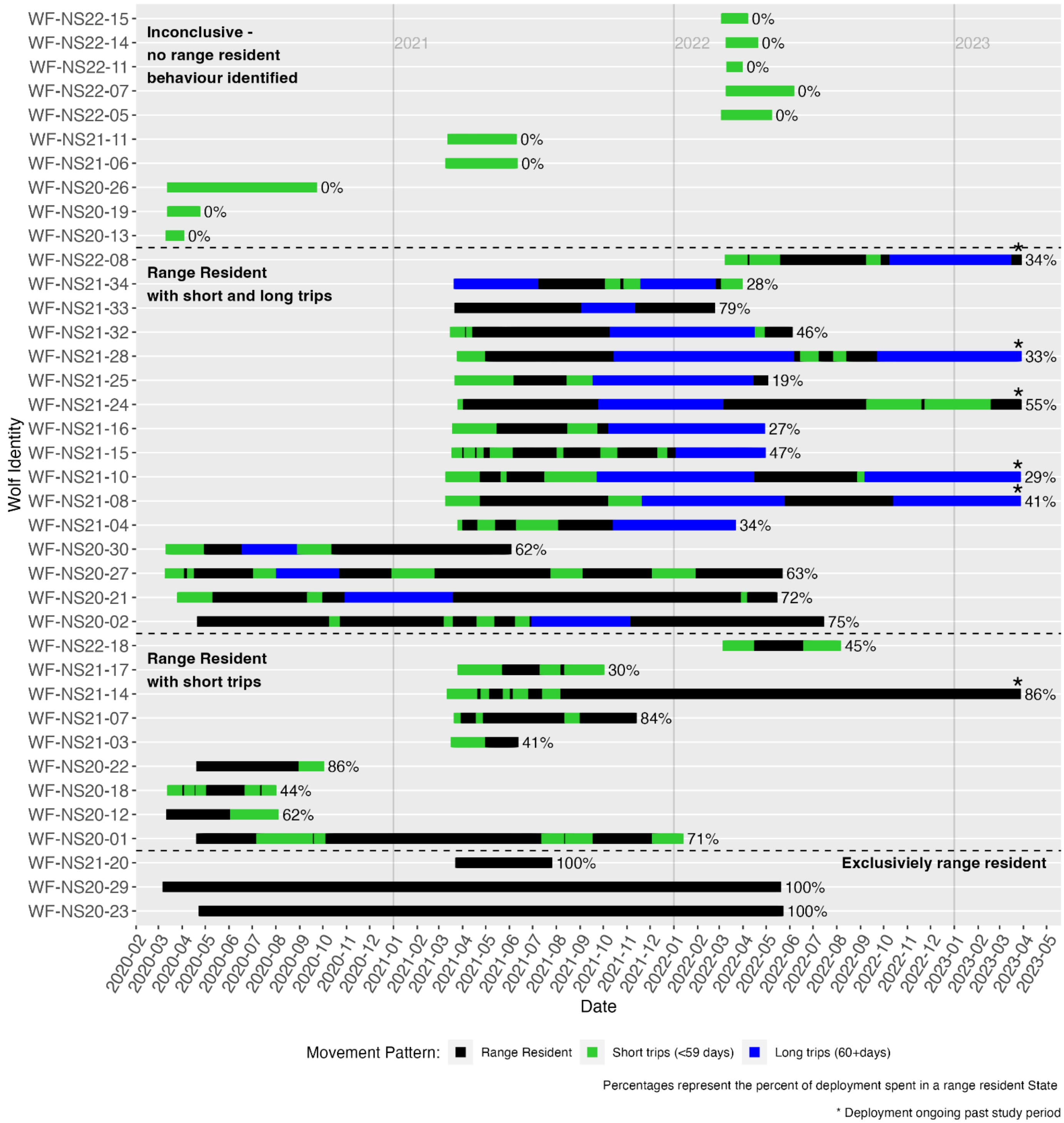

Figure 6. Movement patterns of telemetry monitored grey wolves.

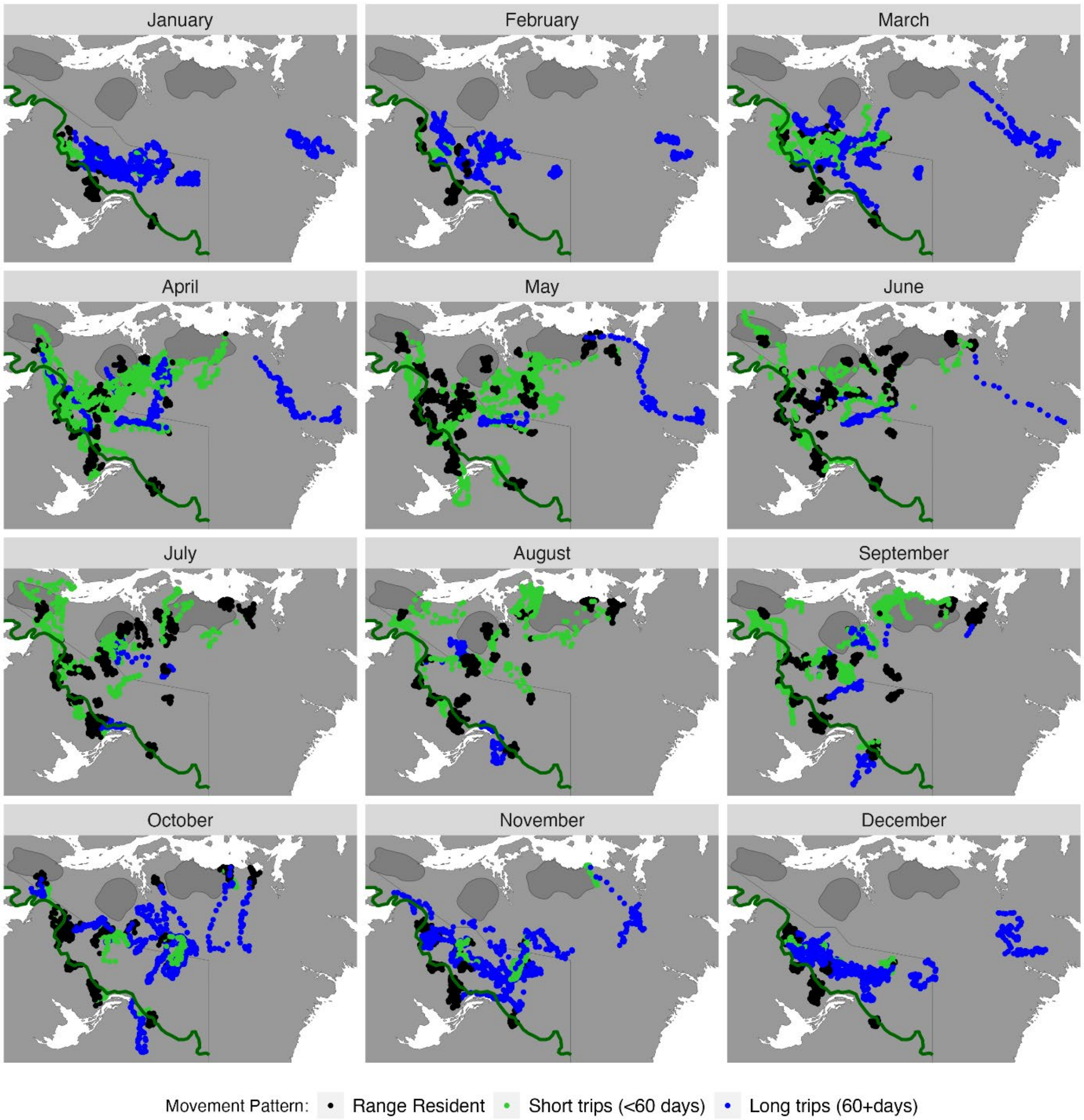

Figure 7. All movement patterns (range resident and non-range resident) of telemetry monitored tundra grey wolves (n=25) by month, March 2020-March 2023. Datasets of wolves assigned to the range resident with short trips or range resident with short and long trips movement categories. Datasets pooled across years, not all deployments last the full time series. Grey polygons from west to east show calving grounds of the Bluenose-East, Bathurst, and Beverly caribou herds respectively.

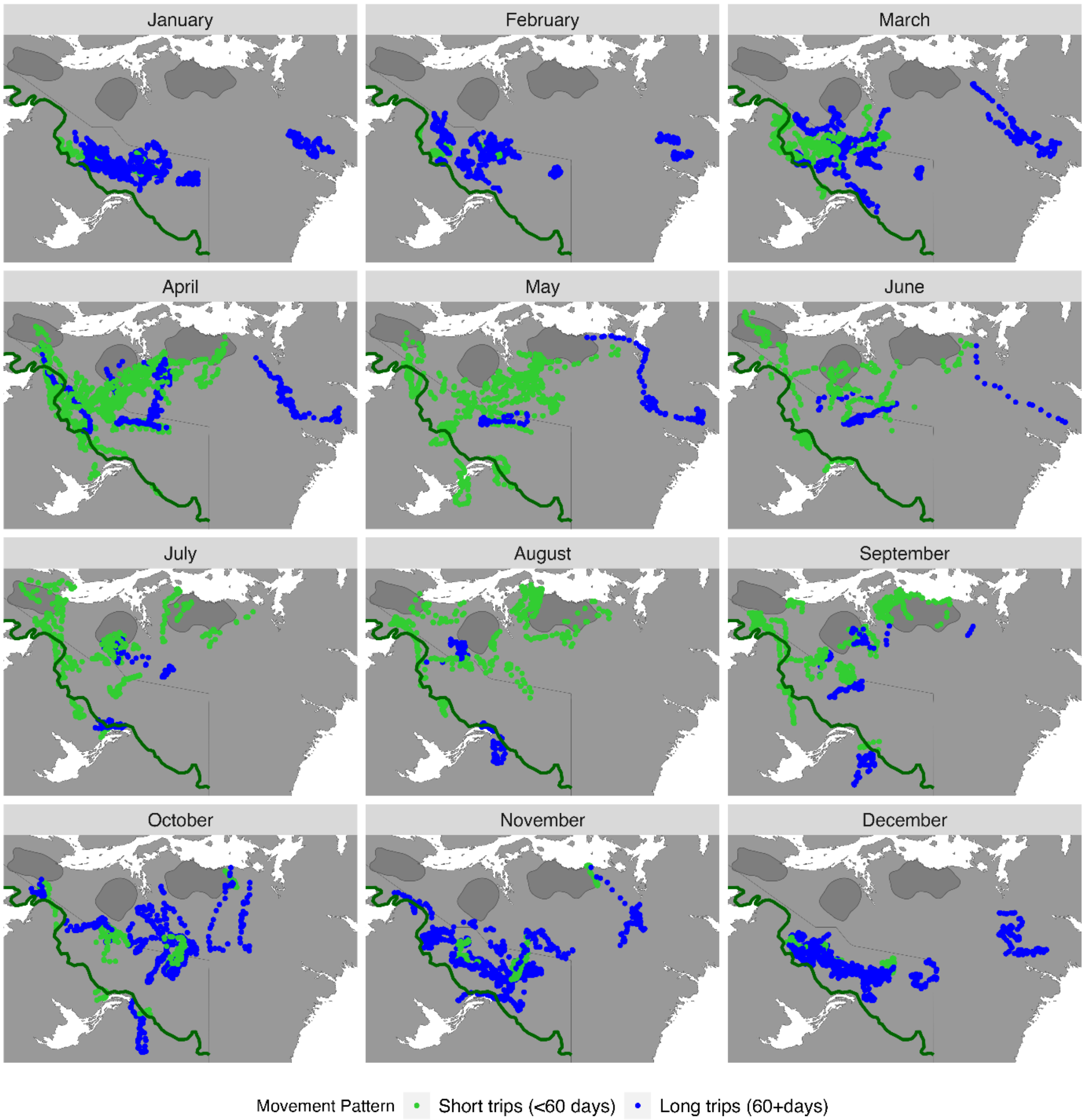

Figure 8. All non-range resident trips of telemetry monitored tundra grey wolves (n=25) by month, March 2020-March 2023. Datasets of wolves assigned to the range resident with short trips or range resident with short and long trips movement categories. Datasets pooled across years, not all deployments last the full time series. Not all individual deployments last the full time period. Grey polygons from west to east show calving grounds of the Bluenose-East, Bathurst, and Beverly caribou herds respectively.

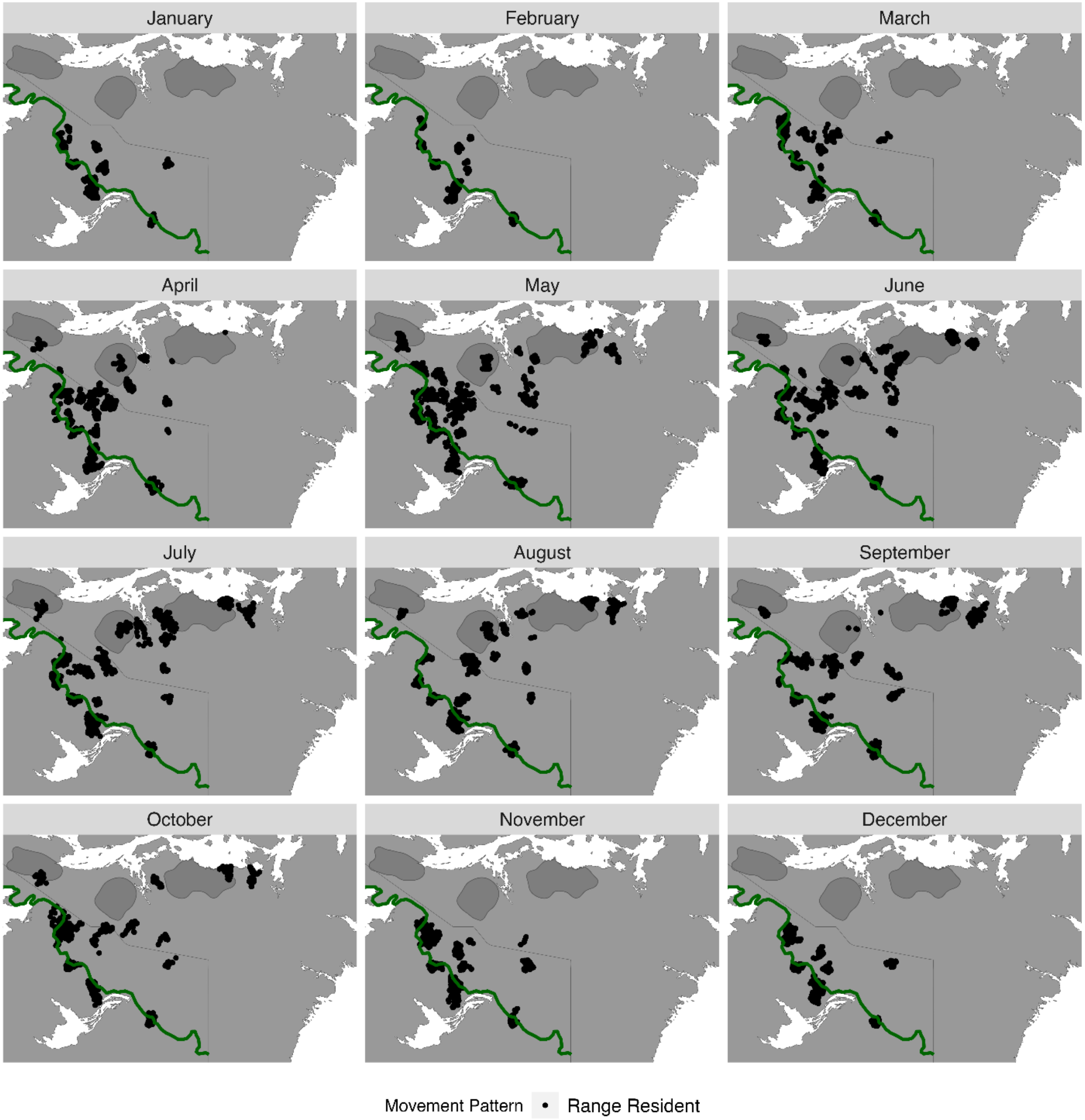

Figure 9. Range resident movement of telemetry monitored tundra grey wolves (n=25) by month, March 2020-March 2023. Datasets of wolves assigned to the range resident with short trips or range resident with short and long trips movement categories. Datasets pooled across years, not all deployments last the full time series. Not all individual deployments last the full time period. Grey polygons from west to east show calving grounds of the Bluenose-East, Bathurst, and Beverly caribou herds respectively.

2.2.5 Results: Range size and distribution

Annual ranges were computed for all sections of an individual wolf's range resident behavior within each complete wolf-year (n=23). Locations when the animal was on a short or long trip were excluded from range calculations. The mean area of annual range distributions for exclusively range resident wolves (2 individuals, n=3), was 3,282km^2 ± 719 km^2 (Table 5), however these estimates are biased in that they were from two females within the same pack. For wolves who went on short trips only (1 individual, n=2) the average area of the annual range was 2,143 km^2 ± 1,001 km^2 (Table 6). For wolves that went on longer trips (14 individuals, n=18) annual range area averaged to 4,132 km^2 ± 2,796 km^2 (Table 6). Degrees of freedom represent effective sample size (compared to number of locations) after identifying the best fit continuous time movement model of each wolf's trajectory, essentially representing the sample size after accounting for autocorrelation within the dataset.

Table 5. Range distribution of range resident wolves.

			Area estimates (kilometres squared)					
	Wolf Year*	Degrees of freedom	lower 95%	estimate	upper 95%	locations	% Wolf Year Monitored	Outcome**
WF-NS20-23								
Female	YR2	108	2,319.5	2,826.9	3,383.6	830	1.0	annual
WF-NS20-29								
Female	YR1	56	3,103.0	4,111.1	5,258.9	857	1.0	annual
Female	YR2	98	2,362.2	2,908.5	3,510.8	819	1.0	annual

*Wolf year was defined as March 1 to February 28
**To compute annual ranges wolf needed to be monitored for ~90% of wolf year, otherwise ranges categoriesed as partial and not reported on here

Table 6. Range distribution of wolves that went on short and/or long trips.

Animal Id		Wolf Year*	Degrees of freedom	Area estimates (kilometres squared) lower 95%	estimate	upper 95%	locations	% Wolf Year Monitored	Outcome**
Range resident with short trips									
WF-NS21-14	Female	YR2	58	2,167.2	2,852.0	3,629.3	756	95.1	annual
WF-NS21-14	Female	YR3	105	1,174.5	1,435.8	1,722.8	1168	99.7	annual
Range resident with short and long trips									
WF-NS20-02	Female	YR2	15	3,999.2	7,086.3	11,042.0	649	99.7	annual
WF-NS20-21	Female	YR2	151	2,146.4	2,535.0	2,955.5	763	99.7	annual
WF-NS20-27	Male	YR1	25	3,148.5	4,847.2	6,906.6	416	95.6	annual
WF-NS20-27	Male	YR2	21	8,281.2	13,333.9	19,570.5	608	99.7	annual
WF-NS20-30	Male	YR1	55	3,223.0	4,279.0	5,482.5	500	95.3	annual
WF-NS21-08	Female	YR2	60	3,097.6	4,062.1	5,155.5	450	95.6	annual
WF-NS21-08	Female	YR3	76	1,881.0	2,387.1	2,952.5	395	99.7	annual
WF-NS21-10	Male	YR2	58	1,893.5	2,492.9	3,173.6	226	95.6	annual
WF-NS21-10	Male	YR3	83	2,581.2	3,238.5	3,969.3	383	99.7	annual
WF-NS21-15	Female	YR2	116	1,513.6	1,832.1	2,180.6	528	93.4	annual
WF-NS21-16	Male	YR2	56	1,697.2	2,248.1	2,875.2	299	93.2	annual
WF-NS21-24	Female	YR3	118	2,144.9	2,592.1	3,081.1	420	99.7	annual
WF-NS21-25	Female	YR2	25	2,266.4	3,502.9	5,004.0	138	92.3	annual
WF-NS21-28	Male	YR2	74	3,485.7	4,441.1	5,510.6	330	91.5	annual
WF-NS21-28	Male	YR3	16	3,678.1	6,416.4	9,904.1	133	99.7	annual
WF-NS21-32	Female	YR2	207	1,499.9	1,727.4	1,970.8	478	94.0	annual
WF-NS21-34	Male	YR2	52	1,370.5	1,837.5	2,372.0	254	92.6	annual
WF-NS22-08	Female	YR3	41	3,966.8	5,531.4	7,352.1	513	95.9	annual

*Wolf year was defined as March 1 to February 28
**To compute annual ranges wolf needed to be monitored for ~90% of wolf year, otherwise ranges categoriesed as partial and not reported on here

Individuals from all movement profiles established ranges (evidenced by range resident movement) in relatively close proximity to the Kyoto treeline (Figure 10). However, moving north and east from the treeline, established ranges were more likely to be from wolves that went on long trips. For exclusively range resident wolves, ranges were a median of 14.1 kilometers and mean of 27.7 kilometers in distance from the treeline. For wolves that took short trips only, the median and mean distance to the treeline was 15.7 and 71.7 kilometres, respectively. For wolves that went on long trips, the median and mean distance to the treeline was 157 and 215 kilometers respectively. Several dens were established within or adjacent to caribou calving grounds of all herds.

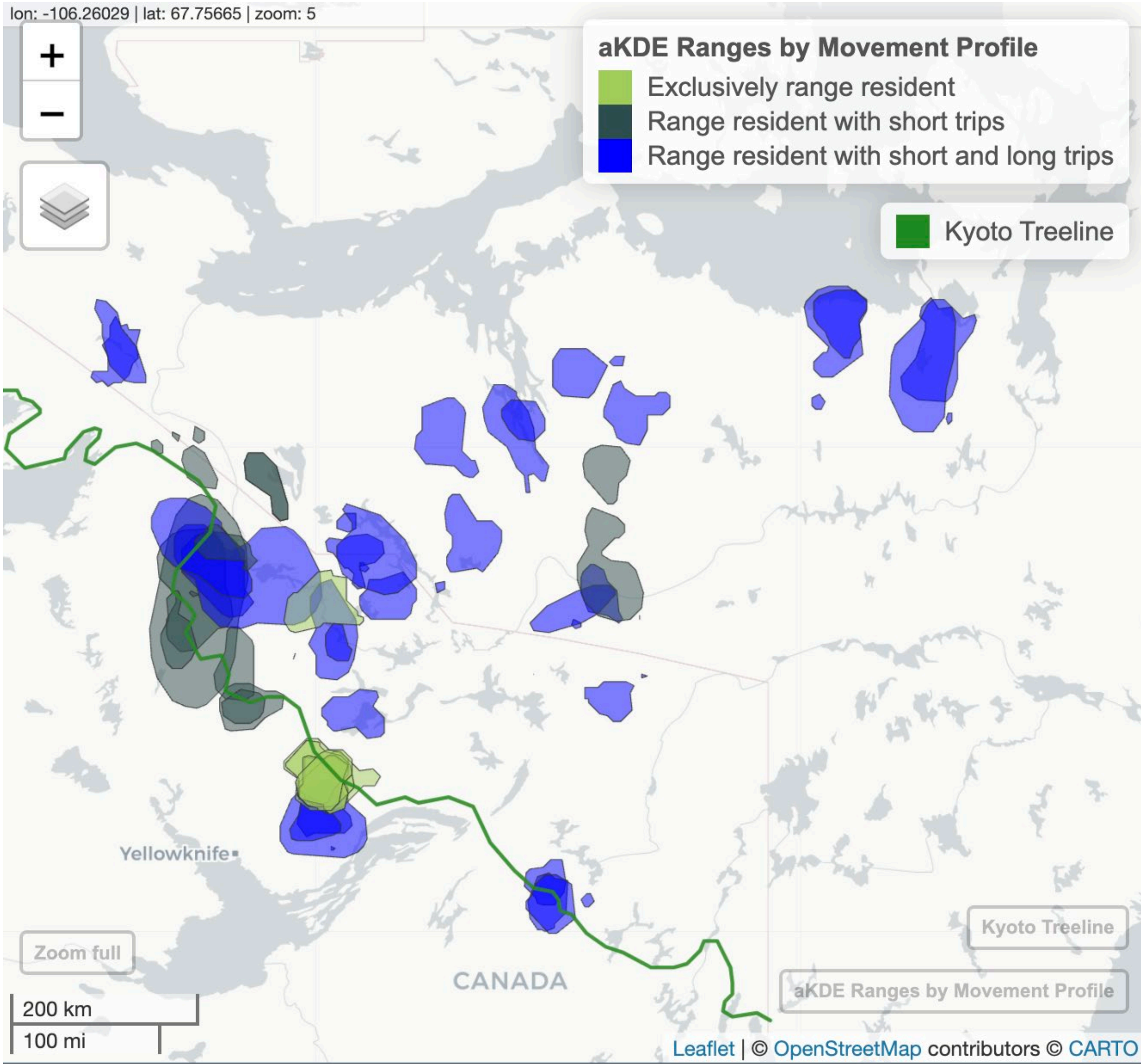

Figure 10. Annual Grey wolf ranges (28 individuals) delineated from the 95% contour of range distribution probability surfaces delineated with aKDEs. Ranges symbolized by wolves movement profile. Ranges are both complete (n=23) and partial (n=26), dependant on proportion of wolf year (March - February) wolf was monitored for with complete ranges representing 90% monitoring coverage of a given wolf year.

The spatial distribution of ranges presented here also provides context to the results of the analysis on spatial movement patterns of grey wolves completed by Caslys Consulting in 2022 (Figure 11; Caslys, 2022). The results of these two analyses aligned tightly for exclusively range resident wolves which were classified as exclusively stationary in the Caslys analysis. There was less alignment between the two analyses when examining wolves who exhibited non-range resident movements. Animals classified as range resident with short trips and range resident with short and long trips were classified in the Caslys analysis as both East-West and North-South movers. Future investigations should examine the spatial distributions of the non-range resident movements to Caslys movement groups to further understand wolf movement relative to caribou herds. So far, neither analysis has demonstrated a proven correlation between wolf movement and specific caribou herds.

