TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Lynn Boettger, Permitting Manager Canadian Zinc Corporation	**Date:**	August 7, 2025
c:		**Memo No.:**	
From:	Jeff Matheson and Karla Langlois	**File:**	704-ENW.BIOS03144-01.007
Subject:	Northern Mountain Caribou Collar Program: Interim Data Summary		

Note: This technical memo provides select summary information and analyses of caribou location data collected to May 14, 2025. The collar program is ongoing. This memo is intended to highlight some high-level patterns of seasonal distribution and use and is not intended to provide comprehensive analyses or in-depth interpretations, which will be prepared at a later date. The majority of the content was generated using automated scripts so that analyses can be easily updated as data accumulates. Accompanying this report is a version in html format that can be viewed in a browser with a connection to the internet. The html version provides maps that are interactive.

1.0 INTRODUCTION

The objectives of the Northern Mountain Caribou collar program are to:

- Identify seasonal habitat use, movement corridors, and local distribution of Northern Mountain Caribou relative to Canadian Zinc's planned All Season Road (ASR);
- Monitor any changing patterns of caribou distribution over time in relation to phase of road development (effects monitoring); and
- Use near-real time location data to adaptively implement mitigation measures to minimize potential impacts to caribou.

The first caribou were collared in November 2022 and data collection is ongoing. This document provides preliminary descriptive summaries and analyses of the collar data collected to date.

2.0 APPROACH

The caribou collar data is warehoused on Movebank and accessible by ECC and PC. Animal IDs are those assigned during capture and collaring and are the same as used by ECC.

Data quality assurance includes checking for duplicates, incomplete data (such as missing coordinates), and outliers, with removal where appropriate.

All analyses were performed in the statistical platform R (R Core Team 2024), including the generation of this document (using Quarto). Key packages used in the analyses include `move2` (Kranstauber et al. 2024).

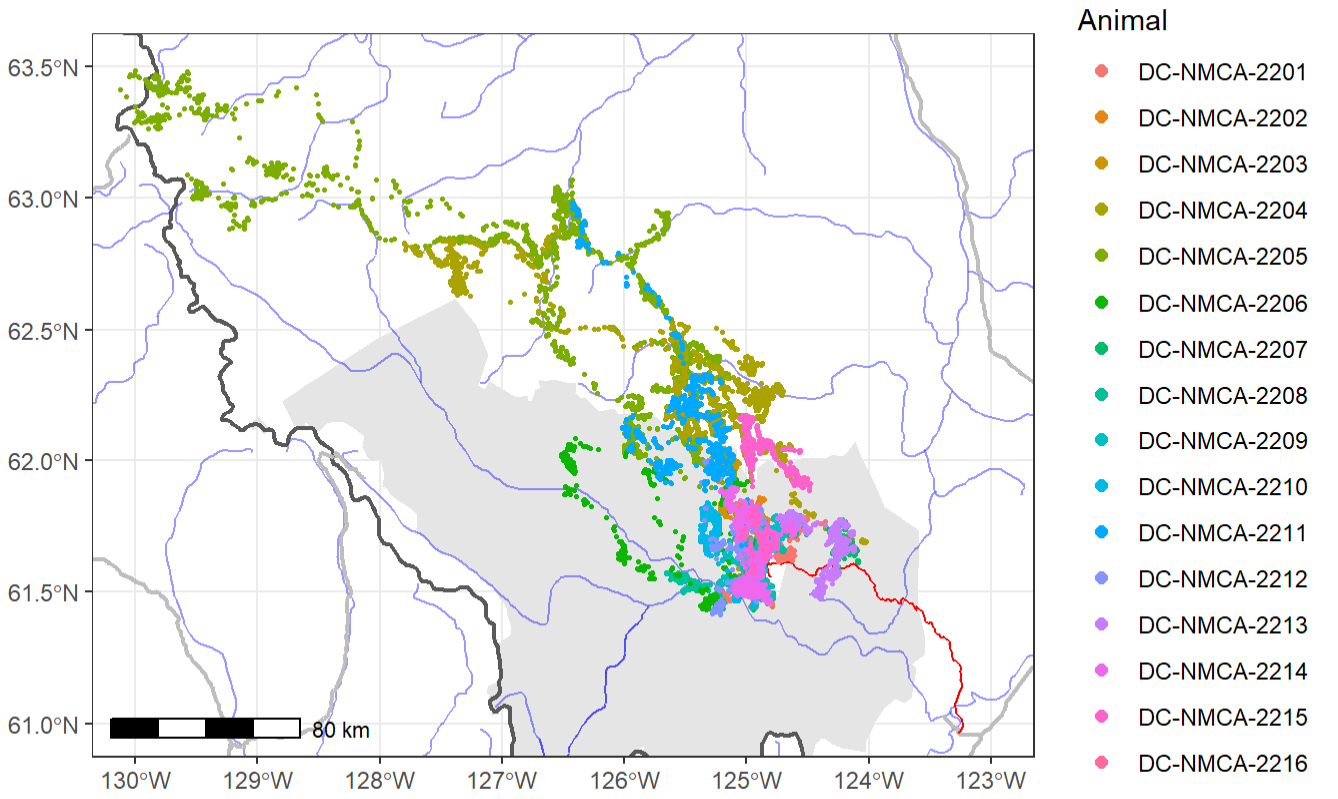
Various seasonal divisions have been reported for Northern Mountain Caribou. For this reporting, we have chosen to use the caribou seasons reported by Chrysalis Ecological (2023) and provided as a guide and for reference only.