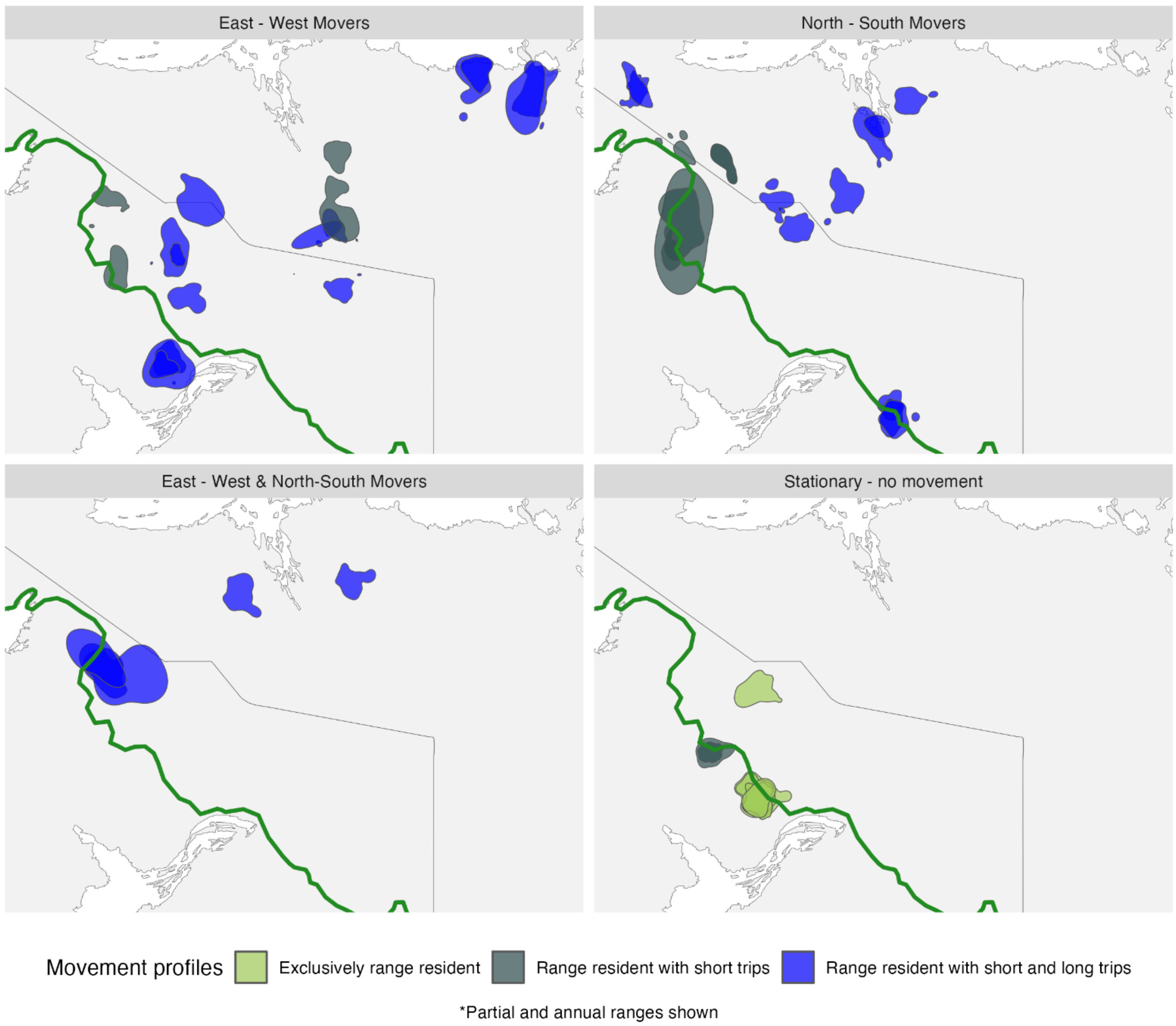

Figure 11. Annual Grey wolf ranges (21 individuals) delineated from the 95% contour of aAKDE range distribution probability surfaces delineated with aKDEs. Ranges symbolized by wolves movement profile. Ranges are both complete (n=17) and partial (n=19), dependant on proportion of wolf year (March - February) wolf was monitored for with complete ranges representing 90% monitoring coverage of a given wolf year.

2.2.6 Discussion

This analysis represents a novel approach of manually segmenting wolf telemetry data on a location-by-location basis not seen in previous telemetry-based investigations of tundra grey wolf space use on the Canadian tundra (Klaczek et al., 2016; Walton et al., 2001). Previous studies have found that tundra grey wolves concentrate denning along the treeline (Heard & Williams, 1992; Parker 1973), migrate below the treeline in the winter, and are not a considerable predation risk on the calving grounds (Heard et al., 1996; Kuyt, 1972; Parker, 1973). Results of previous studies have also suggested that there are few wolf dens on the calving grounds based on caribou centric aerial survey sighting rates (Klaczek et al. 2015). Preliminary results presented here show tundra grey wolves den across the tundra up to and along the Arctic Ocean coastline while also demonstrating relatively little time is spent below treeline. Finally, month by month visualization of both range resident and non-range resident behaviors appear to suggest a pattern of migratory coupling, as seen in other barren-ground caribou and wolf systems (Michelot et al., 2023) rather than predator avoidance.

Several possible reasons could explain differences in tundra grey wolf movement ecology observed between this and previous studies. These results are preliminary, and further statistical analysis should be conducted to confirm there is no treeline selection at play regarding den-site selection. Barren-ground caribou range contraction due to declining populations (Virgl et al., 2017) could explain the reduced amount of time spent below tree level, although treeline definitions themselves could bias this interpretation. Heard and Williams (1992) defined the treeline in their analysis as the northern extent of tree growth which would be further north than the Kyoto treeline used here. Furthermore, the differences in wolf spatial ecology observed here compared to previous research outcomes could be driven by the influence of the past several years of wolf removals from the landscape.

Previous work completed by Caslys Consulting Ltd. (see Wilson et al., 2022) reported caribou-wolf interactions both in terms of the number of grid cells where the two species overlapped and in the number of wolves overlapping with each caribou herd. Their results suggested that the Bathurst caribou herd interacts with more wolves than other herds, but many wolves were interacting evenly across all barren-ground caribou herds. The movement analysis by Abernethy et al., (*in prep*) will be combined with the grid cell analysis to assess caribou and wolf overlap in the future.

2.2.7 Genetic analysis of collared wolves

2.2.7.1 Introduction

Genetic research on wolves has been completed at both a continental scale (Schweizer et al., 2016) and within the arctic specifically, genetic structure of wolves has been shown to correlate strongly to transitions in habitat type (Carmichael et al., 2007; Carmichael et al., 2001). Musiani et al. (2007) reported a boundary at the southern limit of the barren-ground caribou migration in NWT could be used as a distinction between boreal and tundra wolf ecotypes, and further suggested that this genetic differentiation could be caused by prey-habitat specialization rather than distance or topographic barriers. Given that fine scale differences in movement behavior between groups of GPS collared wolves have been elucidated (see section 2.2), we aimed to compare haplotype sequences from wolves collared across the NWT to those from Musiani et al. (2007). By combining this information with the movement analysis, we aimed to understand whether wolves with different movement behaviors had similar genetic characteristics and further understand the different ecotypes across the region. For the sake of this report, only data from wolves collared in the North Slave Region (treeline and above) as part of the wolf management research program is presented and discussed; samples from elsewhere in North Slave, South Slave and Beaufort Delta regions were also analyzed and will be reported on in the future.

2.2.7.2 Methods

From 2020-2022, genetic samples (blood, tissue, and/or hair) were collected from 30 of 38 wolves fitted with GPS collars across the Northwest Territory. Musiani et al. (2007) found that genetic differences between the tundra and boreal were strongest using mitochondrial DNA haplotypes, thus mitochondrial DNA was sequenced in the same region in the new samples so that a direct comparison could be made. Laboratory and data analysis was completed by Dr. Jamie Gorrell at Vancouver Island University in summer 2023. Briefly, DNA was extracted from blood, tissue, and hair samples using Qiagen DNeasy extraction kits. We sequenced the same 425-bp segment of the mitochondrial control region as Musiani et al. (2007), but using primers Thr-L (Leonard et al., 2005; Vilà et al., 1999) and DLHcan (Leonard et al., 2002) to improve amplification success (Muñoz-Fuentes et al., 2009). DNA was amplified by PCR containing 12.5 µl of 2x Master Mix (New England Biolabs), 0.4 µM of forward and reverse primer, 2 µl (~200–600 ng) of template genomic DNA, and ribonuclease-free water, to a final volume of 25 µl. PCR conditions were 4 min denaturation at 94ºC, followed by 35 cycles of 30 s at 94ºC, 30 s at 55ºC, 30 s at 68ºC, and a final extension for 1 min at 68ºC. Amplified products were visualized on 1% agarose gel and cleaned using ExoSAP-IT (ThermoFisher) before Sanger sequencing in both directions. Consensus sequences for each sample were constructed from overlapping forward and reverse sequences after trimming low-quality ends and primer regions, using Geneious v10.2.6 (Kearse et al., 2012). Haplotypes were identified by alignment with known wolf haplotypes from Leonard et al. (2005) or Muñoz-Fuentes et al. (2009) which are available on GenBank. Sequence data from Musiani et al. (2007) is not publicly available though many of the same haplotypes can be obtained from Muñoz-Fuentes et al. (2009). We also received some additional raw sequence data directly from Dr. Marco Musiani but were unable to obtain the original sequence data for haplotypes lu40-lu45.

2.2.7.3 Results

Sequence data was obtained from all 30 samples, and we matched 28 of these to known haplotypes and therefore assigned them to an ecotype based on the relative frequencies of those haplotypes in one ecotype or the other. There were 2 samples (representing 2 different haplotypes) whose sequences did not match any of the haplotype sequences we had available for comparison. These haplotypes are likely to match with lu40-lu45 but without the original sequences for comparison, they remain unknown.

According to Musiani et al. (2007) most haplotypes were observed only in one ecotype or the other which makes it easy to assign samples to one or the other. However, haplotype lu32 was the most common haplotype in both boreal and tundra ecotypes which makes this more difficult. In Musiani's study, haplotype lu32 made up 71% of the tundra population but only 22% of the boreal population. Hence, the deduction was made that any wolf with the haplotype lu32 is three times more likely to have come from the tundra than the boreal, but this does not eliminate the possibility that it came from the boreal as 1 in 5 boreal wolves had lu32.

Like Musiani's findings, lu32, was the most common haplotype found in this study with 76% of sampled wolves having lu32 in this study compared to 71% in Musiani's study; this haplotype is three times more likely to be of the Tundra ecotype. For sampled wolves, those with the lu32 haplotype were found to be exclusively range resident (n=3), range resident with short trips(n=4), and range resident with short and long trips (n=10), or had inconclusive movement patterns (n=6) further supporting that the lu32 haplotype is found in both boreal and tundra wolves, making it difficult to assign any given individual to the boreal or tundra group. Of the 10% (n=3) of sampled wolves with the lu29 haplotype, which are 4 times more likely to be boreal, wolves were assigned to the range resident with short trips movement category (n=2) or had inconclusive movement patterns (n=1). These results highlight inconsistencies in what is traditionally thought to define boreal (small territory with prey other than barren-ground caribou) and tundra (large territory dependent on barren-ground caribou as prey) wolves. Based on the genetic analysis, some wolves were defined as tundra; however, the same wolf showed range resident movement behavior consistent with the boreal ecotype (Figure 12). Both the genetics and movement data (Figures 12 and 13) show that it is difficult to differentiate between the ecotypes. During the winter months (February/March), caribou from multiple herds can congregate in a given area (see previous sections on herd overlap), which is thought to encourage immigration of wolves from different areas. During this time, wolves are also breeding, providing seasonal opportunity for genetic mixing. Overall, the movement strategies defined here do not necessarily align with what Musiani et al. 2007 found.

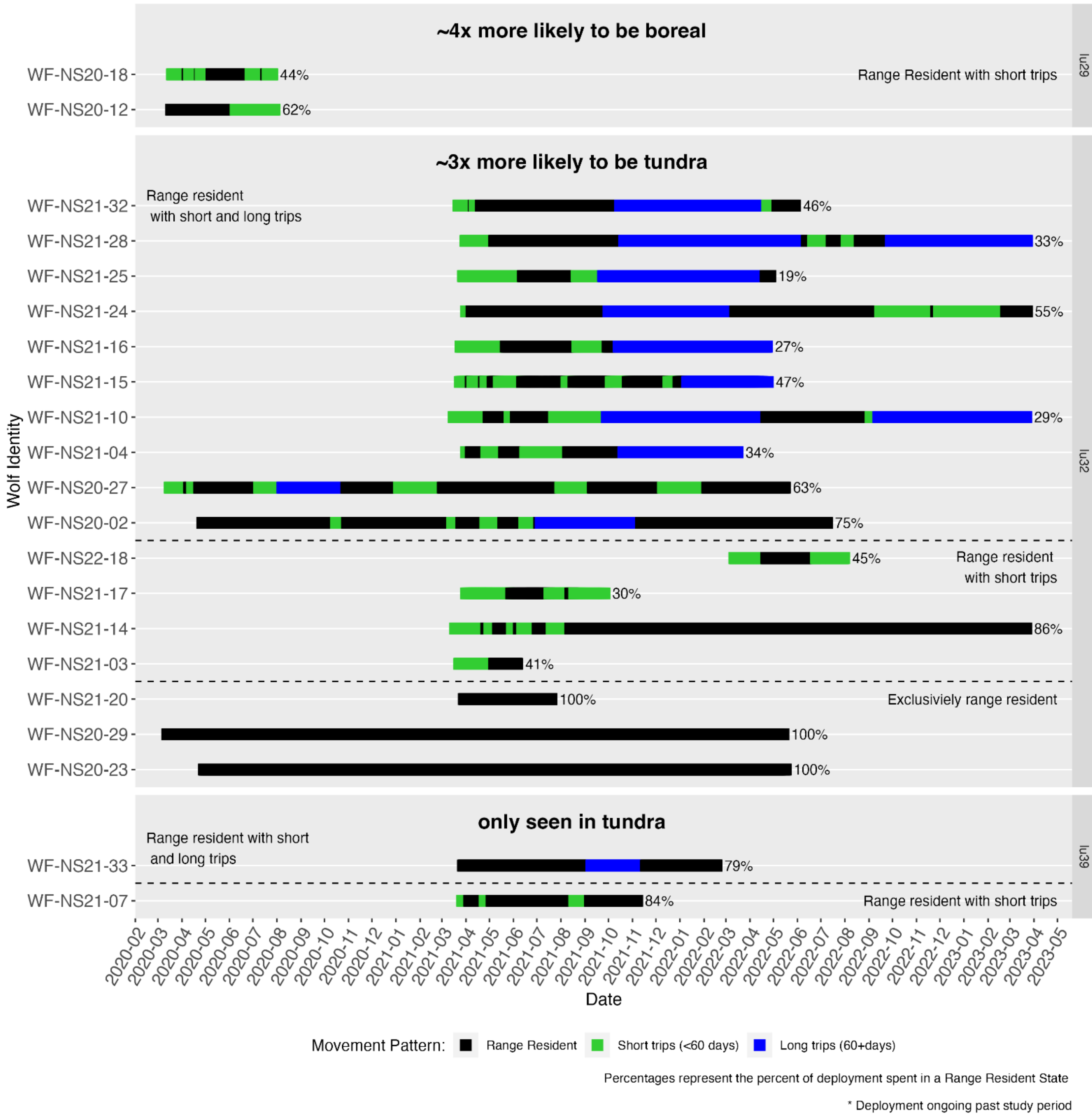

Figure 12. Movement patterns of telemetry monitored grey wolves by haplotype.

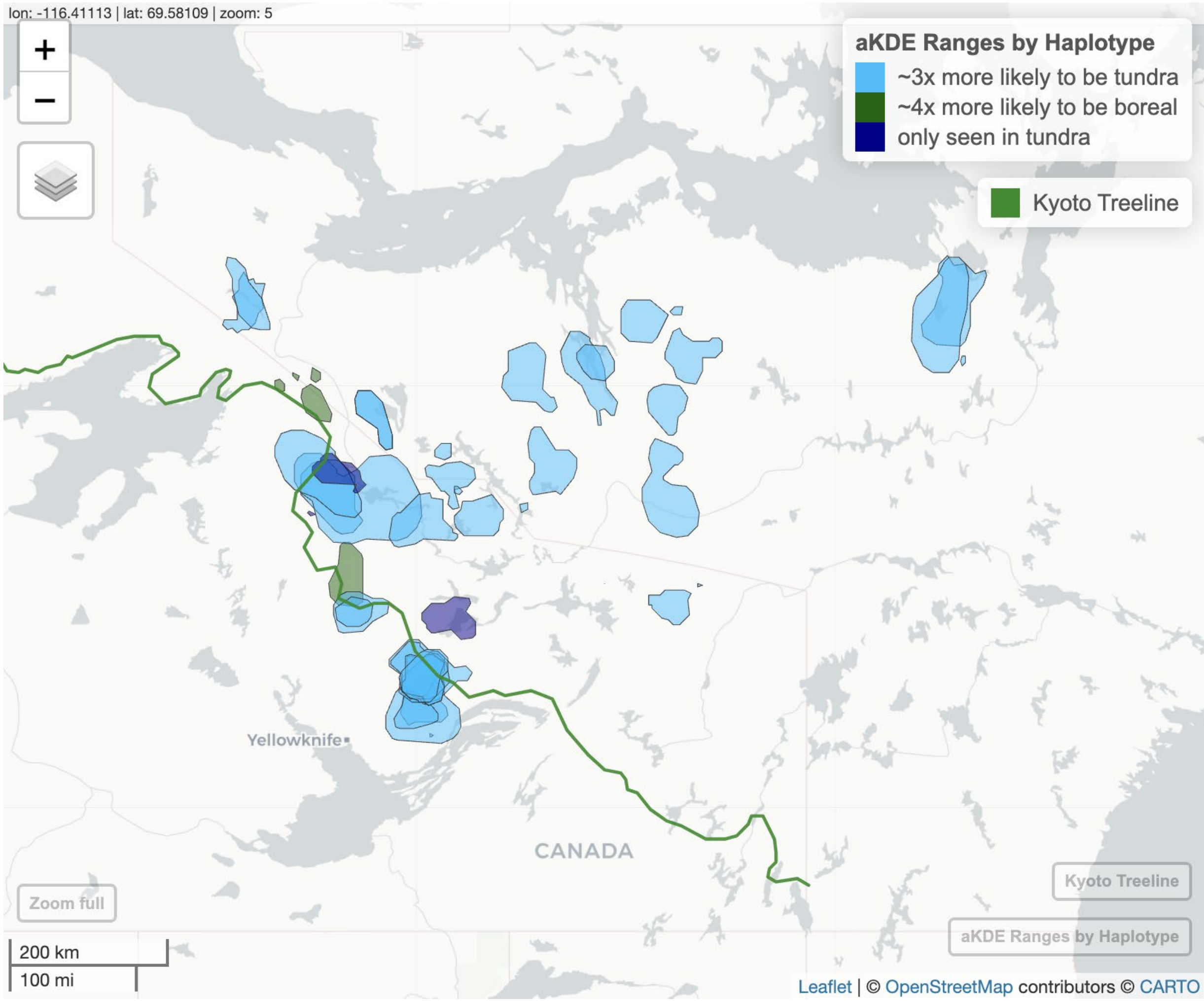

Figure 13. Annual Grey wolf ranges (21 individuals) delineated from the 95% contour of aAKDE range distribution probability surfaces delineated with aKDEs. Ranges symbolized by wolves movement profile. Ranges are both complete (n=17) and partial (n=19), dependant on proportion of wolf year (March - February) wolf was monitored for with complete ranges representing 90% monitoring coverage of a given wolf year.

2.2.7.4 Discussion

Previous studies describe the treeline as the forest-tundra biome where high-latitude subarctic vegetation between the circumpolar boreal forest and the arctic tundra occur (Payette et al., 2001). We found that the genetic delineation between boreal and tundra wolves does not follow a geographically divisive line as Musiani et al. (2007) had previously suggested, but the treeline and the surrounding area may serve as an area of genetic mixing (Figure 12). This area may be the highest area of genetic mixing and movement because the caribou congregate here during the wolf breeding season. While other species such as the sympatric piscivorous "Resident" and marine-mammal eating "Bigg's" killer whale populations show separate genetic ecotypes (Giles et al., 2023), the results here indicate the situation is not replicated in this system. The lack of distinct genetic ecotypes of observed wolves along the treeline is suggestive that the boreal/tundra distinction is a spectrum between two different foraging strategies but there are no social (behavioural) or geographic boundaries between these two groups leading to genetic divergence. Mitochondrial genetic variation represents historical gene flow among populations, while nuclear DNA provides insight into current genetics and may be more applicable to compare with recent telemetry data. However, Musiani found that the degree of differentiation (F_{ST}) between boreal and tundra was 10x higher in mitochondrial than nuclear DNA, suggesting that more genetic mixing is happening now than there used to be. This aligns with the increase in spatial overlap of caribou herds in winter, primarily the Beverly with Bathurst herds observed over the last decade. In the future, we aim to analyze more samples across the territory and scale up to genome sequencing (nuclear DNA) by analyzing samples from harvested wolves. This will allow for higher resolution of contemporary gene flow patterns.

2.3 Wolf Den Survey and Pup Count

GNWT-ECC and TG have been exploring ways to monitor trends in tundra wolf populations. Four vital rates influence wildlife population sizes, 1) survival, 2) reproduction, 3) immigration (movement of individuals into a population), and 4) emigration (movement of individuals out of a population). For wolves, newborn pups typically make up the largest age class in the pack, thus pup production, survivorship, and recruitment into the population are important components in determining trends in wolf abundance. Tundra-denning wolves tend to locate their dens on eskers or similar gravel/sand landforms formed by melting glaciers and often return to the same site each year, providing an opportunity to estimate trends in wolf numbers by tracking changes in wolf den site usage (occupancy) from aerial surveys. Previously, GNWT-ECC conducted a wolf den survey in spring and revisited all the active sites from that survey again in August to count pups for recruitment, with the last survey occurring in 2012 (D. Cluff, GNWT-ECC unpublished data). The goal of this project was to conduct the same den survey and compare the results to the last survey in 2012.

2.3.1 Methods

An aerial survey for wolf dens was conducted from 25-21 May 2023 using a small-fixed wing aircraft on the Bathurst summer range in the North Slave Region (Figure 14). Over 100 wolf den sites in the NWT and Nunavut are known from previous surveys and were revisited for activity (D. Cluff, GNWT-ECC unpublished data 2012; D. Cluff, GNWT-ECC unpublished report 2006). Late May and early June is an opportune time for the survey because wolves rest at the den site during the day and are easily visible. The survey focused on identifying eskers, searching for new den sites, and investigating historical den sites, flying 4637 km over 46 hours (Figure 14). The survey route also optimized flying over eskers and esker-like habitat between known den sites and served as a way to find new den sites. The survey area was characterized by a 10x10km grid cell used in previous surveys and was nearly identical to the last den survey completed in 2012 (excluding den sites in Nunavut, as a permit was not in place at the time of survey), with a focus on following the esker denning habitat. Due to lack of lake ice for landing a fixed-wing aircraft on skis, the base of operations was moved from the Hoarfrost River and Daring Lake to Gahcho Kue mine. This resulted in longer ferry flights but was necessary to ensure the completion of the survey. Den sites were revisited 21-23 Aug 2023 using a small-fixed wing aircraft to confirm the number of pups present at each den site.

2.3.2 Results

Five potential den sites were identified by observing wolves running and/or resting. Additionally, wolves were sighted near the Hoarfrost River Huskies base, which may have been indicative of a den site. However, only two dens near Gahcho Kue and Snap Lake were confirmed to be active by the capture crew in June. These two dens were visited by aircraft (Hoarfrost River Huskies) on 21-23 Aug 2023 and confirmed three pups with one collared wolf and one pup with the other collared wolves. An additional den was confirmed from one collared wolf near Contwoyto lake, but no pups were observed. For comparison, the mean litter size of pregnant harvested wolves was 6.3 pups in 2021 (n=18) and 6.6 pups in 2022 (n=9). However, this does not consider pup mortality rates before and after parturition. In late May/early June of 2012, a survey in the same study area found 22 active wolf dens and out of those dens, only one den site was confirmed to have a single pup.

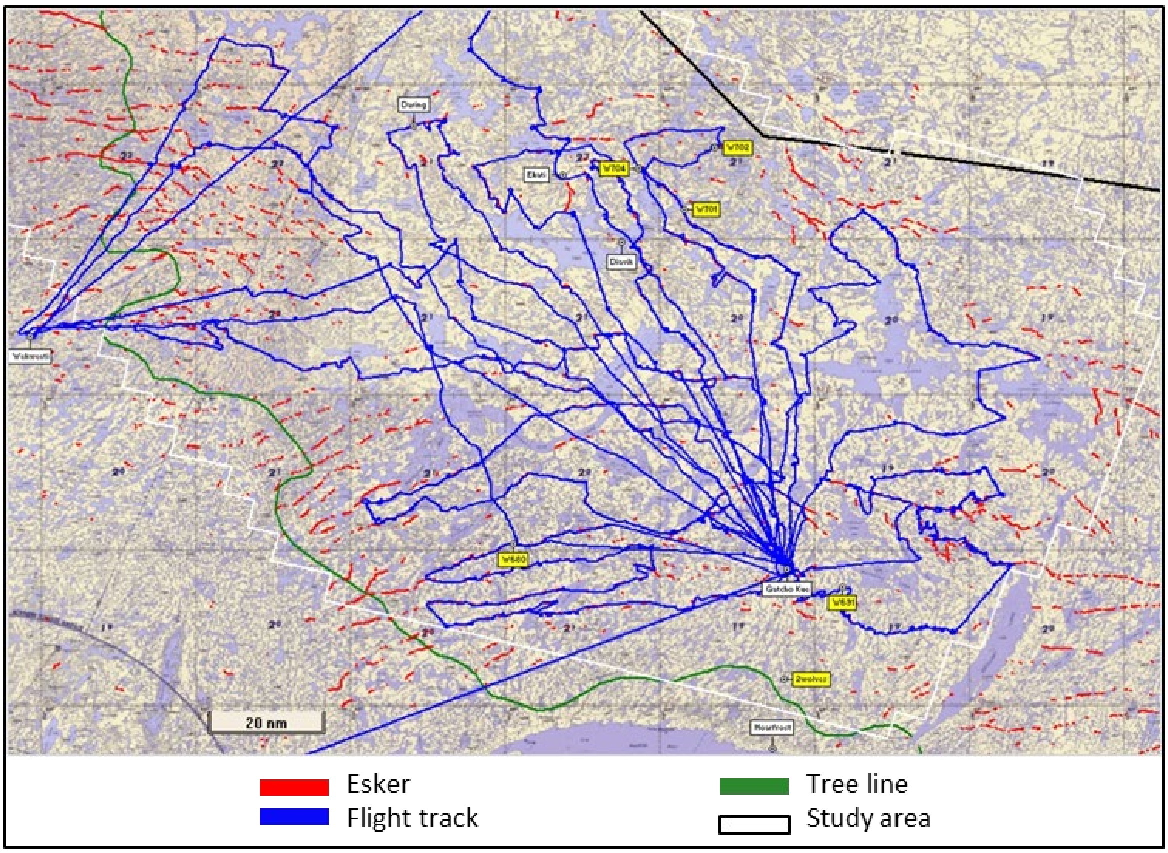

Figure 14. Study area and flight tracks for May 2023 wolf den survey. Yellow labels indicate wolf observations and white labels indicate places of interest.

2.3.3 Discussion

Klaczek et al., (2016) demonstrated that wolves residing on the summer range of barren-ground caribou in the Northwest Territories and Nunavut, Canada (i.e., Bathurst caribou herd) exhibited low reproductive success in denning areas and a decrease in density in response to caribou decline. Therefore, surveying regional wolf abundance and productivity at den sites located on the summer range of barren-ground caribou may serve as a useful indicator of wolf abundance and trends over time in response to harvest. This May den survey revealed 4.8x fewer wolves on Bathurst summer range compared to late May/early June 2012. Although wolves may relocate from a whelping den to a rendezvous site, this behavior is not believed to have happened often when caribou were abundant (Klaczek et al., 2016). However, numbers of Bathurst and Bluenose-East caribou have declined, and active wolf dens from the spring are now abandoned by late August when a pup recruitment survey is normally conducted. The pup recruitment survey in August cannot distinguish between total litter loss or site relocation as the reason why pups are not observed then, but a midsummer recruitment survey may be considered in the future. Understanding the distribution and recruitment of pups in late summer will help to determine if our den site monitoring is an effective index of wolf density. By combining GPS collaring with den surveys, we can determine and locate potential rendezvous sites for pup counts as well as camera and autonomous recording unit deployments. Den surveys may be able to provide information to achieve the following objectives:

- Evaluate wolf den monitoring and pup survey for trend analysis on the Bathurst caribou summer range.
- Investigate changes in spatial distribution of wolf den sites and pup survival on Bathurst caribou summer range.
- Investigate wolf fecundity and pup survival in response to the changing distribution and abundance of barren-ground caribou.
- Use den locations to inform June GPS collar deployments.

2.4 Den Investigations and Camera deployment

Given that several GPS locations are obtained per wolf per day from the GPS collar, the data lend themselves to sequential clustering to identify potential den sites. Cluster analyses have been used to identify potential den sites and kill sites for previous studies and were used to inform the den investigations and camera deployment described below.

2.4.1 Methods

Two methods were used to identify potential den site locations: (A) Using data collected from 2020 to March 2023, a manual retroactive stratification of telemetry datasets (see section 2.2) was completed and (B) Using more recent data (May-June 2023), a clustering algorithm was used to detect potential den site locations (Cluff and Mech, 2022). The parameters used to identify clusters in collar locations from individual wolves were the search radius (SR), the number of “window” days (W-D), and the minimum number of locations for a cluster (CML). The window day is the number of days when the wolf is present in the same location. For example, 10 locations within 200 meters of each other and spread over 5 days will be detected as a den site. For this analysis, locations were sent every 6 hours resulting in 4 locations per day. For identifying potential den sites among clusters, an initial SR of 200m, 5 W-D, and 10 GPS locations was chosen for the CML. If no clusters were identified with these parameters, the algorithm was rerun with 4 W-D and 8 CML, but kept the same 200m SR. If clusters were still not identified, the algorithm was rerun one final time with 3 W-D and 6 CML while keeping the SR constant at 200m.

The cluster algorithm was recently completed for the six wolves newly collared in March 2023 and three in June 2023 (see section 2.1). Eight new wolves (4 females, 4 males) were available for monitoring after March as one wolf was harvested about two weeks after collaring in March. Locations for this cluster analysis were restricted to 01 May-30 June 2023 which should be sufficient to identify putative den site locations for tundra-denning wolves. There were 15 collared wolves (8 females, 7 males) within this period for 2023. This compares to 18 in 2022 (11 females, 7 males), 25 in 2021 (12 females, 13 males) and 11 in 2020 (5 females, 6 males). The 15 collared wolves examined in Spring 2023 include five wolves added this March, plus three collared at two den sites in June, one female wolf from 2022, five from 2021 (2 males, 3 females), and one from 2020 (1 male).

2.4.2 Results

Locations of potential den sites using the two methods are shown in Figure 15. The manual stratification of previous collar data revealed 40 potential den site locations. Application of the cluster algorithm on collar data resulted in ten wolves (7 female and 3 male) showing location clusters for likely den sites in May and June 2023, while five wolves (1 female and 4 males) do not show any location clusters for putative den sites. One wolf of those 5 not showing location clusters for dens had an insufficient number of locations (n = 17) to generate any such clusters. Of the 10 wolves showing location clusters for likely den sites, all 10 were identified by the initial 200 m SR, 5 W-D, and 10 CML. Invoking the other two less stringent criteria resulted in the same number or additional clusters being detected for a given wolf and were almost always the same site coordinates (centroid of GPS coordinates for the cluster membership). Consequently, the den identification algorithm of a 200 m SR, 5 W-D, and 10 CML appears to be suitable detection parameters for tundra-denning wolves. One wolf (NS23-03 male) did not show a location cluster at 200 m SR, 5 W-D, and 10 CML, but did so at the other two other criteria (same site). This was not believed to be a den site because the visitation duration was short and had few visits. If correct, then this result also supports the initial den cluster search criteria of a 200 m SR, 5 W-D, and 10 CML being the most robust.

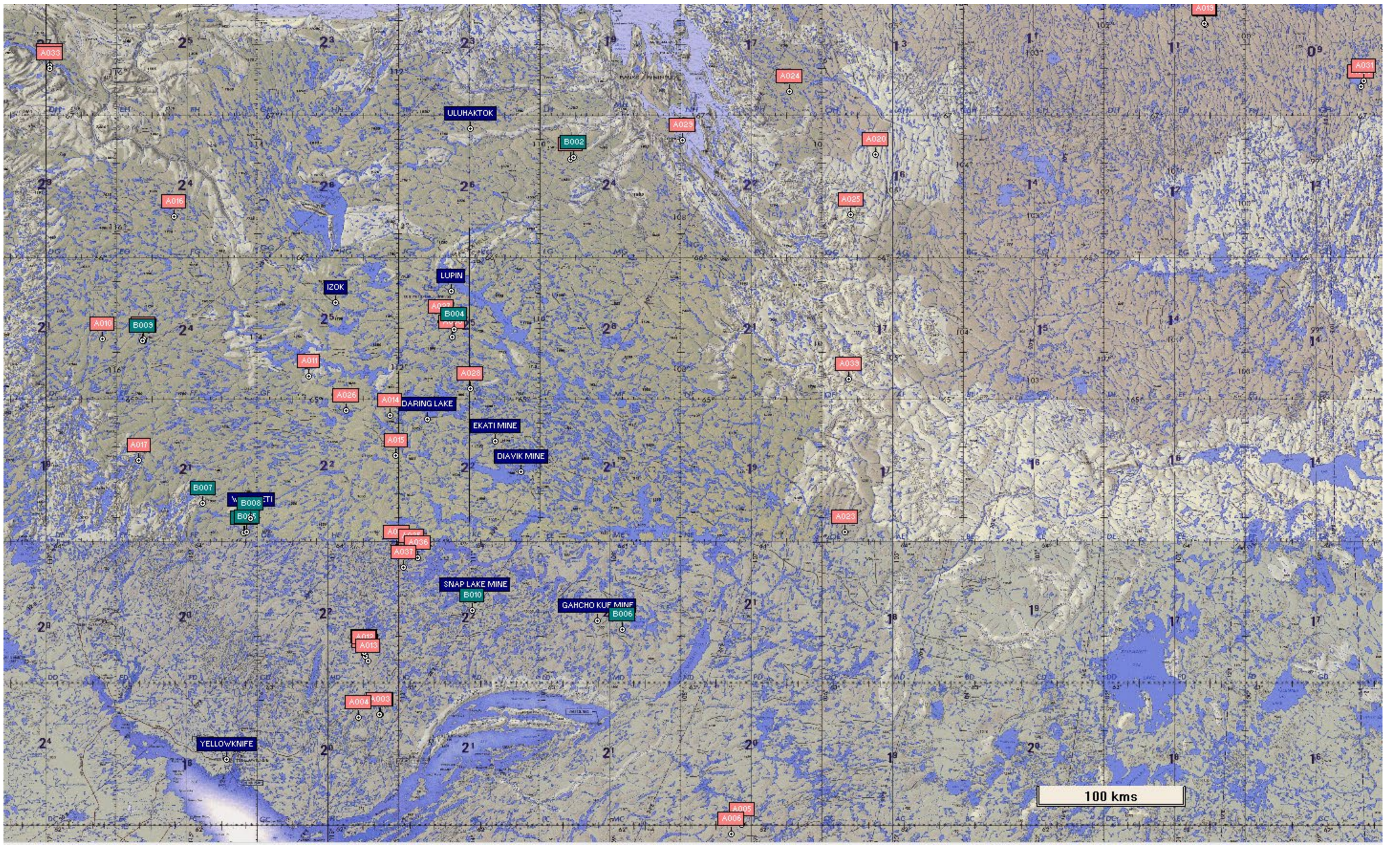

Figure 15. Wolf den sites identified using manual stratification of collar data from 2020-March 2023 (AXX in pink) and the cluster algorithm of collar data from May-June 2023 (BXX in green). Only the locations using SR = 200m, WD = 5 days, CML = 10 locations are shown for the cluster algorithm dens. Places of interest are shown in blue.

A small, fixed-wing aircraft was used to visit nine potential den sites based on the two methods described above. Of the nine sites visited, the following was observed: one den with one collared wolf, one caribou kill site, and one possible old den site. From 20-23 September 2023, cameras and autonomous recording units (ARUs) were deployed at four wolf den sites (based on GPS collar data). One ARU and three cameras were placed at each site, one pointed at the den hole(s) and the other two pointed along any trails leading to the den site (Figure 16). If wolves return to the same den site the following May, the ARUs can provide validation of wolf howls for developing wolf vocalization recognizers and identifying unique individuals and the cameras can provide images to assess pack size, litter size, and survival. A network of cameras at den sites would need to be maintained to determine trends and/or changes in these demographic parameters over time.

Figure 16. Cameras and autonomous recording units deployed at wolf dens in September 2023.

2.5 Kill-site Investigation

Fifty-six location cluster site investigations were completed in March and April 2022 to estimate the kill rate of wolves on large prey, which will be used to estimate wolf predation rate on caribou. Photos of each kill site were collected, and the number of animals present at the site or nearby was recorded. Preliminary data show there were signs of caribou, moose, and muskox predation. Analyses are in progress.

2.6 Winter Distribution Patterns of Caribou in the North Slave Region

Grey wolves are a primary predator of barren-ground caribou and display strong spatial association with caribou (Musiani et al., 2007; Walton et al., 2001) especially during the winter (Hansen et al., 2013). Barren-ground caribou have exhibited a greater amount of annual spatial overlap, especially during winter months (February-April) with adjacent herds on winter ranges in 2021 and 2022 (Adamczewski et al., 2022; Clark et al., 2021; Nishi et al., 2020; Prichard et al., 2020) compared to 2020. This may complicate application and evaluation of winter removal of wolves as a management action to help recovery of a specific caribou herd. Thus, understanding dynamics of winter range use of caribou herds is integral to implementing and evaluating wolf management actions.

An initial analysis of the spatial-temporal patterns of winter range use by Bluenose-East, Bathurst, and Beverly caribou herds based on satellite collar location data from 2015 – 2020, specifically looking at overlapping winter range use of the three herds, was provided in the 2020 Wolf (Dìga) Management Pilot Program Technical Report (Nishi et al., 2020). While previous analyses utilized monthly utilization distributions for barren-ground caribou derived from kernel density estimation (KDE), the authors suggest caution as has been shown that barren-ground caribou movement is not range resident (Abernethy R. in prep), non-range resident movement violates the assumptions of KDE estimation, and furthermore, KDE's are susceptible to autocorrelation which results in the underestimation of range size (Fleming 2017).

2.6.1 Methods

Telemetry data collected by the GNWT between October 2022 and May 2023 were accessed for three herds: Bathurst, Bluenose-East and Beverly. Briefly, data were resampled to daily locations and restricted to include only collars that had at least ten daily locations per month and winter ranges were delineated using a KDE approach on a monthly time scale (see Nishi et al., 2020, Clark et al., 2021, and Wilson et al., 2022 for further details). The overlap of 2022-2023 monthly winter range boundaries between the three herds was quantified by calculating the percent of Bathurst and Bluenose-East herd ranges overlapped by the Bathurst, Bluenose-East or Beverly ranges and the percent that was part of all three herd ranges. Also calculated was the percent of each Bathurst and Bluenose-East monthly range not shared with the other two herds. Overlay analysis was conducted within the R environment (R Core Team, 2022).

2.6.2 Results

Sample sizes of daily collar locations by month and herd are shown in Table 7. The Beverly herd had the highest number of collars in March 2023 (n=96) compared to the Bathurst (n=46) or Bluenose-East (n=87) caribou herds as well as a much lower proportion of collared animals relative to herd size than the Bathurst or Bluenose-East caribou herds.

Table 7. Sample Sizes of Collared Caribou by Herd in 2023.

	Bathurst		Bluenose East		Beverly	
	est. herd size 6,243 (2021)		est. herd size 23,202 (2021)		est. herd size 103,400 (2018)	
Month	# Collared Caribou	# Locations	# Collared Caribou	# Locations	# Collared Caribou	# Locations
October	48	1488	60	1844	32	989
November	49	1459	60	1791	32	959
December	49	1517	60	1830	32	969
January	49	1503	58	1786	31	957
February	48	1334	57	1589	31	854
March	46	1305	87	2292	96	2050
April	40	1200	81	2356	97	2896
May	40	1233	74	2266	95	2944

Figure 17 shows monthly KDE utilization distributions for Bluenose-East, Beverly and Bathurst caribou herds from October to December 2023 showing the movement into and during rut in October, post-rut movements in November and subsequent movement onto winter ranges through December. Figure 18 shows monthly KDE utilization distributions for Bluenose-East, Beverly and Bathurst caribou herds from January to May 2023 showing the high amount of spatial overlap of the three herds during that time period.

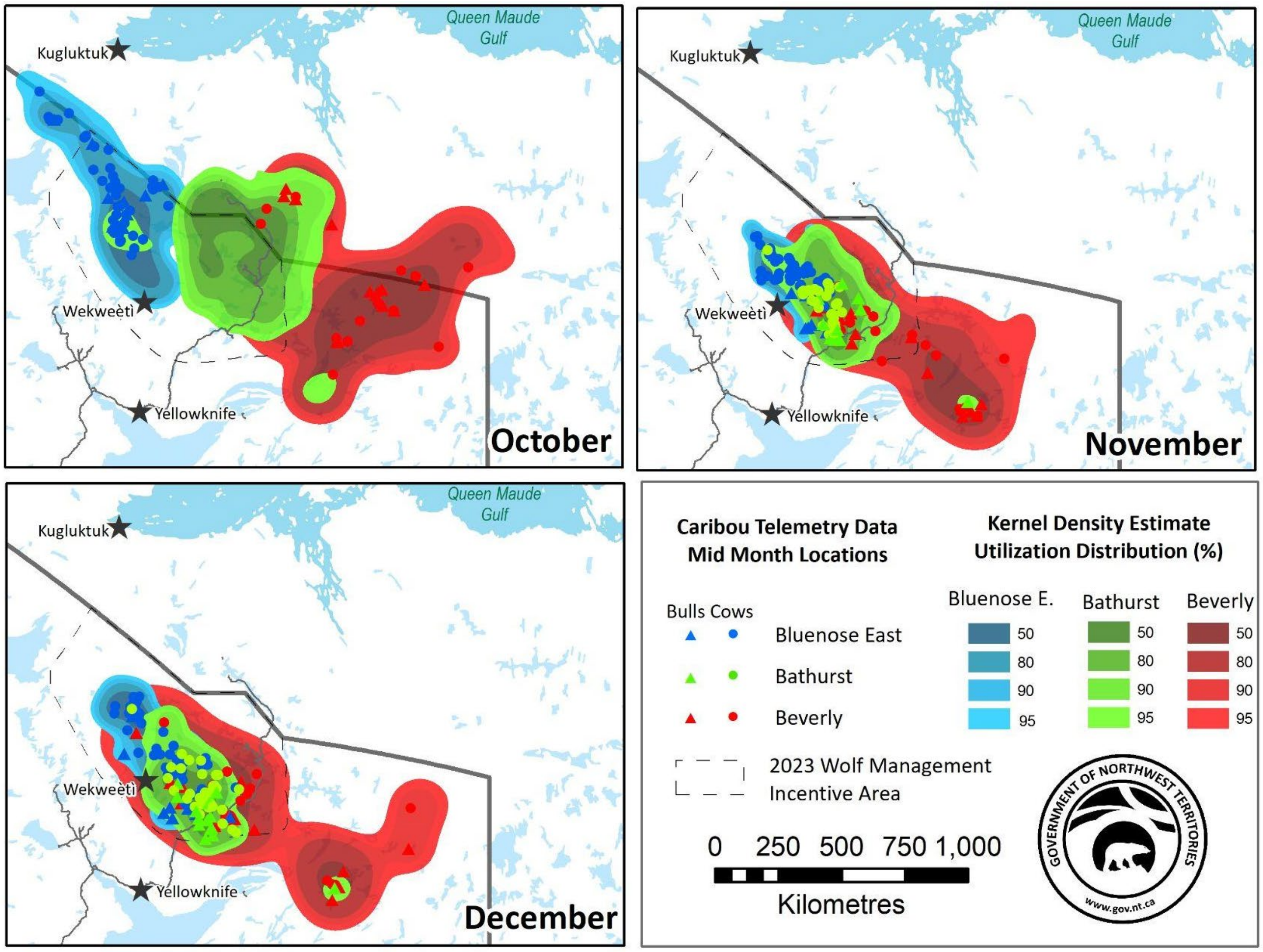

Figure 17. Monthly utilization distributions from October to December 2022 for Bathurst, Bluenose-East and Beverly caribou herds based on kernel density estimates.

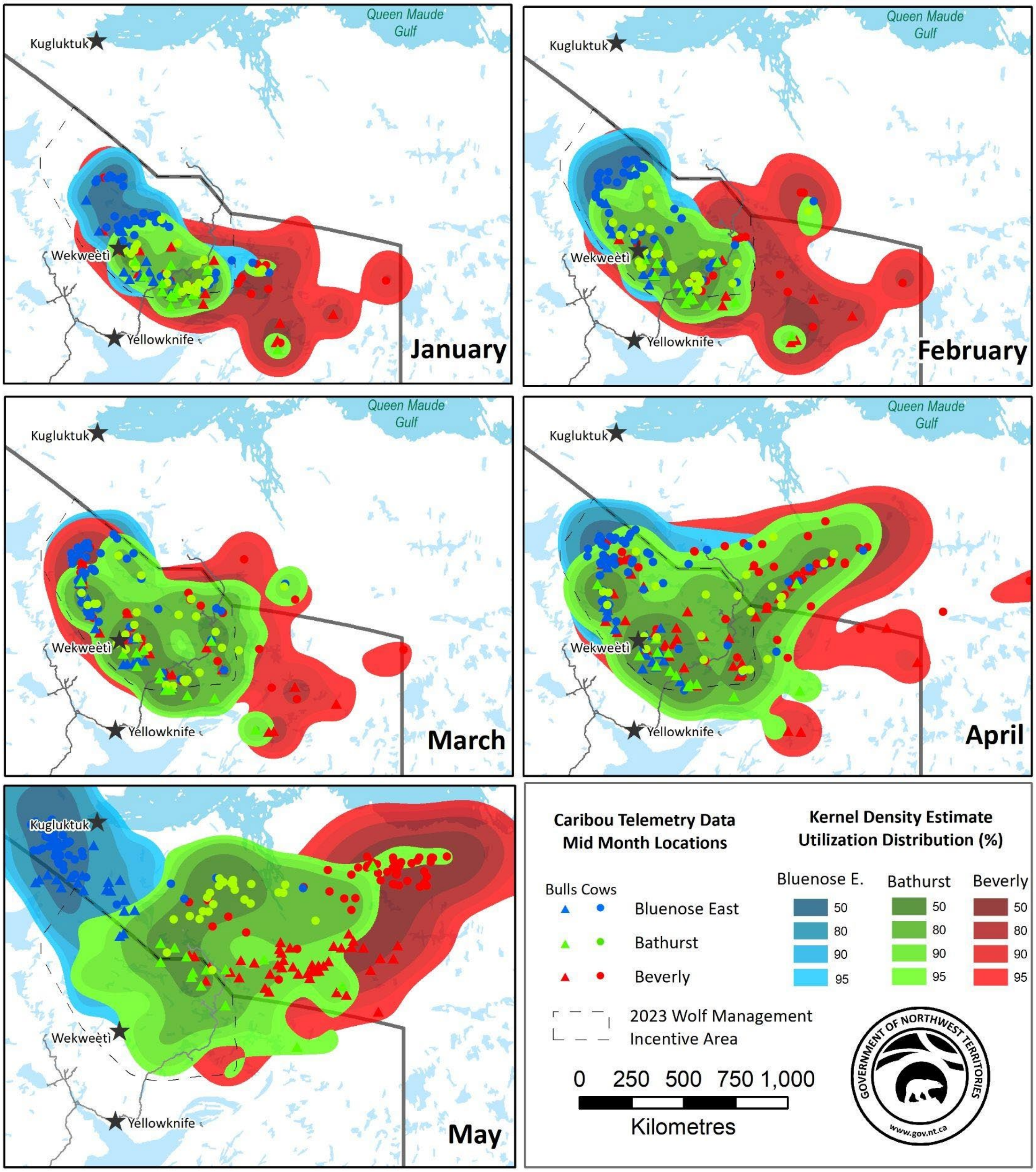

Figure 18. Monthly utilization distributions from January to May, 2023 for Bathurst, Bluenose-East and Beverly caribou herds based on kernel density estimates.

Table 8 provides a summary of the spatial overlap of the Bathurst herd 95% home range contours overlapped by Bluenose-East and Beverly herds individually and combined from October 2022 through May 2023. Only 9.9% of the Bathurst range was overlapped by the Bluenose-East in October but then increased from 45.9% in November to 82% in January, which is a marked increase compared to last year (see Wilson et al., 2022). From February through to May, Bluenose-East overlap of Bathurst winter ranges decreased to 26.7%. From November 2022 to April 2023, the Beverly herd overlapped the Bathurst monthly winter ranges by 93 – 100%. In May (start of spring migration), the Beverly herd overlap of Bathurst was 78.5%. This overlap increased compared to last year. Complete overlap of the monthly ranges of Bathurst by the Beverly was observed in December and January, compared to January alone last year. Both the Beverly and Bluenose-East herds started to overlap the Bathurst winter range in November (41.7%) and then followed the same pattern of increasing to a maximum overlap of 81.9% in January and then decreasing through to May (16.5% overlap) (Table 8).

Table 8. Spatial overlap of collared Bathurst caribou monthly ranges (based on 95% kernel utilization distribution isopleths) with collared Bluenose-East and Beverly caribou during the 2022/2023 harvest season. No overlap represents the amount of territory where solely Bathurst caribou resided. Both herds overlap represents the amount of territory shared among all three herds.