- Spring Migration: 15 April – 15 May
- Calving: 15 May – 15 June

- Post-Calving: 15 June – 15 September
- Fall Breeding (rut): 15 September – 15 October
- Fall Migration: 15 October – 1 December
- Early Winter: 1 December – 1 February
- Late Winter: 1 February – 15 April

3.0 DEPLOYMENT SUMMARY

3.1 Collar Locations Since Inception

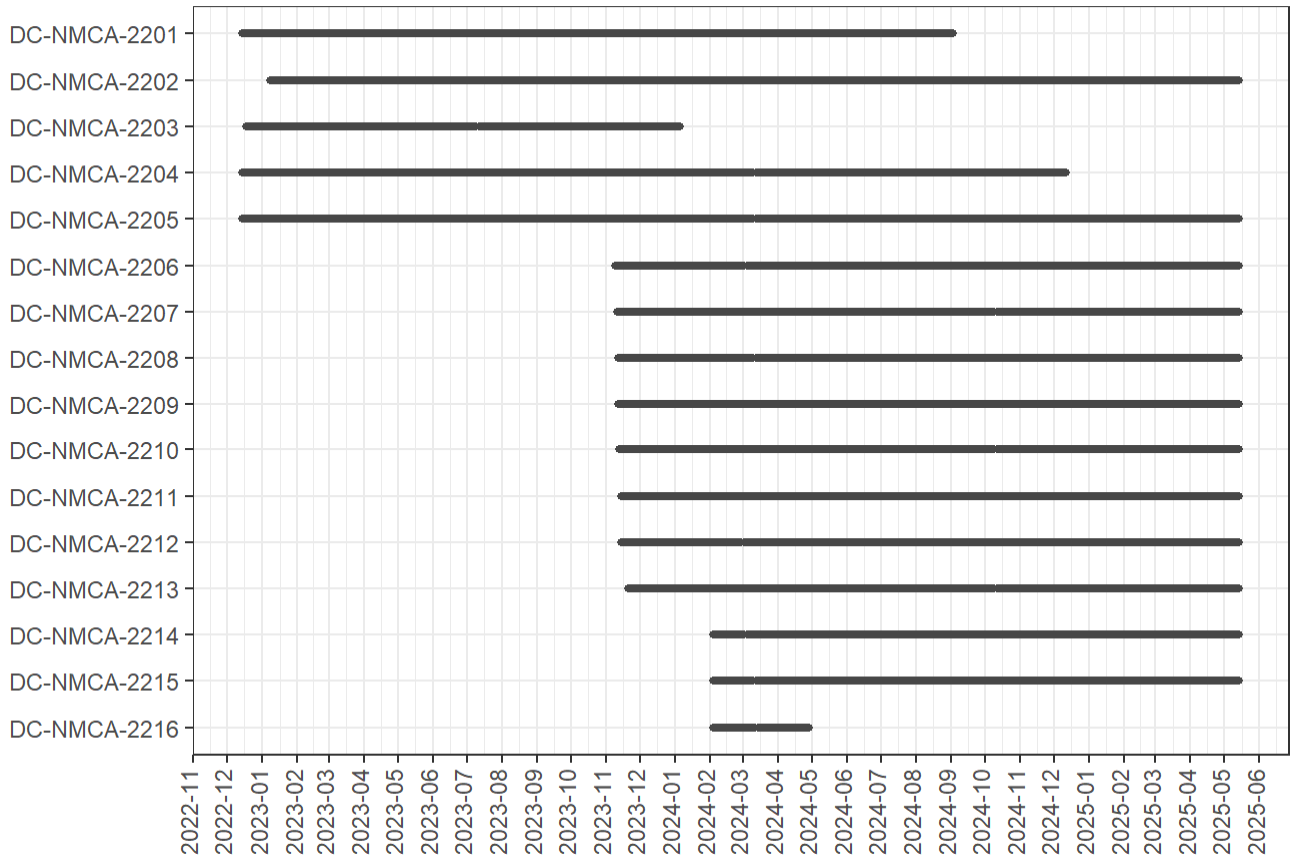


3.2 Collar Deployment Dates and Duration

Sixteen collars have been deployed to date. Four caribou mortalities have occurred (NMCA-2201, NMCA-2203, NMCA-2204, and NMCA-2216), leaving twelve currently active.