	Bathurst			Bluenose East		Beverly		Both Herds Overlap	
Month	Total Area (km2)	No Overlap (km2)	No Overlap (%)	Overlap (km2)	Overlap (%)	Overlap (km2)	Overlap (%)	Overlap (km2)	Overlap (%)
October	68,460.0	23,859.8	34.9	6,774.8	9.9	37,825.4	55.3	0.0	0.0
November	33,172.7	29.2	0.1	15,218.2	45.9	31,760.6	95.7	13,835.3	41.7
December	32,665.3	0.0	0.0	20,356.3	62.3	32,665.3	100.0	20,356.3	62.3
January	43,951.0	0.0	0.0	36,044.5	82.0	43,886.7	99.9	35,980.2	81.9
February	75,699.8	0.0	0.0	61,749.6	81.6	73,673.4	97.3	59,723.2	78.9
March	116,906.8	3,361.8	2.9	79,847.2	68.3	110,990.8	94.9	77,292.9	66.1
April	185,818.7	11,009.6	5.9	120,102.0	64.6	174,440.4	93.9	119,733.3	64.4
May	201,767.6	22,849.5	11.3	53,877.0	26.7	158,375.7	78.5	33,334.5	16.5

Table 9 provides a summary of the spatial overlap of the Bluenose-East herd 95% home range contours overlapped by Bathurst and Beverly herds individually and combined from October 2022 through May 2023. In late fall and winter of 2022/2023, the Bathurst monthly winter ranges overlapped the Bluenose-East minimally in October (14.2%) and by variable amounts ranging from 70.2 – 40.6% November through May, which is higher than last year. The Beverly herd monthly winter ranges overlapped those of the Bluenose-East with a similar pattern, no overlap in October (0%) and variable amounts November through May (72.9 – 27.2%). Both Bathurst and Beverly overlapped Bluenose-East monthly winter ranges the least in October (0%) before and during the rut, and then spatial overlap varied from 63.8 – 25.1% from November through May (Table 9). In all cases, the overlap appears to have occurred earlier in the year than last year. For example, approximately 70% of overlap occurred in November this year compared to 20% in November last year for Bathurst and Beverly herds.

Table 9. Spatial overlap of collared Bluenose-East caribou monthly ranges (based on 95% kernel utilization distribution isopleths) with collared Bathurst and Beverly caribou during the 2022/2023 harvest season. No overlap represents the amount of territory where solely Bluenose-East caribou reside. Both herds overlap represents the amount of territory shared among all three herds.

	Bluenose East			Bathurst		Beverly		Both Herds Overlap	
Month	Total Area (km2)	No Overlap (km2)	No Overlap (%)	Overlap (km2)	Overlap (%)	Overlap (km2)	Overlap (%)	Overlap (km2)	Overlap (%)
October	47,695.7	4,092,084.1	8,579.6	6,774.8	14.2	0.0	0.0	0.0	0.0
November	21,683.9	449,573.7	2,073.3	15,218.2	70.2	15,805.3	72.9	13,835.3	63.8
December	32,545.1	245,177.6	753.3	20,356.3	62.5	30,093.3	92.5	20,356.3	62.5
January	68,425.4	762,871.9	1,114.9	36,044.5	52.7	60,732.4	88.8	35,980.2	52.6
February	86,010.6	1,048,159.5	1,218.6	61,749.6	71.8	73,502.5	85.5	59,723.2	69.4
March	97,569.5	452,697.1	464.0	79,847.2	81.8	90,488.3	92.7	77,292.9	79.2
April	142,067.8	625,458.9	440.3	120,102.0	84.5	135,444.5	95.3	119,733.3	84.3
May	132,862.9	7,616,415.5	5,732.5	53,877.0	40.6	36,156.3	27.2	33,334.5	25.1

2.6.3 Discussion

The high amount of spatial overlap by all three herds in winter 2023, but especially in March and April, resulted in increased caribou density on the winter range. The Bathurst was almost exclusively overlapped by Bluenose-East and Beverly caribou herds in January through April. Compared to last year, the magnitude of overlap has increased, and the increase occurs earlier in the year, approximately one month prior to last year. The high amount of spatial overlap likely had a strong influence on the distribution and relative abundance of wolves on the winter range of the Bathurst and Bluenose-East herds and the ability of the management program to target wolves of any particular herd.

3 Wolf Removal

3.1 Wolf Harvester Workshop

Prior to the harvesting season, a wolf harvester's workshop was held in Yellowknife, NT 12-14 December 2022. This workshop was collaboratively organized by the GNWT-ECC, Tłįchǫ Government and the Kugluktuk Angoniatit Association Hunters and Trappers Organization, and had participants from Tłįchǫ communities, Kugluktuk, and Yellowknife (Figure 19).

 

Figure 19. Photos from the Dìga Harvesters Workshop in Yellowknife on 12-14 December 2023.

The objective was to exchange knowledge and experiences about wolf behavior and harvest techniques among the wolf harvesters. This workshop helped build relationships amongst the NWT and Nunavut wolf harvesters. Discussions centered around the wolf management program, breakout sessions on harvest techniques and wolf behavior, and a necropsy demonstration. The workshop was well perceived and helped facilitate knowledge sharing. Several wolf carcasses were necropsied to show hunters post-mortem examination techniques and health indicators. GNWT-ECC and Tłı̨chǫ Government also received feedback on key aspects of the program (wolf health/necropsies, questionnaires, logistics), which led to revising the harvester questionnaires with feedback from harvesters. A key intent of this workshop was for the Kugluktuk hunters to share their knowledge with the Tłı̨chǫ hunters. After the workshop, the Tłıçhǫ participants agreed to invite 2 Kugluktuk hunters to join the Tłıçhǫ dìga harvesting camp that would be located at Roundrock Lake for the winter 2023 harvesting season.

3.2 GNWT's North Slave Wolf Harvest Incentive Program

Wolves are harvested as a furbearer and as big game in the NWT. Since the 2008-09 harvest season, the North Slave Region (NSR) has administered a region-wide harvest incentive program to encourage more wolves to be harvested in the NWT as part of the traditional economy and to reduce wolf predation on Bathurst and Bluenose-East caribou (Cluff, 2019a). The incentive began as $100/carcass (skinned) for any wolf harvested within the region, dropped to $50/wolf skull for the 2013-14 and 2014-15 harvest years but then increased to $200/carcass (skinned or unskinned) during the 2015-16 harvest season. The wolf harvest incentive was increased to further support caribou herd recovery.

An additional harvest incentive area for wolves was introduced in the 2018-19 harvest season (Cluff, 2019b). This enhanced wolf harvest incentive area (eWHIA) was established where the Bathurst and Bluenose-East caribou herds were expected to winter in 2018-19 and came into effect in January 2019. The incentive for harvesting a wolf (skinned or unskinned) in this new area that year was $900/wolf for both Indigenous and resident hunters. In winter 2020 the financial incentive in the eWHIA was increased to $1200/wolf and tag fees were rescinded across the NWT (cf., General Hunting License holders don't require a tag). The eWHIA was implemented in January 2021, 2022, and 2023. In the latter two years, the eWHIA was extended to the NWT and Nunavut border to accommodate northward spring migratory movements of Bluenose-East and Bathurst caribou, respectively.

3.2.1 Methods

For the 2019-20 wolf harvest season, the boundaries for the eWHIA were again based on mid-January 2020 locations of female and male caribou from both the Bathurst and Bluenose-East herds. In winter 2023, the eWHIA encompassed 91,871 km2, and was slightly smaller than the previous year when it was 97,464 km2 (Figure 20). In winter 2023, the Beverly caribou herd substantially overlapped the distribution of Bathurst and Bluenose-East herds (Figure 20).

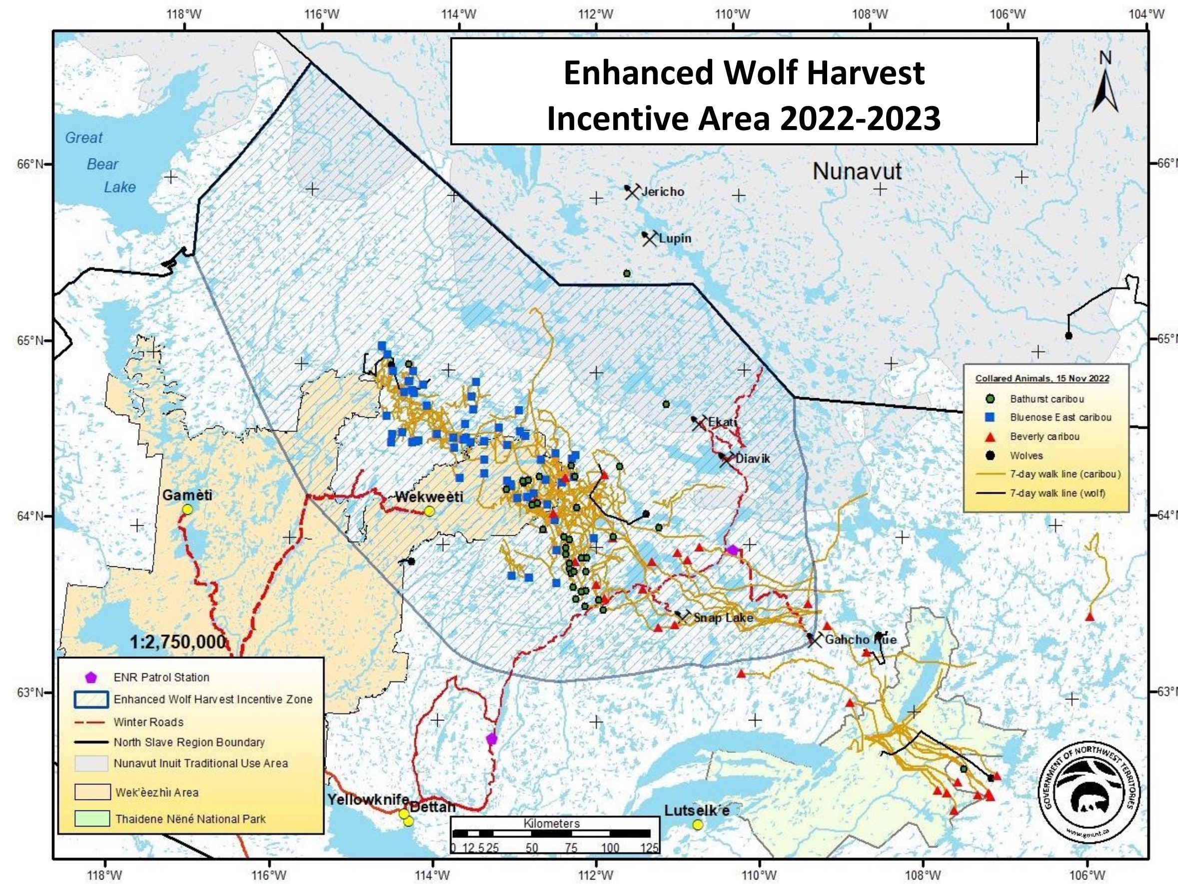

Figure 20. The 2023 Enhanced Wolf Harvest Incentive Area in the Northwest Territories to facilitate barren-ground caribou recovery. The area is based on the locations of collared caribou for the Bathurst and Bluenose-East herds. There was extensive overlap on the winter range again this year with the Beverly caribou herd.

Harvesters received $1200 per carcass if the wolf was killed inside the eWHIA or $200 per carcass when the wolf was killed outside the eWHIA. In addition to providing carcass payments, the GNWT arranged for an Indigenous person to skin any submitted wolf carcasses with the hide on. Skinners would take possession of the pelt afterward and receive payment under the Genuine Mackenzie Valley Fur Program. Under the program, a skinner can receive a minimum of $400 as advance payment for shipping a wolf pelt to auction, regardless of what the pelt would sell for. If the pelt sold for more than $200 at auction, then a $350 prime fur bonus was paid. If a harvester killed a wolf in the eWHIA and skinned and prepared the pelt for auction, they could expect $1950 per wolf ($1200 for the carcass, $400 for the pelt, + $350 prime fur bonus). If the pelt sold for more than $400, then the skinner would receive the additional net value. Locations of harvested animals are reported by the hunter and the grid cells used for harvest reporting are 10 km x 10 km (Figure 21).

3.2.2 Results and Discussion

This winter, two hunting camps specifically for harvesting wolves were set up with GNWT-ECC support, one with Tłı̨chǫ hunters at Roundrock Lake and another with Inuit hunters from Kugluktuk based at Contwoyto Lake and Pellatt Lake, Nunavut. Although the Inuit may harvest wildlife from their traditional use area that overlaps into the NWT, permission had been obtained from the Wek'èezhìi Renewable Resources Board (WRRB) for a Special Harvester Licence (SHL) for Inuit hunters to hunt wolves in Wek'èezhìi. The WRRB supported the request on the basis it should promote recovery of the Bluenose-East and Bathurst caribou herds.

The Tłıçhǫ Government's dìga harvesting camp harvested 15 wolves (2 female: 13 male) from 30 January to 17 February 2023, all within the eWHIA (Figure 21). At $1200/wolf, that yielded a total harvest incentive payment from GNWT-ECC of $18,000. Only two of the hunters killed the 15 wolves, averaging 7.5 wolves/hunter, although one of them killed 10 wolves, while the other killed five. The hunter who killed 10 wolves was invited by the Tłı̨chǫ Government from Kugluktuk to help Tłı̨chǫ hunters observe wolf hunting methods by the Inuit. Because all but one of the wolves were unskinned when GNWT-ECC received them, we were able to obtain full weights of these harvested wolves. The average furred weight was 33.283 kg (S.E. = 1.42, n=14) and ranged from 20.0 to 43.02 kg (n=14). There were another six wolves killed on Snare Lake near Wekweètì prior to establishment of the Tłıçhǫ Government's dìga harvesting camp (Figure 20). The two hunters who harvested these six wolves (on 18 and 20 Jan 2023) were not participants in the Tłıçhǫ Government's dìga harvesting camp. In these cases, one hunter harvested five wolves (2 females: 3 males) and the other harvested one wolf (male). These six wolves were not included in the Tłıçhǫ Government's dìga harvesting camp. Thus, the cost to GNWT-ECC was $7,200 for these six wolves.

The Inuit camp involved nine hunters from Kugluktuk during the second half of March to the first half of April 2023 and harvested 47 wolves (22 females, 25 males) in the eWHIA of NWT (Figure 21). The Government of Nunavut paid their hunters $300/wolf carcass this winter (that payment will increase next year), and the GNWT augmented that payment by $900, to bring payment to a total of $1200/wolf. Thus, GNWT-ECC compensated Kugluktuk harvesters $42,300. Another 30 wolves (15 females, 21 males) were taken in the eWHIA by 19 hunters (15 Indigenous, 4 resident) accessing the Tibbitt to Contwoyto winter road, (Figure 21). Thus, the cost to GNWT-ECC was $36,000.

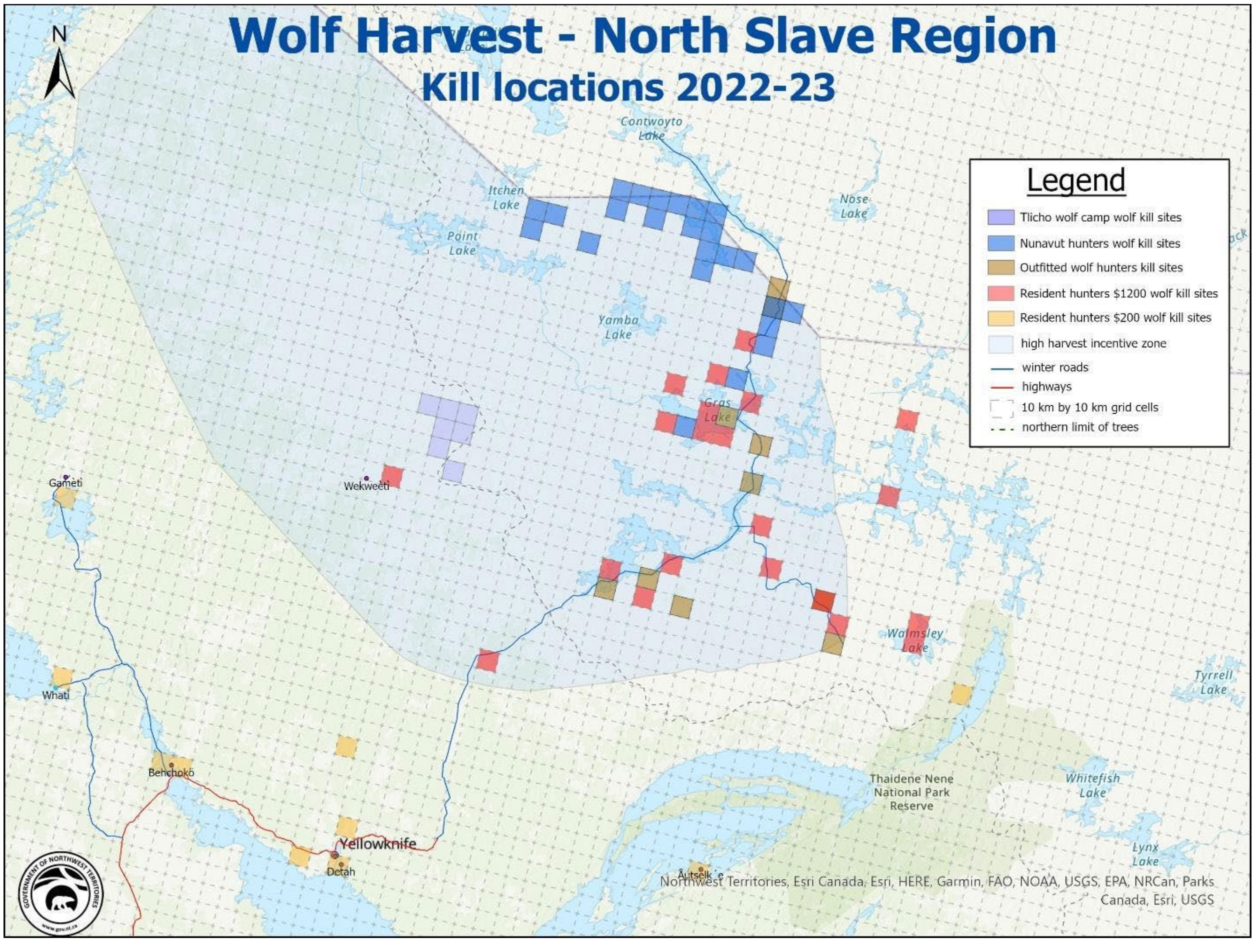

Figure 21. Location of 158 wolves harvested from 62 grid cells (10 km^2 each) in the North Slave Region, 2022-23. Most wolves were harvested inside (142) the enhanced wolf harvest incentive area (eWHIA) than outside (16). Those 142 wolves were harvested from 49 grid cells inside the eWHIA and another 4 grids outside those boundaries. Boundaries for the eWHIA were based on the winter locations of collared Bathurst and Bluenose-East caribou in mid-January 2021 within the North Slave Region.

Although the Inuit hunt camp averaged 5.2 wolves/hunter (S.E. = 1.41), two of the nine hunters killed nine and 15 wolves each. The hunter harvesting 15 wolves during the Inuit wolf camp also harvested 10 wolves during the earlier Tłı̨chǫ Government's dìga harvesting camp, totaling 25 wolves for this hunter (Figure 22). Therefore, the median of 2 wolves per hunter is a more representative statistic of the general number of wolves killed per hunter (Figure 22).

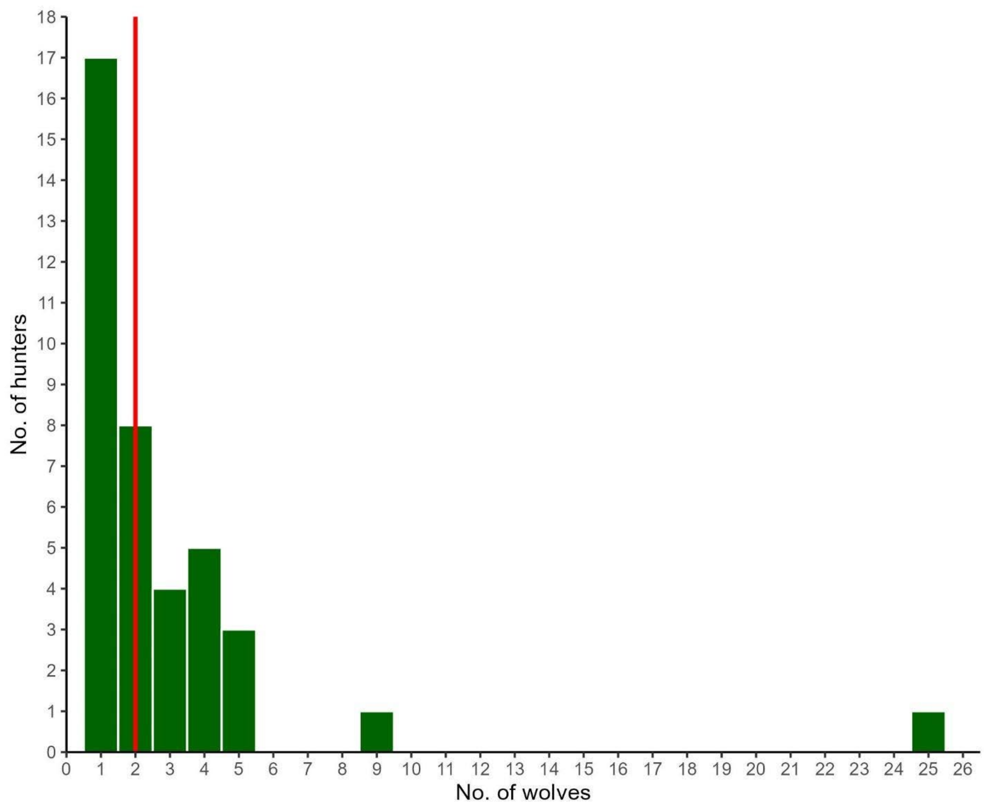

Figure 22. Number of wolves harvested per hunter (median = 2 [red line]) throughout the North Slave Region, 2022-23. Outfitted hunters harvested 44 wolves and are limited to 2 wolves/hunter and are not included here. Of the remaining 114 wolves harvested, 15 are from a Tłı̨chǫ wolf hunting camp, 47 by Nunavut hunters hunting in their asserted territory within the North Slave Region, and 52 by resident hunters (tags required).

Outfitted hunts for wolves typically involve non-resident hunters. Non-resident hunters are not eligible to receive the incentive and have not submitted any carcasses. Most of these hunters keep the head/skull of the wolves they shoot. Because of the lack of formal reporting/carcass collection, we have less information about these wolves. Much of the information below was provided voluntarily by the outfitter upon request. Unfortunately, some key information like sex of the wolf was often not recorded, but discussions were held with the outfitter to facilitate collection of this data in subsequent years. The kill locations provided were descriptive, and therefore they are approximate. We used these descriptions to identify the mostly likely grid cell for plotting. Kill site coordinates are estimated using the grid cell centroid. There were 44 wolves harvested by non-resident hunters. Four of these wolves were killed by their guides. Of these 44 wolves, 12 were killed just north of the NWT/Nunavut border (Pellatt Lake) and 32 wolves were killed in the NWT (Figure 21). Given that all 44 wolves were accessed from the Tibbitt-to Contwoyto winter road corridor and were among the Bathurst barren-ground caribou winter range, all 44 wolves were considered harvested within the eWHIA and were counted as such. The reported sex ratio of these wolves was 9 females and 12 males with 23 of unknown sex. The 44 wolves were removed over 10 grid cells (Figure 21) ranged from 1 to 12 wolves killed/grid cell and averaged 4.4 wolves/grid cell (S.E. = 1.19). By comparison, last year the wolf harvest by non-resident hunters totaled 19 wolves. A few headless, skinned wolf carcasses were submitted by hunters to GNWT-ECC, but they were omitted in the total count because they were opportunistic pick-ups from carcasses from outfitted hunts along the Tibbitt-to-Contwoyto winter road. The outfitter is now aware of this confounding problem, and they will be more discrete in discarding headless wolf carcasses in the future.

Another 16 wolves (8 females, 7 males, 1 unknown sex) were harvested by 12 hunters (10 Indigenous, 2 resident) outside the eWHIA but within the North Slave Region (Figure 20). At $200/carcass for these wolves, a total incentive payment of $3,200 was paid. Therefore 158 wolves in total (56 females, 78 males, 24 unknown sex) were harvested in the North Slave region during winter 2022-23. One additional wolf (unknown sex) died in a vehicle collision along Highway 3; $200 was paid to the individual who submitted the carcass.

There were 1051 hunters in the NWT who received 1609 free wolf tags in the 2022-23 hunting season. The number of wolf tags per hunter ranged from 1 to 12 but averaged 1.53/hunter. There were 622 wolf tags issued to wolf hunters in the North Slave Region. In total, 159 wolves were removed from the North Slave Region in 2022-23. This harvest total matches that of the 2020-21 wolf harvest and has been the highest reported total since 2010 (Table 10). Total incentive paid was $103,500 for the 98 wolves harvested in the eWHIA (no incentive paid for the 44 wolves harvested in outfitted hunts) and $3,200 for the 16 wolves harvested outside the eWHIA ($200/wolf).

Table 10. Wolf harvest records in the North Slave Region based on carcass/skull collections. The harvest season spans 01 July to 30 June annually. Since 2010, regular incentive payments have varied from $100/wolf carcass (or $50/skull) to $200/wolf carcass. An enhanced wolf harvest incentive area was introduced with the 2019-20 harvest season which varies in extent each year.

	Carcass/Skull			
Harvest Year	Regular	Enhanced	Other	Total Removed
2010-11	41	n/a		41
2011-12	80	n/a		80
2012-13	56	n/a		56
2013-14	24	n/a		24
2014-15	35	n/a		35
2015-16	48	n/a		48
2016-17	73	n/a		73
2017-18	40	n/a		40
2018-19	7[a]	59[b]	1[c]	67
2019-20	50[a]	18[d]	1[e]	69
2020-21	22[a]	137[d]		159
2021-22	22[a]	50[d]	1[e] + 19[f]	92
2022-23	16[a]	98[d]	1[e] + 44[f]	159

[a]$200 incentive/wolf carcass (skinned or unskinned).
[b]$900 incentive/wolf carcass (skinned or unskinned).
[c]wolf euthanized by GNWT-ECC.
[d]$1200 incentive/wolf carcass (skinned or unskinned).
[e]mortality from a vehicle collision.
[f]outfitters; no incentive paid

3.3 Tłı̨chǫ Government's 2023 community-based dìga harvesting camp

Through implementation of the Tłı̨chǫ Agreement, the Tłı̨chǫ Government and citizens have been undertaking programs that emphasize their role as stewards within their traditional territory. With an emphasis on direct on-the-land activities by staff and citizens, Tłı̨chǫ Government has implemented three innovative programs in Ekwǫ̀ monitoring and Dìga management respectively. The Ekwǫ̀ Nàxoède K'è (Boots on the Ground) program was initiated in 2016 with the objectives to examine the conditions of and health of hozìı ekwǫ̀ (barren-ground caribou) on its summer range, focusing on four key indicators: (1) habitat; (2) ekwǫ̀ condition; (3) predators, and (4) industrial development. The program is led by Tłı̨chǫ Government, with collaborative support from GNWT-ECC, and WRRB (Tłı̨chǫ Government, 2021). In 2020, the Tłı̨chǫ Government implemented the Ekwǫ̀ Harvest Monitoring program focusing efforts on monitoring harvest on the Beverly ekwǫ̀ along the Tibbitt to Contwoyto Winter Road. Objectives of the winter road program also focuses on educating and promoting traditional harvesting laws as well as ensuring Tłı̨chǫ harvesters are following the rules of the "no-hunting zone" (Mobile Core Bathurst Caribou Management Zone). The third program, the Dìga Harvesting Camp, was implemented in 2019 with the main goal to sufficiently reduce dìga predation on the Koketi Ekwǫ̀ and Sahti Ekwǫ̀ herds to allow for an increase in calf and adult ekwǫ̀ survival that would contribute to the stabilization and recovery of both herds. Based on the WRRB's recommendation *(#4-2020 Predator[6])*, the Tłı̨chǫ Government initiated a community-based Dìga harvesting camp in winter 2019/2020 and GNWT-ECC's Enhanced North Slave Wolf Harvest Incentive Program was continued. The community-based Dìga harvesting camp reflects Tłı̨chǫ Government's multi-year commitment to provide training and support for Tłı̨chǫ harvesters to participate in dìga management and increase their knowledge and skills for ground-based harvest of dìga.

3.3.1 Methods

The Tłı̨chǫ Government's dìga harvesting camp was located at Roundrock Lake for the winter 2023 harvesting season. The camp was originally scheduled to start on January 13, 2023 but due to the exceptionally warm temperatures it was necessary to postpone the start date until January 22, 2023. This year the camp ran for 2 rotations at 2 weeks each starting January 22 to February 19, 2023. For the 2022/23 season, a reconnaissance survey was done just prior to the camp starting (Figure 23). The reconnaissance survey was flown on 20 January 2023 by a pilot and two observers (GNWT-ECC staff and Tłı̨chǫ observer) in a Found Bush Hawk-fixed wing aircraft. The survey was flown around Roundrock Lake, which was where the Tłı̨chǫ Government's dìga harvesting camp was planned to be set up. Observations made during this reconnaissance survey included: a pack of 4 dìga along the south shore of Snare Lake and roughly 450 ekwǫ̀ in the survey area (Figure 23).

[6] Wek'èezhìı Renewable Resources Board (WRRB). 2019. Reasons for Decisions Related to a Joint Proposal for the Management of the Kǫk'èetì Ekwǫ̀ (Bathurst ekwǫ̀) Herd. Wek'èezhìı Renewable Resources Board, Yellowknife, NT. 53 pp. + 8 Appendices

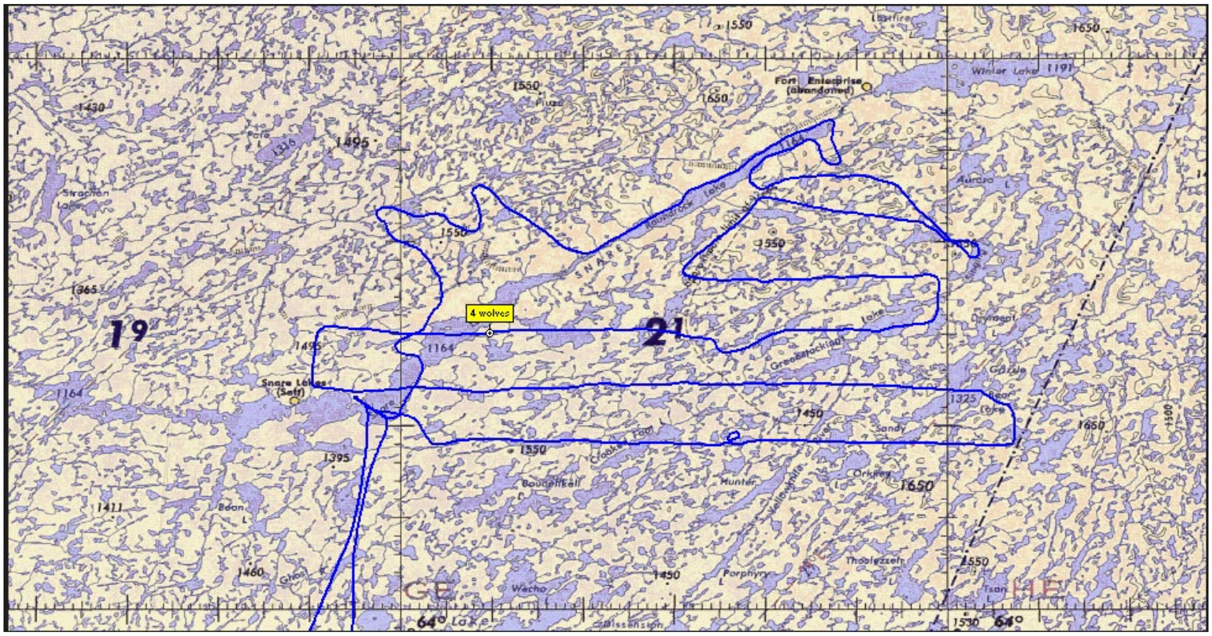

Figure 23. Reconnaissance aerial survey flight lines conducted by GNWT-ECC staff centered around Roundrock Lake on 20 January 2023.

Once the camp location was confirmed, workers were hired from Wekweètì to set-up camp before the harvesters arrived. Having the camp set up before the harvesters arrive allows for more time to strategize and prepare for the harvesting of dìga. While the team is hired to set up camp, having them traveling to camp from Wekweètì also allows for them to break trail for the oncoming harvesters, making it easier for the harvesters to travel to camp from Wekweètì.

Typically, the teams consist of 8 people, which includes, a cook and camp helper, and six hunters. The cook and camp helper make sure the hunters are fed before going out harvesting and to have the camp ready when hunters return. The camp helper gets firewood, maintains a tidy camp and helps the cook prepare meals. Among the harvesters, there are designated roles such as a k'àowo (foreman), a safety person and a scout. The k'àowo makes decisions including travel routes for the day, the daily plans and leads the prayers each day. The safety person is usually the designated first aid person who leads safety meetings, maintains electronic equipment (satellite phone, inReach, and GPS) and is responsible for proper identification and tagging of harvested dìga and must complete the harvester questionnaires provided by GNWT-ECC. After each dìga is harvested, the GNWT-ECC questionnaires are filled out and submitted to the camp lead at the end of their rotation. The scout is typically a local participant from Wekweètì who knows the area well and informs the crew of which areas are safe or unsafe to travel and where the teams should travel for the day.

Each day consists of a safety meeting in the morning to plan for the day and determine hunters' traveling routes. On some days, all six hunters would travel together and scout for dìga and on other days they would break up into smaller groups of two or three; the majority of the time, they were in two groups. One Garmin inReach was given to the harvesters and one was kept at the camp with the cooks unless they broke up into groups, then each group would have an inReach to record distances travelled and hunting locations by each group and to also use as a safety communication device.

It was decided that fuel drums would no longer be purchased, instead participants travelled to Wekweètì every 3-4 days to get gas. With the conditions we had due to the COVID-19 pandemic, we had to hire a local person to purchase the gas in a contactless manner. The hunters would take all the empty jerry cans to Wekweètì and drop them off at the airport where the hired person would pick them up, fill them up and drop them off at the airport while the hunters waited. Another reason the hunters had to wait at the airport was that they were following another Tłı̨chǫ protocol, whereby snowmobiles that are used for hunting dìga should not go into town. By having the hunters stay at the airport, it eliminated the possibility for dìga blood being inadvertently brought into town. This process of purchasing fuel has continued into the 4th year of the program.

The harvesters typically would go out by snow machines in the morning, search for signs and look for dìga. Once a dìga is spotted, they start the chase. During the chase, sometimes they would break up so that they can reach the dìga at separate angles and the one person with the best angle would take the shot. If the dìga is wounded but still on the go, they will go after it with the kill shot.

In the 4th year of the program (2023), a different hunting approach was taken. As the hunters from Kugluktuk joined the program in 2023, it was a great opportunity to learn the hunting techniques that the Inuit use for hunting dìga. The Kugluktuk hunter was able to lure in the dìga using a predator call. The Tłı̨chǫ hunters had difficulties tracking and finding any dìga prior to the Kugluktuk hunter arriving, even with setting up baiting stations. During the workshop in December 2022, the Kugluktuk group shared a lot of their knowledge and had indicated that using dìga carcasses was very effective to use as bait. Using this new method, our baiting stations were first made with wolverine carcasses harvested the first couple of days being at camp. Once dìga were harvested, their carcasses were used for bait. Combining the use of baiting stations and the predator call was very effective. After luring the dìga closer, and once they were observed by the hunter, the hunters chased down the dìga on their snowmobiles. This approach is typically done by the Tłı̨chǫ hunters as well but the difference between the Tłı̨chǫ and Kugluktuk hunters is the rate of speed they are going while chasing the dìga. The reason the Kugluktuk hunters are so successful at harvesting dìga is because they are going much faster while going after the dìga; high speeds that the Tłı̨chǫ hunters were not used to. The hunters are able to outrun the dìga making their hunt successful at almost every attempt. Once dìga were harvested, a couple of them were skinned and the carcasses were used for bait but the majority of them were sent to Yellowknife for sample collections (Figure 24).

Figure 24. Elder, Joe Mantla, of Behchokǫ̀ kneeling down in front of the dìga pelts he skinned and dried that were harvested through the 4th year (2023) of the Tłı̨chǫ Government's dìga harvesting camp.

To follow Tłı̨chǫ Elders' recommended protocols, immediately after shooting a dìga it was placed into a thick plastic bag so that the dìga's blood would not spill onto the snow machines or the sleds. Before putting the carcass into the bag, the hunter would insert the muzzle of their gun into the dìga's mouth and thank it for its life, paying their respect to the animal. The dìga carcass was tagged with the date and location of the kill; it was then bagged and stored under a tarp on the lake shore near a temporary airstrip built by the base camp. The harvesters did not want to skin the dìga at camp and so the carcasses were picked up by air charters and submitted to GNWT-ECC for subsequent skinning and necropsy. Typically, a Tłı̨chǫ harvester such as elder, J. Mantla was given the carcasses to skin and then brought back to GNWT-ECC for necropsies. Following Tłı̨chǫ protocols, the carcasses were sent straight to Yellowknife so that there would not be any blood of dìga dropped in any of the Tłı̨chǫ communities as requested at the elders meeting.

3.3.2 Results

The Tłı̨chǫ Government's dìga harvesting camp was located at Roundrock Lake for the winter 2023 harvesting season and harvesters traveled almost 4,000 km via snow machine to remove 15 wolves during the program (Figure 25). On January 20th, the temperature reached an unseasonal high of -9.5°C; this was concerning because the warm temperature could deteriorate traveling conditions, including the formation of overflow and potential opening of ice cracks on creeks and rivers. The first crew left Behchokǫ̀ on 22 January and they did not arrive at Wekweètì until late into the night, as they encountered heavy and wet snow conditions and open water in some areas. The crew stayed in Wekweètì for two days to rest and conduct a maintenance check on snow machines. On the trip, one of the participants was injured and not able to continue; this person was the designated communication person and therefore much of the reporting for this crew was not completed.

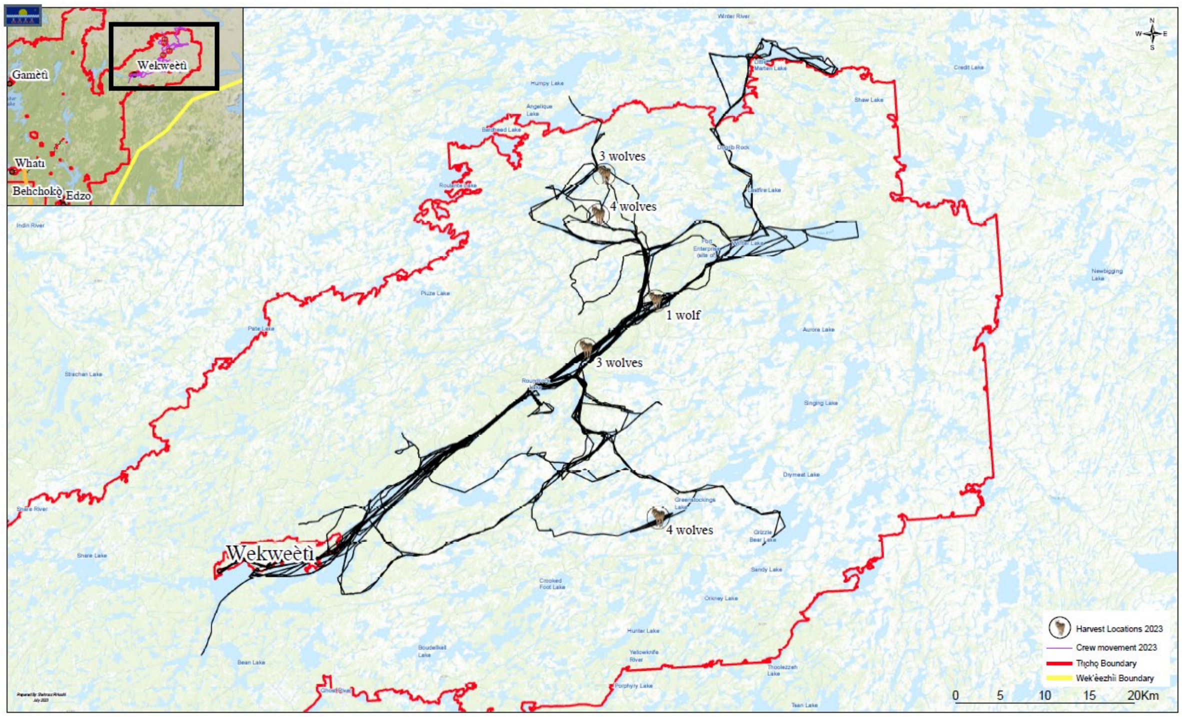

Figure 25. Snowmachine tracks (total of 3,778 km) and five kill locations for 15 harvested wolves during the 4th year (Jan-Feb 2023) of the Dìga Harvesting Program.

The crew arrived at camp on 24 January and began to explore the area looking for signs of dìga. They set up baiting stations, but after a few days the harvesters did not have any luck luring any dìga. Arrangements were made for a Kugluktuk hunter to participate in the program who arrived at camp on 29 January. Shortly after arriving at camp, he applied his knowledge and used methods such as calling for dìga with a predator call. The predator call worked effectively and the next day the dìga started showing up and harvesting them became easier; it was almost every second day that they harvested dìga or saw signs (Figure 25). There was an abundance of ekwǫ̀ in the area the entire time the camp was set up. However, caribou abundance declined around camp in mid-February when they slowly started moving north. After about two weeks of the program around February 09, harvesting of dìga began to slow down, the dìga started following the ekwǫ̀ north and the harvesters had to travel further away from camp to see any sign of dìga. Figure 26 shows the 14th of 15 wolves were killed on 5 February, which also coincided with a marked reduction in daily caribou sightings and increased kilometers traveled. In total, we harvested 15 dìga for the Tłı̨chǫ Government's dìga harvesting camp in 2023 (Figure 26). Table 11 shows the total amount of dìga harvested through the Tłı̨chǫ Government's dìga harvesting camp since its inception.

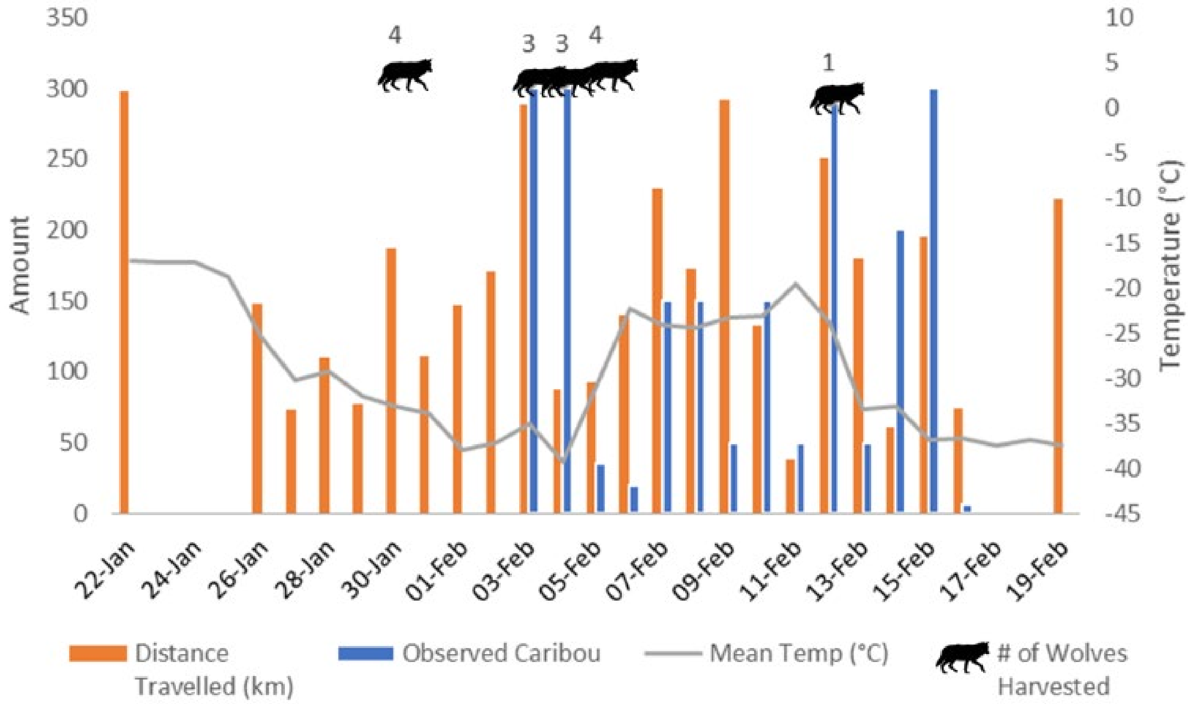

Figure 26. Data collected during the Tłı̨chǫ Government's dìga harvesting camp in 2023 (Year 4); this includes the number of dìga harvested, number of ekwǫ̀ seen, daily distance (km) traveled by hunters and mean daily temperature.

Table 11. Summarized data for the Tłı̨chǫ Government's dìga harvesting camp in all years that the camp was implemented.

	# of Field Days	**# of Hunters**	**Days Spent Hunting**	**Distance Travelled**	**Harvested Dìga**
Year 1 – 2019/20	49	19	37	4484	3
Year 2 – 2020/21	66	15	49	3839	32
Year 3 – 2021/22	31	12	21	3951	9
Year 4 – 2022/23	29	9	19	3778	15

3.3.3 Discussion

Since the inception of the Tłı̨chǫ Government's dìga harvesting camp in 2019, there have been many important lessons learned for harvesters and the program manager. Dìga harvesting has been a long-lost practice that hasn't been done by many in the Tłı̨chǫ region for quite some time. Tłı̨chǫ have many strong cultural beliefs about harvesting dìga. There is a very strong spiritual and cultural connection between the Tłı̨chǫ people, ekwǫ̀ and dìga. Thus, when harvesting either species it must be done in the most respectful ways. As the Tłı̨chǫ Government's dìga harvesting camp evolved, there have been many significant cultural practices that the Tłı̨chǫ people take pride in which has been incorporated into planning and methods of the program. Such practices include:

- Avoiding having any drop of dìga blood into the Tłı̨chǫ communities
- Avoiding having any women at camp
- Equipment used for the camp cannot be used for any other program that DCLP runs
- Paying respect to the dìga immediately after killing it by thanking it for its life

There have also been non-traditional ways that we have identified where our hunters can be more respectful and that includes using certain calibers to ensure a quicker, more humane kill. Although chasing an animal to kill it seems disrespectful, having a quick kill ensures they do not suffer as long. Other techniques were used to avoid chasing the animal, which includes snaring and trapping dìga, but the fear of capturing non-target species such as ekwǫ̀ is high and therefore it was decided to not use snares or traps.
Incorporating other cultures and expertise into the program has also contributed to the learning process for the program manager. Getting advice from the Kugluktuk hunters and working with them has been an attribute to the program. Since time immemorial, dìga hunting has been a part of the Inuit culture and to work with them can only increase the success of the program. The program is continuously evolving and improving even with all the trials and tribulations that arose. One major setback to the program was the occurrence of the COVID-19 pandemic and associated travel restrictions. By being adaptable and working through unexpected challenges, the program continued to run under the complex scenarios and different options were proposed for the program including:

- lending out Tłı̨chǫ Government snowmobiles for hunters;
- Tłı̨chǫ Government providing all equipment and supplies needed to go out;
- Tłı̨chǫ Government sending out multiple teams of two with everything supplied to them;
- Tłı̨chǫ Government providing extra financial incentive once a dìga was harvested; and
- cancel the program.

During the COVID-19 pandemic, an additional $500 was given for each wolf harvested in the eWHIA. When dìga sightings and harvest numbers decline over a week, it was suggested that camp be moved. In one of the meetings with participants, a harvester mentioned that when hunting or trapping you can't stay in the same location, you must move around. It's been considered to move camp a couple of times, but logistically it became too difficult and so equipment and supplies were offered to any harvesters who wanted to go out on their own. Being adaptable to field and hunting conditions has shown to be the most critical strategy for achieving successful outcomes in the Tłıçhǫ Government's dìga harvesting camp.

The success of the program heavily relies on experienced harvesters. There is a limited amount of people that have this skill set. The Tłı̨chǫ people have strong connections to dìga and so only certain families are allowed to harvest this sacred animal. Having a limited amount of people involved can cause some complexity in planning for the program. Not only are we limited with hunters due to cultural significance, but we are also competing with the priorities of hunting for caribou. We are also constrained for time because the winter road is open only for a short period and hunters from the isolated communities may not be available because they prefer to travel south for groceries. There are many factors that are considered each year of running this program all for the hope of decreasing the amount of dìga on the landscape with the end goal of helping the ekwǫ̀.

4 Measures of Effort

4.1 Wolf Harvester Questionnaire

In winter 2023, a wolf harvester questionnaire was used to collect information on harvesting effort. The questionnaire asked hunters about harvest location and number of wolves taken, wolf and caribou sightings, hunter effort (i.e., hunting days and kilometers travelled), weather conditions, and other relevant factors and observations (see Appendix B). Winter road harvesters were provided $50 gas cards for the submission of completed questionnaires. GNWT-ECC handed out the questionnaires to hunters travelling on Tibbitt-Contwoyto Winter Road, who were encouraged to stop at the GNWT-ECC check stations. The same questionnaires were also given to the Tłıchǫ and Kugluktuk harvesters at their respective camps. Revisions to the questionnaires were completed in 2022 after analyzing the questionnaires from previous years and receiving feedback from the harvesters. All harvesters used the revised questionnaire. This year's questionnaire included reporting if the animal was baited and if a sample kit was submitted rather than a full carcass.

4.1.1 Data compilation

Harvesters returned 30 completed questionnaires, dated between 24 January 24 and 13 April 2023, reflecting 86 wolf harvests (seven were baited) in the North Slave eWHIA. No sample kits were submitted. Four questionnaires were incomplete because harvesters did not record the number of hours spent hunting and an additional two questionnaires were incomplete because the number of kilometers spent hunting was not recorded. The additional two questionnaires that did not report the number of kilometers spent hunting were harvesters in the same hunting party and were ultimately removed from CPUE analysis (see section 4.2.1). Based on the completed questionnaires, there were 82 days when hunters were active in the eWHIA. During this period, an average of 7.6 hunters/day were actively hunting for wolves in the eWHIA. Kugluktuk harvesters were active from March 13 to April 13; winter road harvesters were active between February 10 and March 26, and Tłıchǫ harvesters were active from January 24 to February 16 (Figure 27). Seven (7) animals were reported to have been baited (Inuit harvesters: 2 baited, Tłıchǫ harvesters: 4 baited, and Winter Road: 1 baited).