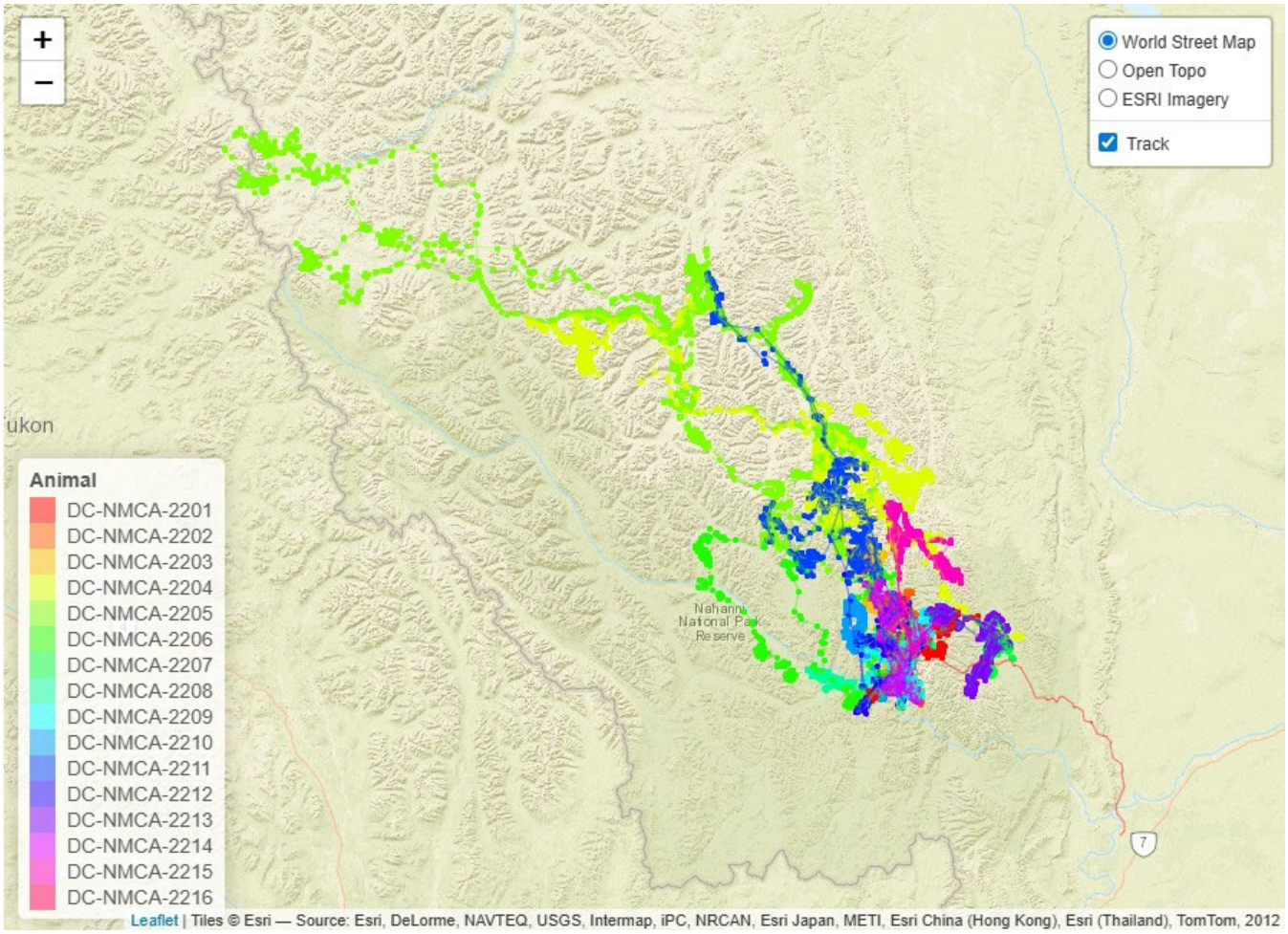
Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days
DC-NMCA-2201	6.18	2022-12-14	2024-09-02	628
DC-NMCA-2202	1.99	2023-01-07	2025-05-14	859
DC-NMCA-2203	18.01	2022-12-17	2024-01-05	383
DC-NMCA-2204	17.46	2022-12-14	2024-12-11	726
DC-NMCA-2205	18.84	2022-12-14	2025-05-14	879
DC-NMCA-2206	11.27	2023-11-09	2025-05-14	552
DC-NMCA-2207	11.46	2023-11-10	2025-05-14	550
DC-NMCA-2208	12.09	2023-11-11	2025-05-14	549
DC-NMCA-2209	5.24	2023-11-11	2025-05-14	549
DC-NMCA-2210	3.85	2023-11-12	2025-05-14	548
DC-NMCA-2211	18.73	2023-11-14	2025-05-14	544
DC-NMCA-2212	19.86	2023-11-14	2025-05-14	545
DC-NMCA-2213	15.46	2023-11-20	2025-05-14	539
DC-NMCA-2214	10.81	2024-02-03	2025-05-14	465
DC-NMCA-2215	19.89	2024-02-04	2025-05-14	463
DC-NMCA-2216	18.23	2024-02-03	2024-04-28	81