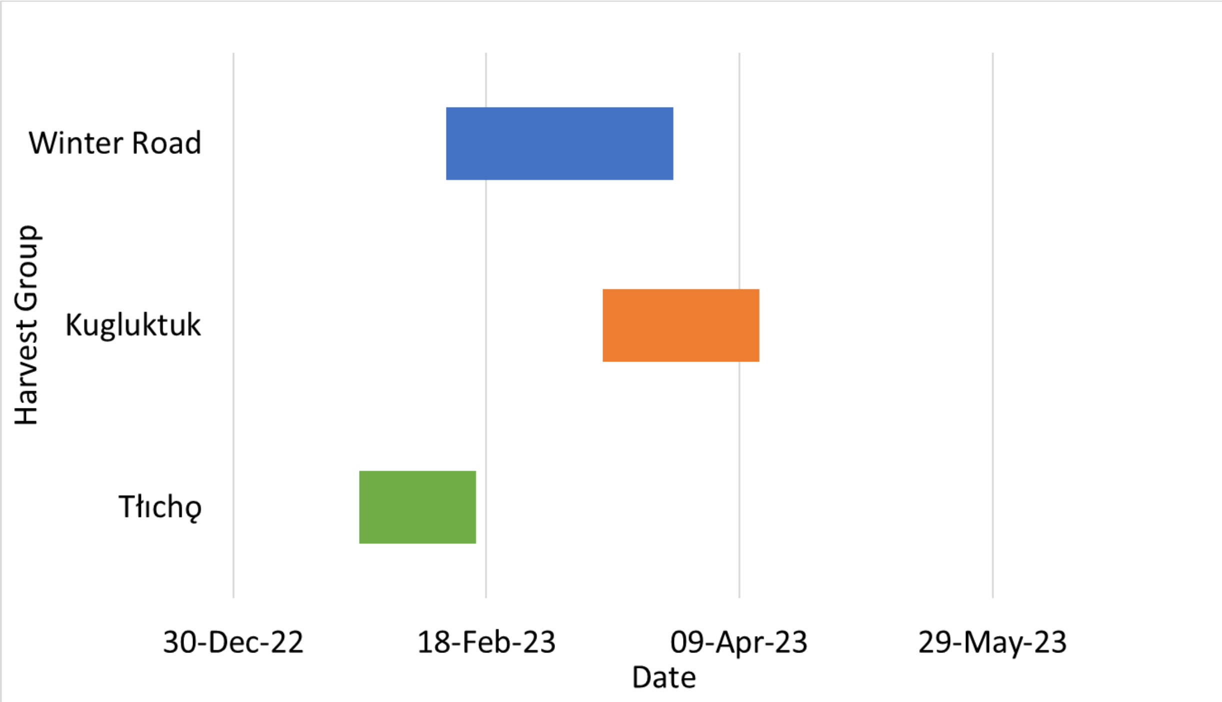

Figure 27. Comparison of winter road, Kugluktuk, and Tłı̨chǫ harvest dates. All grounds were finished hunting by 13 April 2023. The Tibbett-Contwoyto Winter Road was open to public traffic from 31 January 2023-31 March 2023.

4.1.2 Hunting experience

Hunting experience likely influences a hunter's ability to harvest wolves and should be accounted for when assessing harvest data. Three questions were asked related to hunter experience. The first question was "How many years have you been hunting wolves?" with responses that included less than 5, 5-10, or over 10 years. The second question was "How recently have you hunted wolves?" with responses including before 2010, 2010-2015, 2015-2020, 2020-present. The majority of completed questionnaires reported that hunters had recently hunted, 2020-present (63%). The last question was "About how many wolves have you harvested in your lifetime?" For this question, responses were categorized into three groups: less than 5 wolves, 5-10 wolves, and greater than 10 wolves. Most (72%) of the completed questionnaires reported greater than 10 wolves harvested in their lifetime. Similarly, 75% of completed questionnaires reported that hunting of wolves has occurred for greater than 10 years (Figure 28).

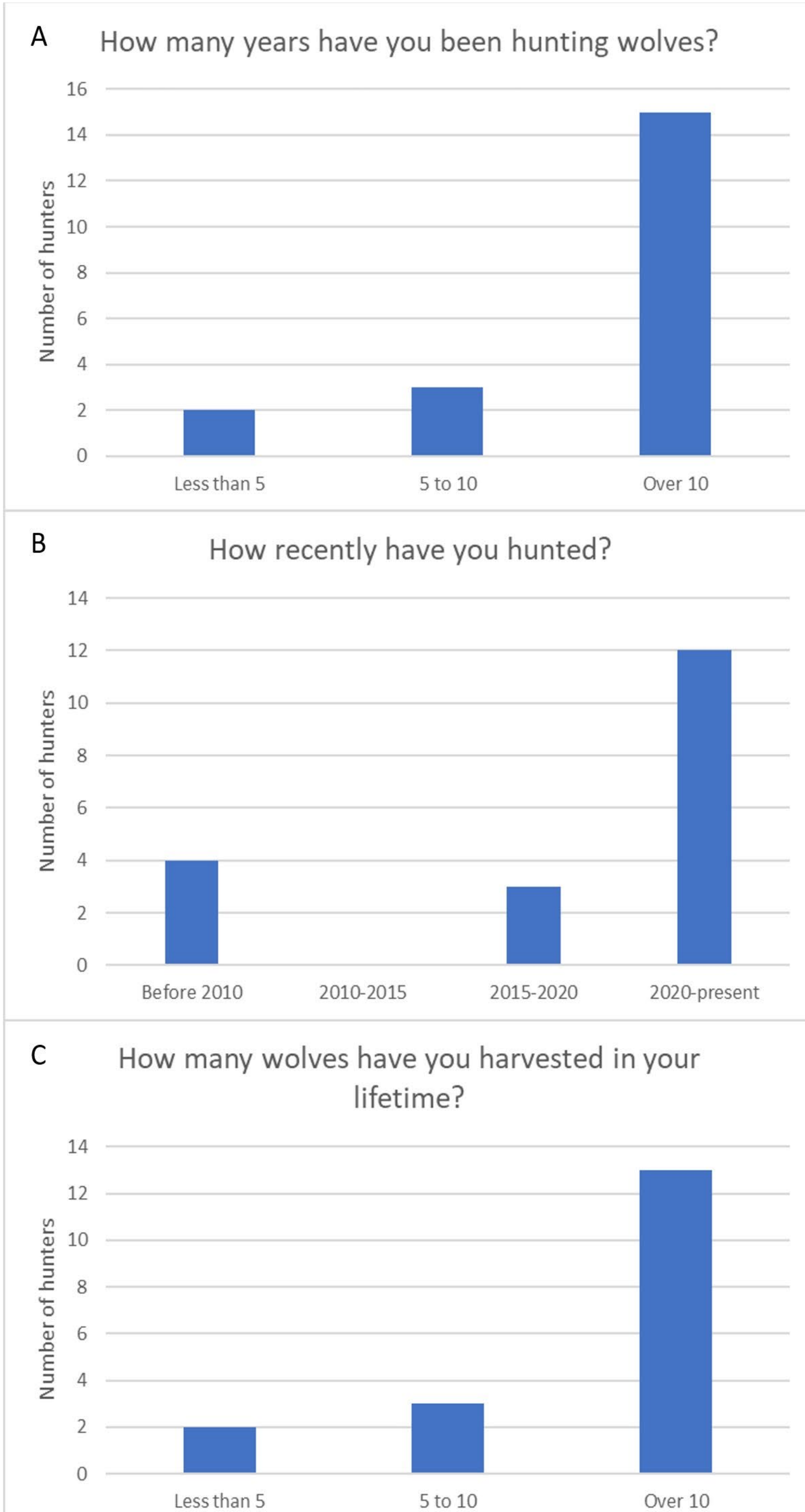

Figure 28. Qualitative summary of hunting experience reported in completed harvester questionnaires (n=30), winter 2023.

4.1.3 Wolf Sightings and Effort

To better understand how the number of wolves is changing on the landscape, the questionnaire asked three questions related to wolf sightings and hunting effort. The first question was "In total, how many wolves did you see on your trip?". The second question was "How big were the packs (circle number range)?" with choices of less than 5, 5-10, 10-15, 15-20, and over 20. The last question was "How hard was it to find wolves (circle one)?" with choices of very difficult, somewhat difficult, easy, and very easy. These answers can provide a qualitative indication of annual changes in the wolf population. If fewer wolves are sighted during hunting trips, packs were smaller, and finding wolves was more difficult, it may suggest that the wolf population numbers are lower than the previous hunting season. For how many wolves did you see on your trip, the responses from the Tłı̨chǫ Government's dìga harvesting camp were for the entire camp, not each person. Most questionnaires (6) reported seeing no wolves, while 10 questionnaires reported seeing between 1-5 wolves (Figure 28). Most questionnaires reported that finding wolves was very difficult (27.8%) and somewhat difficult (25%). Only some reported that finding wolves was easy (16.7%) or very easy (2.8%). The majority (58.3%) of the wolf pack size reported were less than five wolves and none had more than ten wolves (Figure 29).

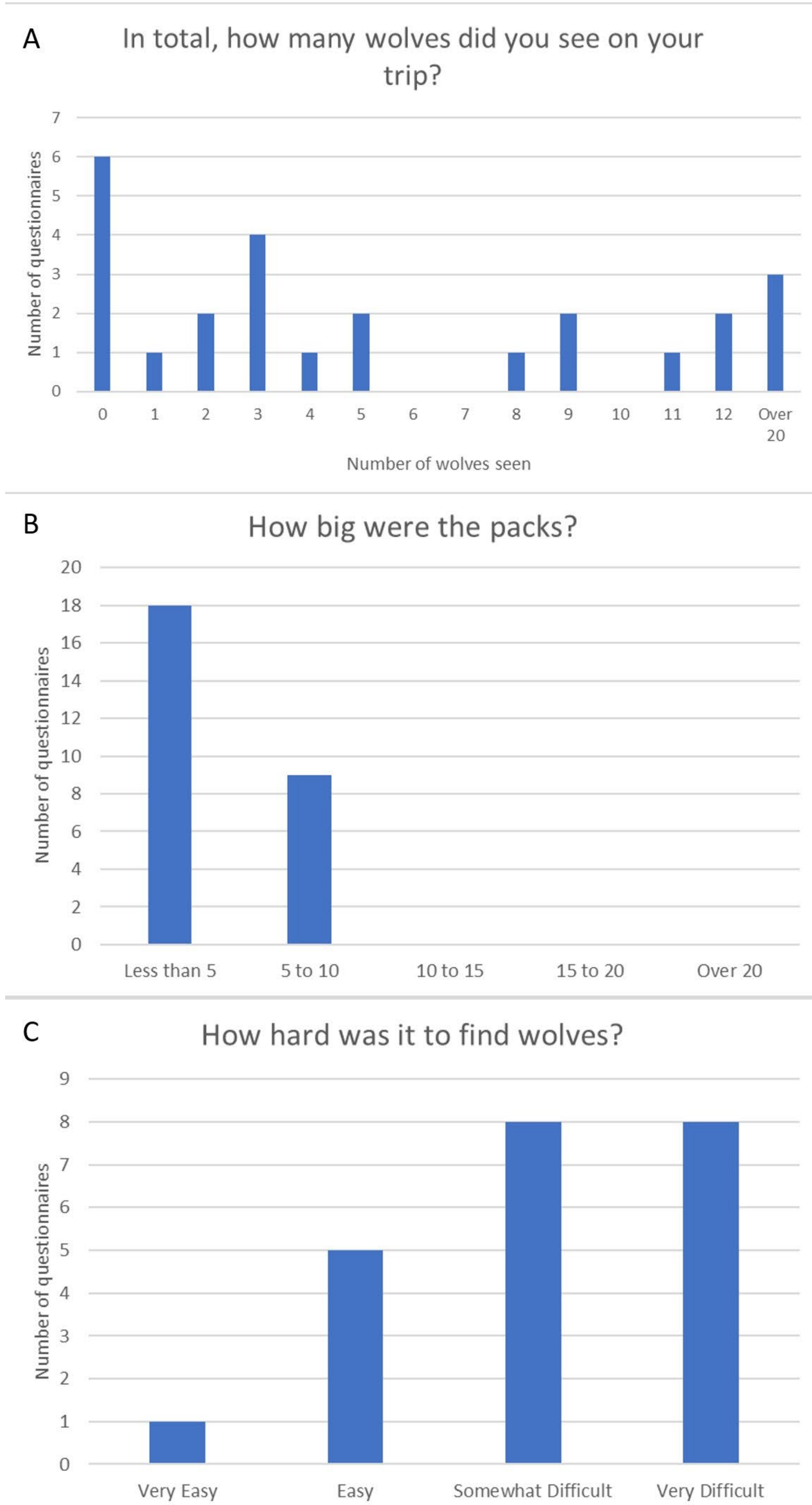

Figure 29. Qualitative summary of wolf sightings and effort reported in 2023 harvester questionnaires.

4.1.4 Number of Caribou observed and other harvest

Respondents were asked to record the number of caribou seen while hunting wolves. Winter road hunters reported seeing groups of caribou anywhere between 0 and over 500, while Tłıçhǫ hunters reported groups of 101-500 caribou (one reported number for the camp). All Kugluktuk hunters reported seeing caribou groups greater than 500 individuals. In addition, hunters were asked to record the number of caribou carcass remains that they thought were a result of wolf kills. Kugluktuk harvesters recorded seeing 10 or less caribou remains likely killed by wolves, while Tłıçhǫ hunters reported seeing less than 5 caribou remains likely killed by wolves. All winter road harvesters recorded seeing less than 5 caribou remains likely killed by wolves. Due to the questionnaire format, the respondents only provided one instance of observation for the duration of the trip. In other words, a group would record seeing 21-100 caribou during their trip whether they saw the same or different herd once or multiple times or if they also encountered other herds of smaller sizes. Therefore, the response summary to these questions should be interpreted with caution as they likely underestimate hunters' sightings of caribou groups and carcass remains. Kugluktuk harvesters also reported harvesting six wolverines and two caribou while hunting for wolves. The winter road harvesters reported harvesting ten wolverines, nine foxes, four muskox, five caribou, one ptarmigan, and one loon, while the Tłıçhǫ harvesters reported harvesting one fox and one wolverine (Figure 30). Qualitatively, it appears that a high number of caribou have been observed, yet there are few caribou carcasses likely killed by wolves, which may suggest that caribou numbers are high and that wolf numbers are low or the detectability of caribou carcasses killed by wolves is low.

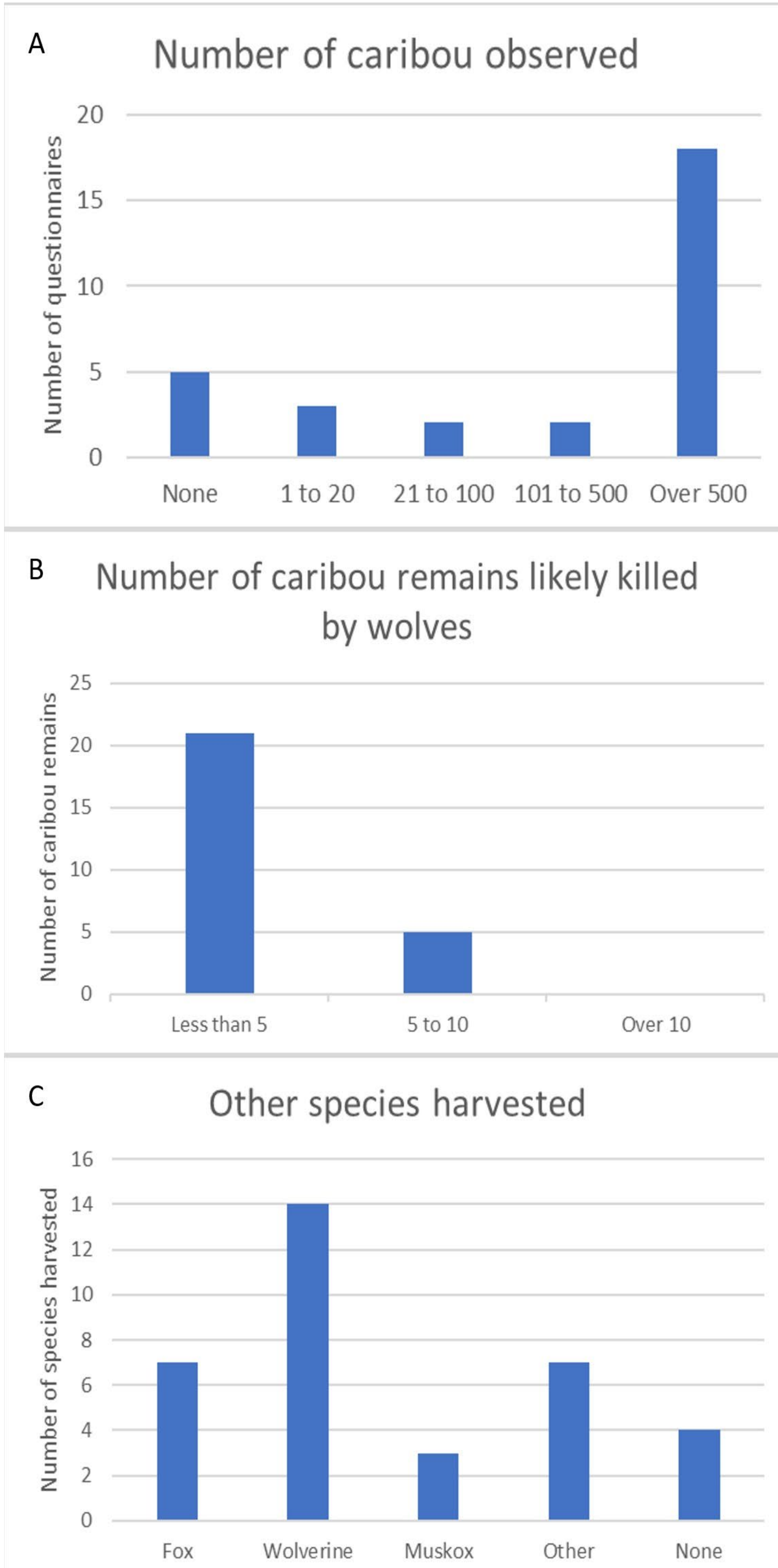

Figure 30. Qualitative summary of number of caribou observed and other harvests reported in 2023 harvester questionnaires.

4.1.5 Weather Conditions

In the wolf harvester questionnaire, hunters were asked to comment on the weather conditions during each day of their trip by circling perfect, good, bad (low visibility), or very bad (stormed in). Some hunting days were recorded to have two different weather conditions like good and bad, but these were counted as "good" weather days for the comparisons. Out of 82 hunting days, 59 of those reported comments about the weather. More than half (76%) of the hunting days were reported to have good (47%) and perfect (29%) weather conditions. The other hunting days (24%) recorded poor weather with 20% of them being classified as bad and 3% being very bad. The remaining 28% of days had no weather conditions recorded. In comparison, approximately half (47%) of questionnaires reported poor weather conditions that only contained adverse weather, such as "cold", "windy days", "white-out", "blowing snow", or "soft snow conditions" in 2022.

4.2 Catch Per Unit Effort

Catch per unit effort (CPUE) is used to model the relationship between the probabilities of harvest and hunting effort to elicit information about the harvested population's abundance (Allen et al., 2020; Mitchell et al., 2022). CPUE is derived by dividing the total catch (i.e., harvest) by a unit of effort over a specified period of time (i.e., daily, weekly, or monthly). This report used two units of hunter effort, days spent hunting and kilometers travelled daily, for harvesting a wolf. The questionnaire asked hunters to record the number of hours spent hunting each day, which was used to estimate the number of days spent hunting (i.e., >0 hours was classified as a hunting day; 1 hour would be rounded up to 1 day; see Wilson et al., 2022 for justification) and the number of kilometers spent hunting each day of their trip. The intent of these questions was to collect the time spent and distance travelled on the hunting grounds, searching for wolves; and the time and distance travelled once wolves are seen, such as stalking, active pursuit and shooting.

4.2.1 Methods

The analysis for the 2023 CPUE is based on the submitted completed by harvesters from Kugluktuk, Tłı̨chǫ Government's dìga harvesting camp and hunters accessing the Tibbit-Contowyto Winter Road. A series of steps were taken to only include questionnaires with usable data, resulting in 19 questionnaires used for CPUE analysis:

- Started with 30 questionnaires provided by harvesters.
- Four questionnaires from winter road harvesters did not report any effort data and therefore were not included in the CPUE analysis. However, these hunters removed 3 wolves and thus these wolves were not included in the total wolves harvested. Effort data was also not recorded for some of the Tłı̨chǫ Government's dìga harvesting camp, but the remaining data was used.
- Removed 6 questionnaires with duplicate effort (i.e., multiple questionnaires from the same hunting party based on dates, hunting hours, and kilometers traveled)
- Removed 1 questionnaire with a baited harvest. Two more instances of baiting were recorded on specific days within one questionnaire. Therefore, the effort data associated with those days were removed, but the effort data on the remaining days on the questionnaire were used for analysis.

The questionnaires reported 86 wolf harvests, accounting for 87% of the carcasses submitted to GNWT-ECC. To compare CPUE-day and km across multiple years, a series of steps were taken to standardize the previous harvest and effort data (see Wilson et al., 2022). Kugluktuk harvesters typically hunt in groups and often report the same hunting trip on multiple forms. Thus, field days, hunting days, and kilometers travelled were removed for hunters reporting within the same party. These duplicates were defined as reporting the same hunting dates and number of hunting days (calculated from hours reported). There were submitted questionnaires that appeared to be from the same Kugluktuk hunting party, as hunting dates and number of hours spent hunting were reported the same for each hunter. However, the reported number of kilometers spent hunting was different for each hunter. Therefore, to consider one hunting party (similar to last year's analysis and reported by Tłįchǫ Government's dìga harvesting camp), the total number of kilometers spent hunting for each harvester within one hunting group was calculated and the average across the harvesters within the group was used as the total distance travelled for the CPUE analysis. Given that winter road harvesters typically travel alone, and inconsistent information was reported, it was assumed there were no duplicates for winter road harvesters. Some Kugluktuk harvesters also only reported effort data on days that wolves were harvested, even though hunting was assumed to occur on days when no wolves were harvested. For example, effort data was provided for 04/03/2023 and 04/13/2023, but not every day in between these two dates. Even if hunters were active during those days, we do not know if they were hunting and therefore assumed they were not. Data from those missing days were not assumed or included in the analysis. If the hours spent hunting were not recorded, then we checked if a wolf was harvested that day and if so, counted it as a day spent hunting. The revised questionnaire included reporting if a wolf was baited at harvest, but baited wolves were not included in the CPUE analysis. The data used to calculate the catch per unit effort metrics is shown in Table 12.

Table 12. Number of field days, hunters, harvested wolves, days spent hunting and distance travelled calculated from harvester questionnaires for non-baited wolves only from 2020-2023.

	No. of Field Days	No. of Hunters	No. of Harvested wolves	No. of Days Spent Hunting	Distance Travelled (km)	No. of questionnaires used for CPUE
Tłı̨chǫ						
Year 1 - 2020	49	19	3	37	4484	0
Year 2 - 2021	66	15	32	49	3839	0
Year 3 - 2022	31	12	9	21	3951	0
Year 4 - 2023	23	10	11	21	3070	1
Kugluktuk						
Year 1 - 2020	134	9	36	118	19869	12
Year 2 - 2021	189	15	86	142	19505	16
Year 3 - 2022	30	7	25	18	3484	3
Year 4 - 2023	27	9	45	20	4883	5
Winter Road						
Year 1 - 2020	51	10	1	47	11170	23
Year 2 - 2021	82	20	14	60	15734	25
Year 3 - 2022	46	10	19	46	27001	12
Year 4 - 2023	42	13	15	41	13036	13

[1]Data for the Tłı̨chǫ Government's dìga harvest camp was provided by them rather than recorded on the questionnaires.

4.2.2 Results

To compare across multiple years, CPUE was calculated for each group and year (Figure 31A-B). The Tłı̨chǫ Government's dìga harvest camp reported a CPUE-day of 0.52 wolves/hunting day in 2023, which was greater than the CPUE-day from 2022 (0.43 wolf/hunting day) and 2020 (0.081 wolf/hunting day), but less than the CPUE-day from 2021 (0.65 wolf/hunting day). The effort data reported by Kugluktuk harvesters showed an increase in CPUE-day from 2020-2023. The effort data reported by the winter road harvesters showed an increase in CPUE-day from 2020-2022, but a decrease in 2023 (0.37 wolf/hunting day) compared to 2022 (0.41 wolf/hunting day). On average, the CPUE-day also increased from 2020-2023 (Figure 31A).

The Tłı̨chǫ Government's dìga harvest camp reported a CPUE-km of 3.6 wolves/1,000 km in 2023, which is greater than the CPUE-km from 2022 (2.3 wolves/1,000km) and 2020 (0.7 wolves/1,000km), but less than the CPUE-km from 2021 (8.3 wolves/1,000km). Similarly, winter road harvesters reported a larger CPUE-km in 2023 compared to 2022, 1.15 wolves/1,000 km and 0.7, respectively. Kugluktuk harvesters reported a CPUE-km of 9.21 wolves/1,000 km, which was higher than last year (7.2 wolves/1,000 km). On average, CPUE-km was highest in 2021 and 2023, was much lower in 2020 and was slightly less in 2022 (Figure 31B).

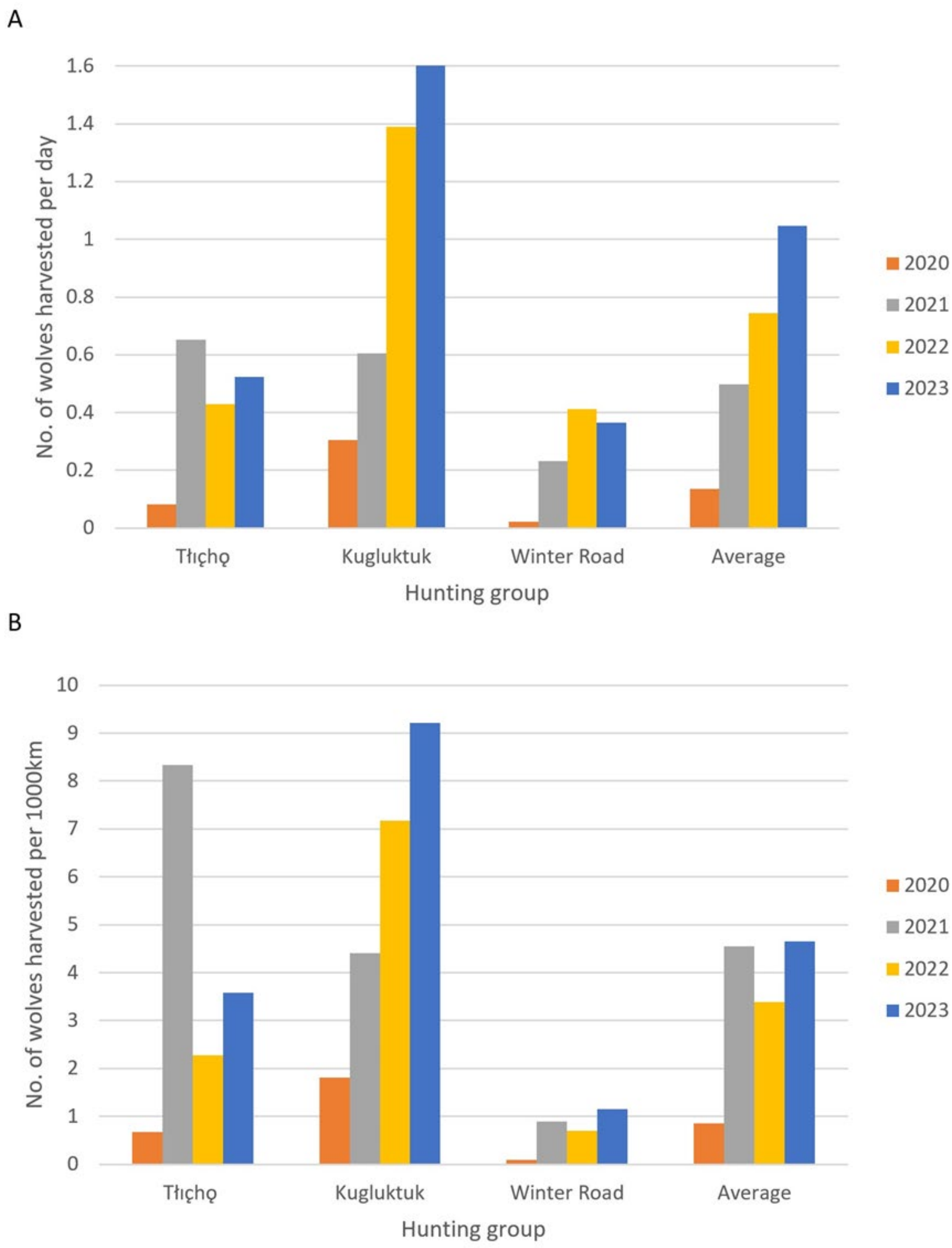

Figure 31. Catch per unit effort (CPUE) relative to hunting days (A) and distance travelled (B) for the Tłı̨chǫ Government's dìga harvest camp, Kugluktuk harvesters, and winter road harvesters in 2020, 2021, 2022, 2023 as well as the average CPUE across all groups within each year.

4.2.3 Discussion

Overall, the revised questionnaires provided ample space for harvesters to record information for every day of their trip, were easy to fill out, and captured the information needed to calculate CPUE. However, only 19/30 questionnaires (63%) were usable for the CPUE analysis because effort data not being recorded, duplicate effort within the same hunting party, and baited animals. All of which will influence CPUE calculations. Further conversations with harvesters and considerations around duplicate effort and baited animals will need to be addressed in the future. We recognize that these questions need to be considered from the harvester's perspective and not be difficult or burdensome to record information but will still provide the needed information.

The number of wolves harvested per hunting day increased for Kugluktuk, Tłįchǫ, and winter road harvesters as well as on average from 2020 to 2023, suggesting that the effort (measured by days spent hunting) it takes to harvest wolves decreased over time. Similarly, the number of wolves harvested per 1,000km increased from 2020 to 2023 for the Tłı̨chǫ Government's dìga harvesting camp, winter road harvesters, and on average. This may indicate that the effort (measured by distance travelled) it takes to harvest wolves decreased over the last three years. Poor snow conditions (e.g., wet and melting) reported by Tłįchǫ harvesters may have influenced the number of wolves harvested this year for that group.

In CPUE analyses, a general assumption is that the harvested population is closed, meaning that there is not a significant movement of individuals in or out of the population within the given period and area when harvest effort is applied (reviewed by Hubert & Fabrizio, 2007). Thus, in a closed population and with other covariates held constant, CPUE should decrease as abundance and density of animals are reduced by the cumulative harvest. An equivalent version to the assumption for population closure, is that the population is relatively constant with respect to its exposure to harvesting effort. In this context, non-migratory wildlife are more likely than migratory wildlife to meet this assumption of constant exposure to harvest. For example, it would be difficult to attribute changes in CPUE solely to a reduction in density due to cumulative harvest for a given area, when the overall density changes are also strongly influenced by the transient and dynamic occurrence of migratory wildlife in the area. In addition, the response of CPUE to declining population abundance may be scale dependent, which means that a detectable reduction in CPUE may occur within a small, localized area, but that same trend may not be detectable within a larger area.

Additional analysis is required to assess whether training and/or incentivizing wolf hunters is sufficient to elicit a measurable effect to lower wolf density, i.e., a numerical reduction through higher rates of additive mortality and how to determine if a declining trend in CPUE is a reliable indicator of reduced wolf density (abundance). Further statistical modeling is needed to determine what factors influence harvest success and consequently CPUE and will assist in determining if CPUE is an appropriate measure of effort for the migratory barren-ground wolf population in the NWT.

4.3 Sighting rates

The number of wolves sighted per hour flown during aerial surveys or collaring efforts has been used as a metric to monitor changes in the number of wolves on the landscape over time. A decrease in the number of wolves sighted per hour flown may suggest a decrease in the number of wolves present and therefore less opportunity for predation on caribou. Zero wolves were sighted during the March 2023 caribou collar deployment and this number has decreased when compared to previous years of coordinated collar deployment of both wolves and caribou (0.86 wolves per hour in 2022 and 1.82 wolves per hour in 2021). Sighting rates of wolves during March caribou composition surveys decreased from 2010-2020. From 2020-2023, sighting rates of wolves in areas of highly mixed caribou and Bluenose-East caribou only initially decreased and have slightly increased in the last year (Figure 32). Additionally, observed pack sizes during collaring have not changed from March 2020-2023, ranging from 1-5 to 1-11.

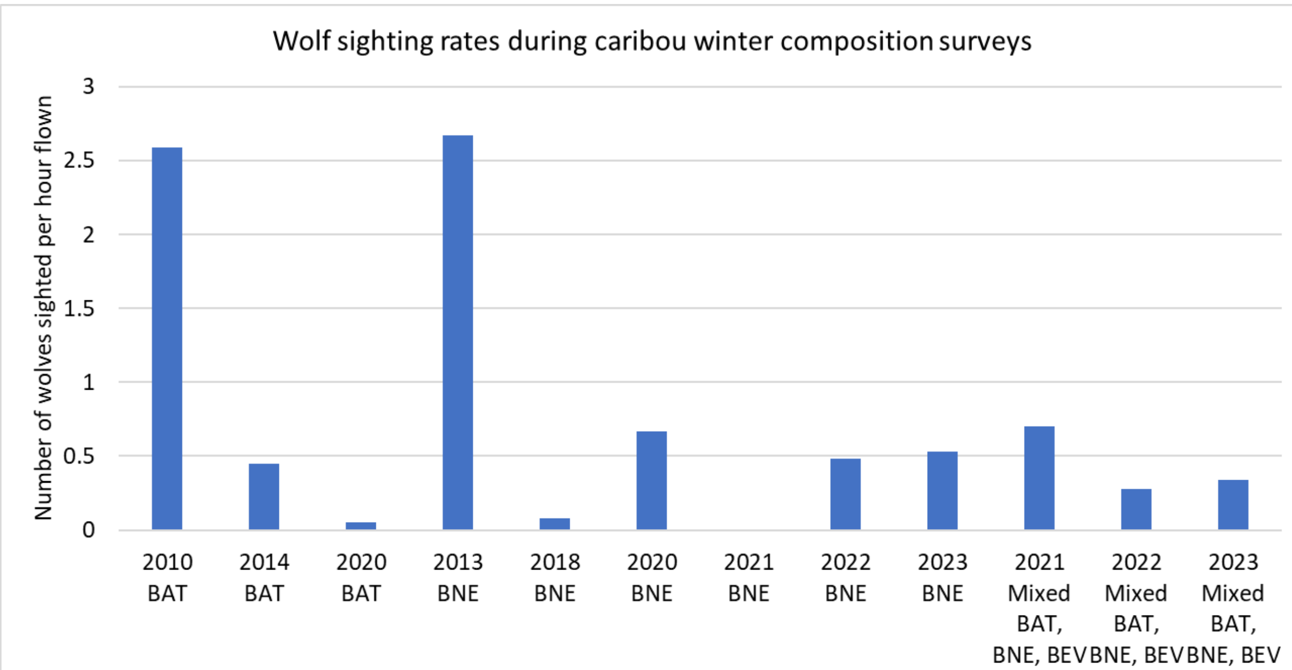

Figure 32. Wolf sighting rates during caribou winter (March) composition surveys.

For comparison, sighting rates during wolf management activities have varied over the years (Figure 33). Helicopter flights for wolf collar deployment were conducted with a separate crew and targeted already collared wolf packs in March 2023 resulting in a sighting rate of 1.23 wolves per hour. During the wolf den survey conducted in May 2023 (see section 2.3) 6 wolves were sighted over 46 hours (0.13 wolves per hour). Due to differences in methodologies that can influence sighting rates (e.g., aircraft type, observer experience, weather conditions, and snow cover), sighting rates reported for different types of management activities should be interpreted with caution.

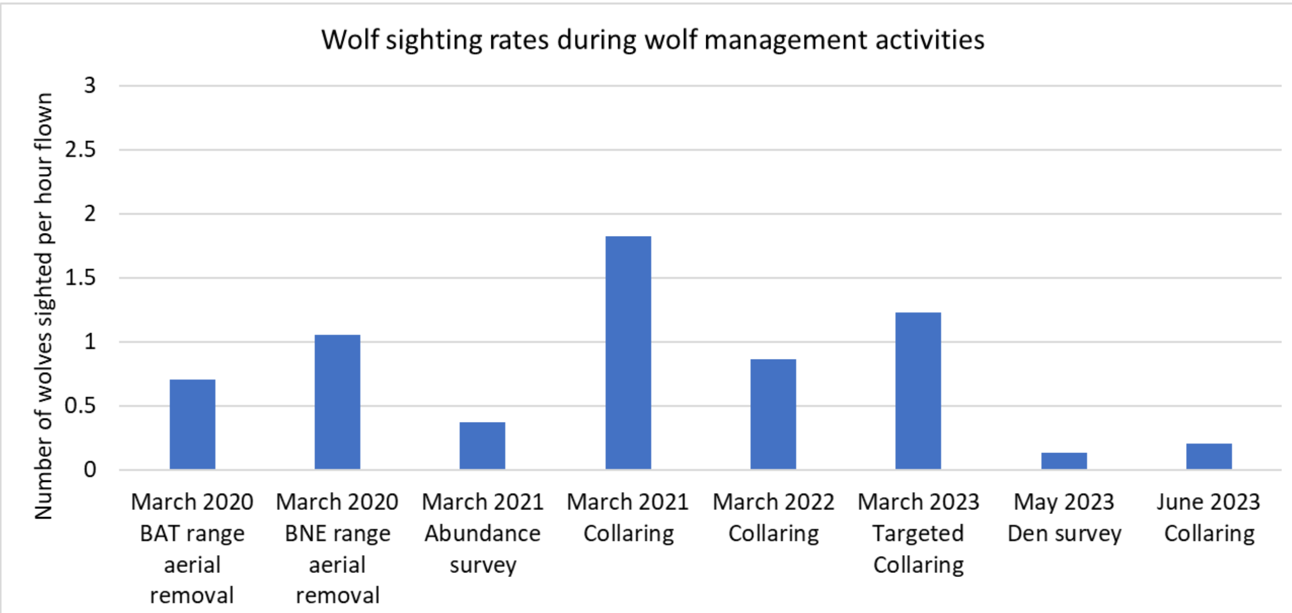

Figure 33. Wolf sighting rates during various wolf management program activities.

5 Demographics and health of harvested wolves

Based on the Joint Proposal on Management Actions for Wolves (dìga) submitted in August 2020, and responses to the WRRB Reasons for Decisions Related to a Joint Proposal for Dìga (Wolf) Management in Wek'èezhìi, the Tłįchǫ Government and the Government of the Northwest Territories (GNWT) agreed to necropsy a sample of wolves removed as part of this program to assess the health and condition of harvested wolves.

5.1 Objectives

It should be noted that numbers in this report may appear different than in the *Veterinary Assessment of Wolf Removal Outcomes 2021*. This is due to a post-hoc adjustment made to analyze only animals which were harvested in the eWHIA – the previous report contained 12 animals harvested outside the prescribed zone, which have since been removed from the dataset for consistency and to allow year-to-year comparisons specific to this enhanced management program and its unique variables (prescribed area, increased monetary incentive amount, management/monitoring objectives, etc.). Necropsy investigations were conducted in all three years on animals harvested outside the prescribed zone – though those individuals were removed for analysis and reporting.

5.2 Methods

From 26 January- 19 April 2021, 02 February- 08 April 2022, and 13 December 2022-09 April 2023, 228 carcasses of grey wolves were submitted by at least 42 different harvesters to GNWT-ECC. Necropsies were conducted on 228 carcasses from wolves harvested by either ground-based shooting or trapping methods. Examinations included an assessment of health and harvest-related injuries, in addition to standard biological monitoring. Wolves were accompanied by a tag which had spaces for harvesters to indicate location of kill/death, date of kill, method of kill, submitter name, and animal sex. Carcasses submitted to GNWT-ECC were stored frozen at -20 degrees Celsius until examination. Storage conditions between harvest in the field and submission of carcasses are unknown.

In lieu of available ante-mortem data regarding harvest details and to gain additional professional perspectives on necropsy findings, the author consulted with wildlife health professionals, wildlife biologists with backgrounds in carnivore biology and ecology, and experienced Indigenous Knowledge holders/community wolf harvesters locally, at a Tłįchǫ Government harvester workshop (December 2021), at meetings with Kugluktuk wolf harvesters and the Kugluktuk Angoniatit Association Hunters and Trappers Organization (June 2022), and at the wolf harvester workshop (December 2022; see Section 3.1).

5.2.1 General Necropsy and Health Investigation

All necropsies followed standard protocols recognized for wild and domestic canids and were conducted by or under the direct supervision of a wildlife veterinarian. All individuals involved in necropsy procedures had up-to-date rabies pre-exposure prophylaxis vaccination and used appropriate personal protective equipment.

Individually assigned identification numbers, date of necropsy, and any information included on the tag associated with each wolf carcass were recorded. Skinned weight of carcasses was obtained using a laboratory-grade floor scale and recorded to the nearest hundredth of a kilogram, and any missing body parts for each individual carcass were documented. High resolution full body photographs of wolves laying in lateral recumbency, both left and right, were taken using a digital single-lens reflex camera. Morphometric measurements recorded in centimeters included full contour length (tip of nose to base of tail), tail length (when possible), neck girth, chest girth (at axillae; using measuring tape), and rump fat depth (millimetres; using laboratory grade electronic calipers, CARMA, 2008; see Figure 34). Skull measurements were taken using calipers, including zygomatic width, condyle-basal length, and total skull length. High resolution photos of skulls were also taken, including dorso-ventral, rostro-caudal (with focus on incisor dentition), and right and left lateral views. Age class was approximated visually according to Gipson et al (2000), sorted into puppy, juvenile (1-2 years), adult (3-7 years), and geriatric (est. 8+ years). A premolar tooth will be submitted to an external reference laboratory (Matson's Laboratory, Manhattan, Montana) for aging by cementum annuli analysis (Ballard et al., 1995). An external body condition score was assigned on a semiquantitative scale of 0-4 (with 0 being poorest and 4 being best condition) based upon coverage and thickness of subcutaneous fat stores. Similarly, an internal nutritional condition score was assigned based on abdominal visceral fat deposits. An average of external and internal scores provided an overall coarse subjective nutritional condition indicator for each wolf. Hair samples (when available) were plucked and placed in paper envelopes and stored at room temperature for future analysis (i.e., genetics, stable isotopes) – samples were taken from wherever available on the already-skinned body, typically the perianal region or tail.

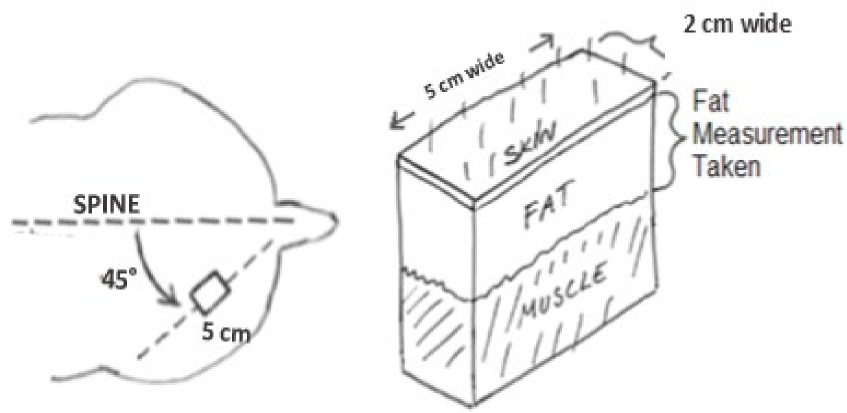

Figure 34. Location used to measure rump fat depth as an indicator of wolf body condition status.

Necropsies were performed in left lateral recumbency. All 4 limbs were reflected initially to examine associated skeletal and soft tissue structures/spaces. Blood was collected on Nobuto filter paper strips from the femoral artery. When this was not possible, jugular venous or carotid arterial blood, blood from the thoracic cavity (when not contaminated by ingesta), or blood directly from cardiac structures (thoracic aorta, inferior vena cava, or heart) was used. Eight to 10 strips were collected for each animal where possible, and air dried for 24 hours before being stored in envelopes at room temperature. Filter paper eluate are being submitted to reference laboratories for analysis of exposure to various canine pathogens related to individual and population health. The right femur was collected, cleaned, measured for circumference, diameter, and length using calipers, and marrow was extracted from the diaphysis and air dried to determine percent femoral marrow fat as an indicator of nutritional condition (adapted from Lajeunesse and Peterson, 1993; Lefebvre et al., 1999; CARMA, 2008). Where the right femur was damaged or unavailable, the left femur was collected instead. The abdominal cavity was opened and the integrity (presence or absence of negative pressure) of the thoracic cavity was assessed using a small incision to the abdominal surface of the diaphragm. The right rib cage was removed with large shears at the level of the vertebral column and costochondral junctions. Photographs were taken of the internal neck, thoracic, and abdominal cavities, in addition to wider full body internal photos. The 'pluck' (tongue, esophagus, trachea, thymus, heart, lungs, and associated structures) was removed by disarticulating the hyoid bone and releasing the tongue from skeletal muscle attachments through the ventral jaw, and extending the incision along the neck, to the thoracic inlet, and into the thoracic cavity while applying ventral tension to the tongue along the length of the thoracic tissues being removed. The pluck was photographed ex-situ and also examined in detail for any trauma or pathology – this included incising esophagus and trachea, lung tissue, and gross examination of the heart (unless incision was indicated). Subjective/relative prominence of the thymus was recorded as a contributing indicator of age class estimate. Abdominal organs, including the liver, spleen, stomach, intestines, kidneys, adrenals, gonads (when applicable), and lymph nodes, were examined incised when indicated by evidence of trauma or pathology.

Samples were collected in sterile WhirlPak™ bags, individually labelled to correspond with the identification number assigned to each carcass and stored at -20°C. A subsample of lung tissue, heart (2021 and 2023 only), and tongue were collected from the pluck. Kidneys were removed with peri-renal fat per methods described in Riney (1955) and weighed. They were subsequently weighed with peri-renal fat removed to facilitate calculation of renal fat index (Riney, 1955). The entire xyphoid/falciform fat pad was excised, weighed, and subsampled. Kidneys (2021 only), liver sample, and spleen were collected. The full stomach was removed at the esophageal cardia and the gastroduodenal junction and weighed with contents. Stomach contents were removed from the organ, photographed, and subsampled. The empty stomach was then weighed. Photos of stomach contents and/or subsamples were sent to an experienced contractor for analysis and identification. The small and large intestines were tied off at the proximal duodenum and distal colon/rectum and stored frozen for future analysis. The uterus was removed (when applicable) and assessed for the presence of fetuses or evidence of implantation sites (i.e. placental scars or lochia). Samples collected were analyzed in-house, submitted to reference laboratories, or archived for future analyses.

5.2.2 Statistical Analyses

R 3.6.0 was used to perform any descriptive or regression statistical analyses. The Shapiro-Wilk test and visualization of q-q plots were used to assess normality assumptions of data. Parametric statistical tests (t-tests, linear models, ANOVA, and Tukey post-hoc tests) were used for analyses of normally-distributed data assessing temporal trends and interrelationships among metrics of health. Non-parametric tests (Kruskal Wallis, Spearman Rank correlation, Chi-Square, Mann-Whitney U tests) were used when normality assumptions were not met. ANOVAs were considered robust enough to deal with non-normal datasets where sample size was sufficient ($n>100$).

5.3 Results

Ninety-nine (99) wolves from the 2021 eWHIA, 45 wolves from the 2022 eWHIA, and 83 wolves from the 2023 eWHIA were necropsied. One carcass in 2022 submitted was indicated as 'found dead' and had no evidence of having been shot or trapped, and therefore was not included in the health and demographics assessment. On necropsy, this animal was severely emaciated and of geriatric age class. Starvation was likely a contributing factor to this animal's death, but the possibility of underlying disease could not be ruled out on gross examination. Samples were submitted to the CWHC Western/Northern Node (Saskatoon, Canada) for additional health analysis, which confirmed gross necropsy findings (case reports available upon request to GNWT-ECC). Based on observations made on necropsy and consideration of tag information, we confirmed that at least two of the wolves in our study sample were snared (2021). Specific snare or trap types used were not reported.

Information documented from each animal included date, method of kill, harvester name, location, and an indication of observed animal sex, but no antemortem data (Appendix K of Feasibility Assessment; Hampton et al., 2015) was documented on the tags. Most tags attached to the harvested wolves did not have complete data recorded. Further information such as if the animal was baited, hunter experience, and weather was recorded on the harvester questionnaires.

Decomposition or tissue damage suspected to be from freeze-thaw cycles and post-mortem scavenging was common among carcasses (present to some degree in 100% of carcasses examined) and hindered complete examinations; many animals were missing the limbs, head, and/or other appendages to varying degrees (Table 13); and the majority of carcasses (142/228) were already skinned at time of presentation to the veterinarian and presented with varying degrees of skinning artifact, which also impacted interpretation of injuries at necropsy.

Table 13. Documentation of body parts removed prior to submission of carcasses for examination (total carcasses, n=111).

Missing Body Part	# Carcasses (2021)	# Carcasses (2022)	# Carcasses (2023)	2021 + 2022
Head	6	0	0	6
Fore paws	65	24	62	89
Distal Forelimbs + paws	27	15	16	42
Proximal + Distal Forelimbs + paws	2	0	0	2
Hind Paws	79	39	78	118
Distal Hindlimbs + paws	18	0	0	18
Tail	61	23	40	84

5.3.1 Health and Demographic Assessment

The wolves examined were distributed across sex and estimated ages (or subjective age classes). Ages determined subjective age classes (Gipson et al, 2000) as well as confirmed sex are presented in Table 14. Some age results determined by cementum annuli analysis (Ballard et al., 1995) have been received, and are presented in Figure 35. Note that results are still pending from all years.

Table 14. Summary of sex (determined on necropsy examination) and age classes (juvenile = 1-2 years old, adult = 3-7 years old, geriatric = 8 years or older; n=228) of harvested wolves.

Sex	**2021 (Freq)**	**2022 (Freq)**	**2023 (Freq)**
Male	53 (53.5%)	22 (47.8%)	49 (59.0%)
Female	46 (46.5%)	24 (52.2%)	34 (41.0%)
Total Wolves	99	46	83
Age Class	**2021 (Freq)**	**2022 (Freq)**	**2023 (Freq)**
Young of the Year	0 (0%)	1 (2.2%)	4 (4.8%)
Juvenile	31 (31.3%)	20 (43.5%)	32 (38.6%)
Adult	50 (50.5%)	20 (43.5%)	39 (47.0%)
Geriatric	16 (16.2%)	5 (10.9%)	8 (9.6%)
Unknown	2 (2.0%)	0 (0%)	0 (0%)

Age structure by subjective age class significantly varied between years (Kruskal Wallis test, $p<0.05$, Figure 35b). The ratio between young (young of the year, juvenile) to mature breeding adults (adult, geriatric), however, was not significantly influenced by year of harvest (Kruskal Wallis test, $p=0.10$). Cementum aging results would provide a more accurate depiction of age structure changes, but analysis for all submitted samples is not yet complete. Preliminary age data are presented in Figure 35a, which shows significant differences between the cementum age (years) with respect to year of harvest (Kruskal Wallis test, $p<0.05$). The cementum age of harvested wolves was lower in 2021 and 2022 when compared to 2020, but not statistically different from 2019, when animals from outside the eWHIA were included (prior to the start of the program). Statistical analyses and corresponding results will be updated with the receipt of the remaining results.

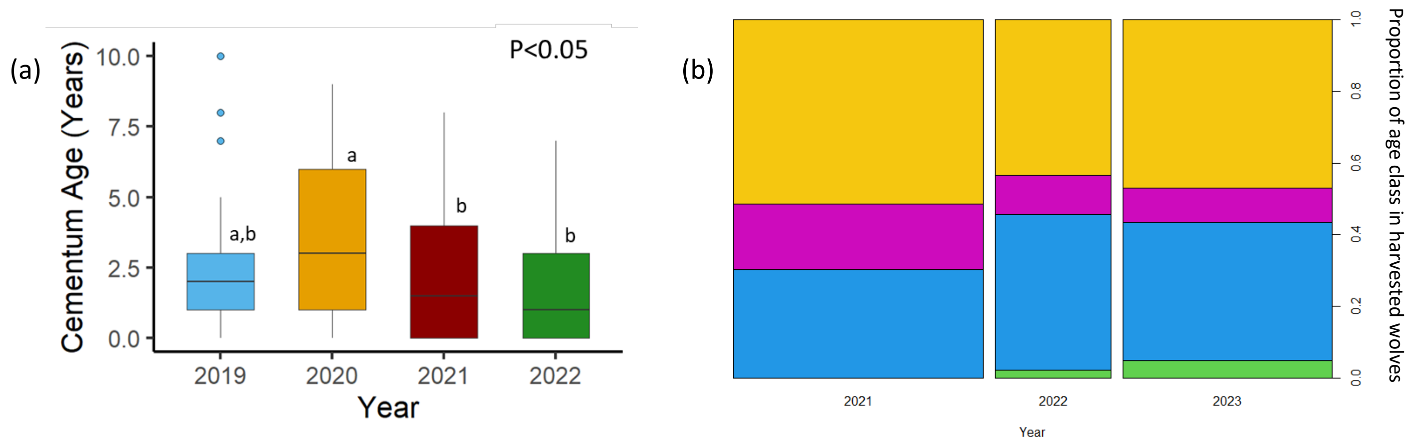

Figure 35. (a) Preliminary analysis of cementum age data from 2019-2022 revealed significant differences between 2020 and 2021/2022. Different letters indicate significant differences. Aging analyses of full dataset still pending. (b) Distribution of subjective age classes from 2021 to 2023 determined at necropsy, where green represents young of the year, blue is juveniles, pink is geriatric adults, and yellow is adults.

Internal and external nutritional condition scores assigned ranged from 0.0 to 4.0. The average coarse (internal and external combined) nutritional condition score was 2.6 (0.0-4.0) in 2021, 1.5 (range: 0.0-3.5) in 2022, and 1.9 (range: 0.0-3.5) in 2023. Condition scores varied significantly with age class (Kruskal Wallis test, $p<0.01$), but not with sex (Kruskal Wallis test, $p=0.5$). A linear model including age class and year as a covariate (best fit, $p < 0.001$) revealed a significantly decreasing trend in nutritional condition score over the three years ($p<0.001$). Average nutritional condition score across all 228 examined wolves was 2.1, subjectively considered fair nutritional condition. Weight of the internal xyphoid fat deposit, a quantitative measure of body condition which has been shown to be an indicator or predictor of animal condition (Robitaille et al., 2012; Kelley et al. (unpublished data)), was significantly lower in 2022 as compared to other years even when taking age class into account (ANOVA, $p<0.001$); weight were on average 138.55 g (2021; range = 18.2-320.7 g, n=95), 98.64 g (2022; range = 0 – 278.8 g, n=42), and 143.97 g (2023; range = 0 – 564.40 g, n=80). Rump fat depth demonstrated a similar trend with 2022 values being significantly lower than the other years; depth of rump fat was on average 7.18 mm (range: 0 mm – 20.75 mm) in 2021; 6.68 mm (range: 0 mm – 20.12 mm) in 2022; and 9.20 mm (range: 0 mm – 22.02 mm).

Findings on reproductive status of females examined are summarized in Table 15. Immature or non-pregnant females were identified based on small size of the uterine body and ovaries and the absence of lochia scarring in the lumen of the uterus. Recent pregnancy was identified based on the presence of uterine scarring caused by lochia remaining from placental attachments of a pregnancy from the previous breeding season. Pregnant females were identified when fetuses or fetal implantations were identified in the lumen of the uterus. Reproductive senescence was diagnosed when an animal of advanced age had an atrophic uterine body without evidence of recent or current pregnancy. Some animals could not be examined for uterine characteristics due to autolysis, scavenging, or tissue destruction due to location of PWTs. Fetuses were developed enough to document crown-rump lengths and fetal weights in 4 cases. The number of pups being produced by females, as indicated by either number of scars, implantations, or fetuses in utero, ranged from 2 to 11, with a mean litter size of 6.3 pups in 2021, ranged 5 to 9 with a mean litter size of 6.7 pups in 2022, and ranged 2 to 10 with mean litter size of 4.9 pups in 2023 – litter size (for observations with evidence of litter size > 1) significantly decreased over the three years (ANOVA test, p=0.03). In 2023, 10/34 (29.4%) of the females examined had uteri which appeared to be mature and/or in heat based on gross swelling and engorgement of uterine and ovarian vasculature, yet unbred/empty with no apparent implantations, fetuses, or placental scars. These individuals are included as 'Immature or Unbred' in Table 15. This was a new finding, not noted in previous years.

Table 15. Summary of female wolf reproductive data. Characteristics defining reproductive categories are described above.

	2021	2022	2023	TOTAL
Immature or Unbred	22 (47.8%)	12 (50.0%)	18 (53%)	52 (50.0%)
Recent pregnancy/ uterine scars	13 (28.3%)	6 (25.0%)	7 (21%)	26 (25.0%)
Pregnant	5 (10.9%)	3 (12.5%)	9 (26%)	17 (16.3%)
Reproductive senescence	1 (2.2%)	1 (4.2%)	0 (0%)	2 (1.9%)
Unknown	5 (10.9%)	2 (8.3%)	0 (0%)	7 (6.7%)
TOTAL FEMALES	46	24	34	104

Most stomachs sampled for ingested contents at necropsy contained barren-ground caribou tissues – findings are described further in Table 16. Stomach contents has been confirmed by high resolution photograph and/or physical analysis by a contracted expert for 2021 and 2022, but 2023 results included below were conducted via visual and gross assessment by the GNWT-ECC Wildlife Veterinarian. The 2023 photos and samples will be sent to the contracted expert with the remaining year of data (2024). Of the stomachs that had sufficient contents to support identification and/or sampling of contents, 95.6%, 67.6%, and 75.0% contained caribou in 2021, 2022, and 2023, respectively. Note that 9.6% of wolves examined from 2023 harvest were baited according to harvester surveys; this should be considered when interpreting prevalence of wolves with certain contents identified.

Table 16. Results of gross analysis of stomach contents. Contents were described based on direct observation during necropsy, and their identity then confirmed by high resolution photograph and/or physical analysis of stomach content subsample by a contracted expert. Results were summarized to reflect likely identity of species or material in the sampled ingesta.

	2021	2022	2023
Stomach Contents	**# wolves (Percentage %)**	**# wolves (Percentage %)**	**# wolves (Percentage %)**
Caribou	66 (66.7%)	23 (50.0%)	42 (50.6%)
Empty/fluid	30 (30.3%)	12 (26.1%)	27 (32.5%)
Other*	2 (2.0%)	9 (19.6%)	13 (15.7%)
Human food material/garbage	1 (1.0%)	2 (4.4%)	1 (1.2%)

***Other includes vegetation, ptarmigan, grouse, rodent, unidentified ungulate, carnivore, etc.

Ten (6.9%) cases with incidental pathological findings unrelated to cause of death (i.e., tumours, congenital anomaly, signs of chronic inflammation or past infection, etc.) were sampled more extensively compared to the standardized approach. Fixed and frozen tissues sampled from cases requiring additional diagnostics by histopathology were submitted to be analyzed by the CWHC Western/Northern Node. These cases appeared to have relevance on an individual health level, but not necessarily a population level.

5.4 Discussion

Monitoring the status and trends of wolf health, condition, and reproductive status is an important component of the Tłįchǫ Government and GNWT Wolf Management Program. Some of these measures can potentially help monitor the impacts of management action at the individual and population levels. The program can also offer a better understanding of the various determinants of wolf health and resilience, how they are changing, and their cumulative impacts – including but are not limited to diet/nutrition, demographics, morphology, behaviour, stress, reproduction, survival, and infection or exposure to different pathogens and parasites. In this report, information specific to demography, nutritional condition, diet, and reproduction in harvested grey wolves which were located within the eWHIA was summarized.

Age structure of submitted wolves based on age class identified at necropsy showed a tendency, albeit non-significant, for more young animals (young of the year, juvenile) compared to mature breeding adults (adult, geriatric) since 2021. We can consider these outcomes from two key perspectives – first, as being indicative of the demography of animals that were removed from the population by this wolf management program; and second, as potentially representative of population level changes in age structure. Depletion of younger individuals may reduce the availability of local young maturing wolves to contribute to reproduction in the population, and perhaps dispersal of young animals between packs (Adams et al., 2008). If these findings are considered as an indicator of population level changes in composition, skewing of age structure towards younger, immature animals is expected in an exploited population (Fuller and Novakowski, 1955; Fuller et al., 2003). A decreasing age structure has implications on reproductive capacity, individual survival, animal hunting success, dispersal rates and movements, territory, and pack social behaviours (Fuller et al, 2003).

Nutritional body condition is an important indicator of animal health which reflects the available energy reserves to that individual, critical for survival particularly in overwintering animals. An animal with greater available energy reserves would reasonably have greater overall fitness, reproductive success, and resilience to stressors such as disease, competition, and environmental change (Sacks, 2005; Schulte-Hostedde et al., 2005). Xyphoid fat deposit mass is an indicator of wolf nutritional condition (Kelley et al., in prep; Robitaille et al., 2012) which varied significantly over time, with 2022 animals in poorest condition. On gross necropsy, rump fat depth was subjectively variable, depending on where an incision was made over the rump muscle and where a measurement was taken, despite attempting to standardize the approach. We did observe a significant declining trend in body condition as indicated by overall body condition score, even when taking age structure changes into account ($p<0.001$). Continued monitoring of this metric is recommended, and investigation into whether it may be an indicator of an exploited population and serve as a potential benchmark for control activities. The relationships between energetics/nutritional condition and other health indicators, such as reproduction or disease, should also be further explored.

Diet analysis thus far has consisted of assessing stomach contents as indicators of prey/diet composition for individual animals. A large proportion of stomachs assessed in harvested wolves are empty – this may be an indication of a wolf that has not ingested a recent meal, but also could reflect behavioural explanations, such as the wolf vomiting or voiding its gastrointestinal tract due to recent stress (chase component of being hunted). Contents of full stomachs only reflect the most recent meal by that animal; in domestic dogs, natural gastric emptying time has been demonstrated to range between 6 and 15 hours (Boillat et al., 2010). This time can also be influenced by circumstantial factors, such as high levels of stress or sympathetic drive. The proportion of stomachs that contained barren-ground caribou tissue declined from 2021 to later years. The proportion of empty stomachs was relatively consistent. Though details as to bait type used are currently unavailable, as of 2022 harvesters were variably baiting animals. This should be accounted for when interpreting stomach contents at time of death.

We observed a significant decline in *in utero* litter size over the years of study so far. In 2023, we also noted a high proportion of breeding age females with mature uteri that were unbred. Further work is needed to explore the possible connections between these findings, body condition, and population structure, all as potential indicators of wolf population resiliency or response to management, prey access, and other extrinsic factors.

Additional health analyses are recommended for existing archived samples and for those collected in coming years to further assess diet, health, and predator-prey dynamics. These include evaluating stable isotope profiles of wolves and prey species (underway), assessing parasite diversity trends and dynamics as trophic and environmental-use indicators, and surveying pathogens that are shared between wolves and ungulates or other prey. Additional metrics of health such as stress and reproductive steroid hormone profiles; pathogens and parasites that may impact reproductive success, survival, resilience, or be indicators of proximity to domestic animals; contaminants and heavy metal profiles; and changes in demography and behaviour are also of interest.

6 Discussion and Lessons Learned

The goal of the wolf management program is to sufficiently reduce wolf predation on the Bathurst and Bluenose-East caribou herds to allow for an increase in calf and adult caribou survival rates to contribute to the stabilization and recovery of both herds. To evaluate the impact of the management actions, both caribou and wolf centered objectives are used (Tables 17-19).

Targets for caribou used to measure the impact of the wolf management program include:

- No less than 85% adult cow survival rates,
- A fall calf to cow ratio between 49-51 calves per 100 cows,
- A late-winter (or spring) calf to cow ratio between 38-45 calves per 100 cows,
- Two consecutive estimates of breeding females, adult females, and herd size with no decline. Breeding females are assumed to be pregnant, adult females include pregnant and non-pregnant females, and the herd estimate includes adult females and males.

Targets for wolves used to measure the impact of the wolf management program include:

- A decrease (with no reduction in effort) in the number of wolves removed,
- A decrease in catch per unit effort by hunters (number of days spent hunting and kilometers travelled while hunting),
- A decrease in wolf sighting rates per hour flown during March caribou composition survey,
- An increase in the number of young wolves harvested compared to adult wolves through cementum age analysis.

A comprehensive assessment of objectives after 5 years will be completed to determine one of the following steps: (1) the objectives have been met through the first 5 years and further wolf management is not required; (2) the objectives have not been met and the wolf management program has been ineffective and should be suspended; (3) the objectives have been met or partially met and a further or modified wolf management program should be considered.

Table 17. Targets for Bathurst caribou used to measure impact of the wolf management program. No calving ground survey was completed in 2019, 2020, and 2023.

Metric	2019	2020	2021	2022	Target met?
Adult cow survival rates	95%	87%	73%		No
Fall calf to cow ratios	32	39.1		38.4	No
Late-winter calf to cow ratios		30.4		No survey due to herd mixing	No
Breeding females estimate			2,878	3,237	No
Adult females estimate			3,808	4,179	No
Herd estimate*			6,240	6,850	No

*Rate of decline has slowed after 2018, but not yet any clear evidence of stability.

Table 18. Targets for Bluenose-East caribou used to measure impact of the wolf management program. No calving ground surveys were conducted in 2019, 2020, and 2022.

Metric	2019	2020	2021	2022	2023	Target met?
Adult cow survival rates	80%	89%	87%			Yes
Fall calf to cow ratios	37.8	51.7	49.6	52.3		Yes
Late-winter calf to cow ratios		41.8	46.7	46.9	40.9	Yes
Breeding females estimate			12,863		18,580	Yes
Adult females estimate			13,991		24,466	Yes
Herd estimate			23,202		39,525	Yes

Table 19. Targets for wolves used to measure impact of the wolf management program.

Metric	2020	2021	2022	2023	Target met?
Number of wolves removed	40	132	53	98	No
Average CPUE day	0.14	0.50	0.74	1.07	No
Average CPUE distance	0.86	4.54	3.39	4.73	No
Sighting rates	0.05 (BAT)	0 (BNE) 0.7 (Mixed)	0.48 (BNE) 0.28 (Mixed)	0.53 (BNE) 0.34 (Mixed)	No
Age structure*	3.4	2.1	1.6	In progress	Yes

*Average cementum age, but not all samples have been analyzed.

Based on the 2021 estimates of breeding females and adult herd size and analyses of demographics for the Bathurst and Bluenose-East herds of barren-ground caribou reported in the 2021 calving ground photographic survey reports (Adamczewski et al., 2022; Boulanger et al., 2022), the demographic indicators for a stabilizing population have improved for the two herds since 2018, most notably in the Bluenose-East herd. The estimates for the Bluenose-East herd for 2021 suggest stabilization from 2018, based on estimated numbers of females, and possibly the beginnings of recovery based on the herd estimate that includes the males. This was a major improvement from the trend in 2018 for that herd, which was in rapid decline. The most recent calving ground survey was conducted on the Bluenose-East herd in June 2023 and estimated 39,500 individuals, which was a 32% increase since the last survey done in 2021 (unpublished data, Adamczewski et al., 2023). The estimate for the Bathurst herd (6,850 in 2022) suggests a slower rate of decline and an improvement in demographic indicators from 2018. While population estimates and demographic indicators have improved, it is difficult to know to what extent it may reflect wolf removals, or any other specific management action currently being undertaken; additional demographic and modelling analyses will be conducted to evaluate this further.

Overall, the 2023 wolf management program provided valuable information and areas of key learnings that provide opportunity for program improvement and adaptation. These are summarized below.

- The collaring program will continue in March 2024 to achieve and maintain 30 collared wolves in the region with which to examine wolf movements, predation rates, and inform future surveys. Nine wolves were captured and collared using modified capture and handling techniques in March and June 2023, bringing the sample size to 36 collared wolves, with 12 collars currently transmitting data.

- Wolf movements show range resident and non-range resident behavior and time spent on the wintering grounds of different caribou herds.

- A decrease in the number of active dens since 2012 was observed, suggesting less wolves on the Bathurst summer range.

- Spatial overlap of the Bathurst, Bluenose-East and Beverly caribou herds on the winter range was greater in 2023 compared to 2022 and likely influences the local abundance and seasonal movements of wolves.

- Ground-based harvest of wolves in 2023 (142 wolves) on the combined winter range of the Bathurst and Bluenose- East caribou herds was more than that of 2022.

- Thirty hunters participated in the program and received incentive payments (total $103,500) for 98 wolves harvested in the North Slave Enhanced Wolf Harvest Incentive Area. The remaining 44 wolves were harvested by guided non-resident hunters.

- In collaboration with hunters and trappers, revisions to the wolf harvester questionnaire design and delivery were completed, which improved survey completion and calculation of CPUE and response rates. However, CPUE is dependent on many variables and should be interpreted with caution.

- Results of detailed post-mortem examinations of carcasses suggest that the percent of stomachs that contained caribou was similar to last year – this is not unexpected given the prescribed locations of harvest. Body condition score and litter size significantly decreased over the three years. Based on gross examination, 29.4% of females with uteri appeared to be mature and/or in heat yet unbred this year. Preliminary results suggest age structure was significantly lower in 2021 and 2022 compared to 2020.

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9 Appendix A – WRRB Recommendations

Reference	Response	Final Recommendation
#1-2020	VARY	GNWT and TG update the objectives of the dìga management program to be measurable for effects on ekwǫ̀ and dìga in order to be able to assess the impacts of the program and provide these objectives to the WRRB by ~~May 1,2021~~ July 31, 2021. Updated objectives should consider that the Kǫ̀k’èetì and Sahtì ekwǫ̀ herds have different vulnerabilities and vital rates and, thus, success may be measured differently.
#2-2020	VARY	GNWT and TG identify ~~and implement~~ alternative methods to measure and index dìga abundance and calibrate these with the Ungulate Biomass Index to ensure the most accurate and precise population estimates are used for dìga management by ~~May 31~~ March 31, 2021.
#3-2020	ACCEPT	Dìga sighting rates, during ɂekwǫ̀ sex and age composition surveys, be assessed by GNWT to determine if and how it contributes to understanding seasonal trends in dìga abundance on the Kǫ̀k’èetì and Sahtì ekwǫ̀ ranges by May 1, 2021.
#4-2020	VARY	The ground-based harvest proceed as proposed with the addition of harvester supports provided by TG and GNWT. This should include ɂekwǫ̀ and dìga distribution information, gas caching, and could include ~~/or~~ bait stations, starting in the 2020/2021 harvest season. These supports are necessary for ground-based harvest removals as per the Wolf Technical Feasibility Assessment: Options for Managing Dìga on the Range of the Bathurst Barren-ground Caribou Herd (2017).
#5-2020	ACCEPT	GNWT and TG improve the harvest reporting program to ensure that appropriate information is being collected through questionnaires, starting 2020/2021 harvest season. This could be accomplished by using a contractor with expertise in this area.
#6-2020	VARY	GNWT and TG incorporate lessons learned from Nunavut’s high success rate with their harvester’s questionnaire responses and ~~ensure~~ invite Nunavut harvesters to attend Harvester Training Workshops, starting 2020/2021 harvest season.
#7-2020	VARY	GNWT and TG should not continue aerial removals of dìga on Kǫ̀k’èetì and Sahtì ekwǫ̀ ranges in winter 2020-2021. Instead, more resources should be put towards ground-based harvest. Subject to review based on an annual assessment of evidence during the annual review of the program, the WRRB would consider a proposal of other methods of dìga removal
#8-2020	VARY	TG and GNWT explore alternative methods of assigning harvested dìga to an ɂekwǫ̀ herd ~~and to statistically determine confidence in the allocation~~. GNWT and TG should provide enough information to determine how the uncertainty affects the success of the program and submit results to the WRRB by September 30, 2021.
#9-2020	VARY	GNWT and TG will review the feasibility of monitoring dìga den occupancy to measure pup production, recruitment, and diet ~~and disease incidence~~ to describe the extent of compensatory breeding and to better understand the minimum number of dìga on the Kǫ̀k’èetì and Sahtì ekwǫ̀ summer ranges, starting in the 2020/2021 harvest season.
#10-2020	VARY	GNWT and TG ensure ~~all~~ a sufficiently representative sample of dìga removed as part of this program from 2021-2024 undergo a full necropsy to determine injuries, physical condition, reproductive status, and diet, to fully understand health of the dìga on the ranges of the Kǫ̀k’èetì and Sahtì ekwǫ̀ herds.
#11-2020	ACCEPT	GNWT continue the dìga collaring program, beginning in 2021, using a statistically rigorous design to measure dìga movements relative to the dìga-ɂekwǫ̀ spatial distribution, including reducing the uncertainties involved with assigning dìga to ɂekwǫ̀ herds.
#12-2020	VARY	GNWT and TG develop an approach to assessing ~~complete a~~ caribou (ekwǫ̀) calf mortality ~~study in conjunction with 2021 calving~~

		~~ground surveys~~ to determine the effect of dìga and other predators on calf survival beginning on the ~~both~~ Kǫ̀k'èetı̀ ekwǫ̀ calving ground, and potentially expanding to the Sahtì ekwǫ̀ calving grounds, if feasible. This calf mortality study should, if possible, be done in cooperation with Government of Nunavut and with the assistance of experienced Dene and Inuit elders as field observers.
#13-2020	ACCEPT	TG collect and document stories about the changes that Tłı̨chǫ elders and their families have observed to the dìga and ɂekwǫ̀ relationship through time, and in the present considering other animal behaviour, climate change, loss of habitat, and population declines.
#14-2020	ACCEPT	TG collect Tłı̨ç hǫ stories about dìga and ɂekwǫ̀, while on the land, from elders participating in the Ekwǫ̀ Nàxoède K'è program to increase the understanding of the current relationship between dìga and ɂekwǫ̀ and how it has changed through time.
#15-2020	VARY	GNWT and TG explore possibilities and develop an approach ~~undertake field studies and modelling~~ to determine causes of death of collared ɂekwǫ̀ ~~so that the assumption that 60% of mortality is caused by dìga predation can be tested~~, and to estimate the influence of other factors in mortality of caribou (ekwǫ̀), by Sept. 30, 2021 ~~in the 2020/2021 harvest season~~.
#16-2020	VARY	GNWT and TG, in collaboration with the WRRB through the Barrenground Caribou Technical Working Group, establish benchmarks for key caribou (ekwǫ̀) vital rates and integrate them into the Adaptive Co-Management Framework to identify at which point dìga removals would stop in time for the annual fall meeting ~~by March 31, 2020~~.
#17-2020	VARY	Any key vital rates of dìga and Kǫ̀ k'èetı̀ and Sahtì ekwǫ̀ collected by GNWT and TG be reported to the Barren-ground Caribou Technical Working Group throughout the year~~, in alignment with the Adaptive Co-Management Framework, to contribute to the implementation of the adaptive management framework~~.
#18-2020	ACCEPT	The annual review of the dìga management program be collaborative with TG, GNWT, and the WRRB and coincide with the November Barren-ground Caribou Technical Working Group Meeting, beginning in 2021.
#19-2020	ACCEPT	In time for the 2021 annual review, GNWT and TG implement the recommendations in the Wolf Technical Feasibility Assessment: Options for Managing Dìga on the Range of the Bathurst Barren-ground Caribou Herd (2017) to develop the annual monitoring protocols for efficiency, effectiveness, and humaneness.
#20-2020	VARY	An annual report on the wolf (dìga) management program be prepared by GNWT and TG and presented to the Board at a scheduled board meeting to allow for the discussion of adjustments in methodology based on the evidence, beginning fall 2021.

10 Appendix B – Example Wolf Harvester Questionnaire

Wolf harvest survey in the North Slave Region, NWT

WOLF HARVEST – Please report every wolf harvested

Date (MM/DD/YY)	Wolf ID	Sex (circle one)	Weight with fur (kg)	Latitude	Longitude	Baited? (circle one)	Submitted to ENR? (circle one)
01/16/23	TC-XXX-YYY	male / female	45	64.68930	112.48750	Yes / No	full carcass / sample kit
01/16/23	TC-XXX-YYY	male / female	42	64.68930	112.48750	Yes / No	full carcass / sample kit
01/19/23	TC-XXX-YYY	male / female	40	65.6822	112.45600	Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit
		male / female				Yes / No	full carcass / sample kit

WOLF SIGHTINGS

1. In total, how many wolves did you **see** on your trip? 8
2. How big were the **packs** (circle number range)?
   Less than 5 5-10 10-15 15-20 over 20
3. How hard was it to **find** wolves (circle one)?
   Very difficult somewhat difficult easy very easy

HUNTING EXPERIENCE

1. How many years have you been hunting wolves (circle one)?
   Less than 5 5-10 over 10
2. How recently have you hunted wolves (circle one)?
   Before 2010 2010-2015 2015-2020 2020-present
3. About how many wolves have you harvested in your lifetime (circle one)?
   Less than 5 5-10 over 10

HUNTING EFFORT AND CONDITIONS – Please report every day of trip

Date (MM/DD/YY)	Number of wolves harvested	Number of hunters in group	Number of hours spent hunting	Number of kilometers spent hunting	Weather (circle one)
01/16/23	2	3	10	300	Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
01/17/23	0	2	8	150	Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
01/18/23	0	2	10	200	Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
01/19/23	1	1	10	250	Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)
					Perfect / Good / Bad (low visibility) / Very Bad (stormed in)

WILDLIFE OBSERVED

1. Number of caribou seen while hunting wolves (circle one)? None 1-20 21-100 101-500 over 500
2. How many caribou remains likely killed by wolves did you see (circle one)? Less than 5 5-10 over 10
3. What other species did you harvest during your trip (circle multiple)? Fox wolverine muskox other:________