3.3 Deployment Timeframes



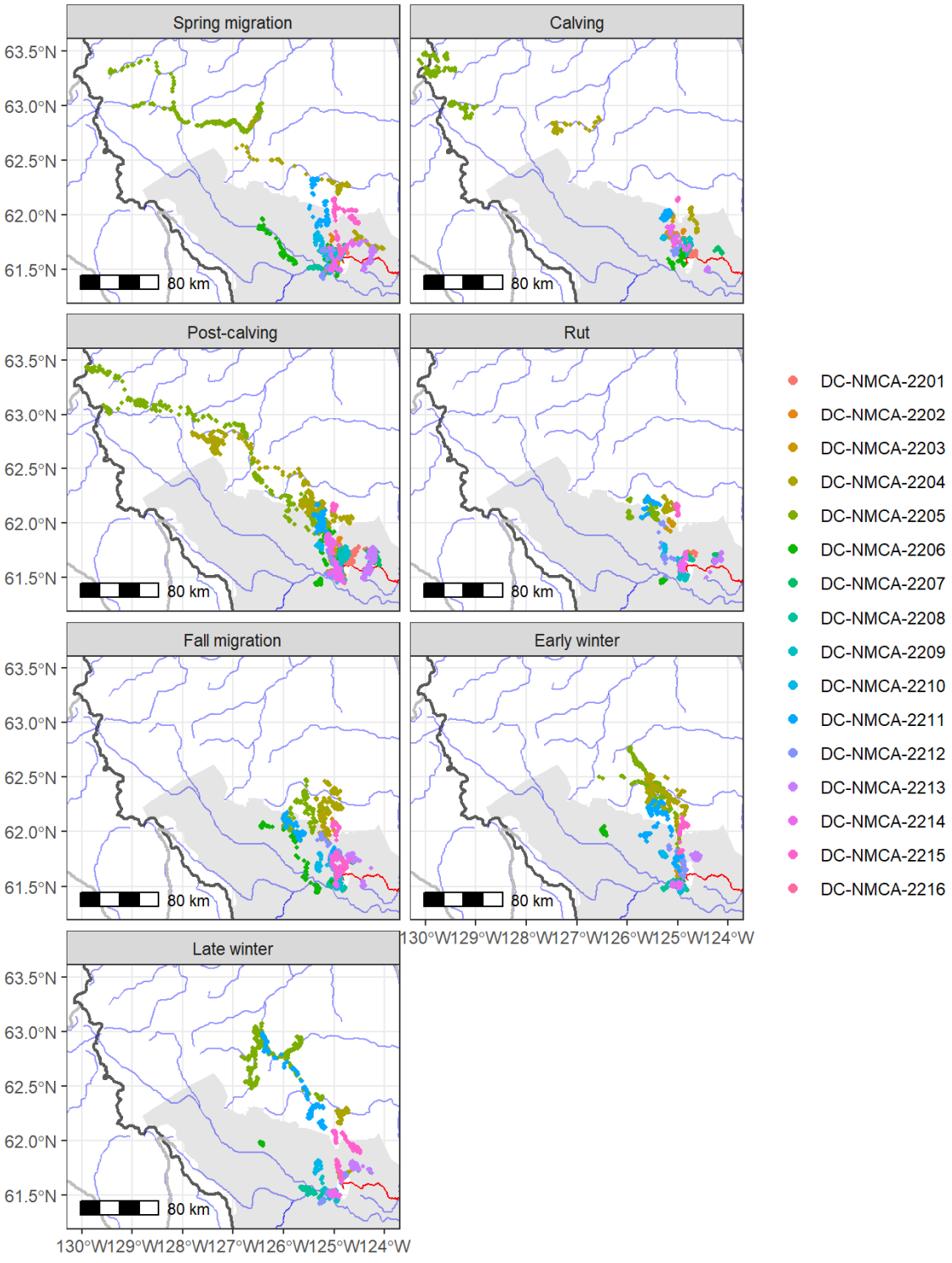
4.0 DISTRIBUTION

4.1 Map of Caribou Locations Since Inception

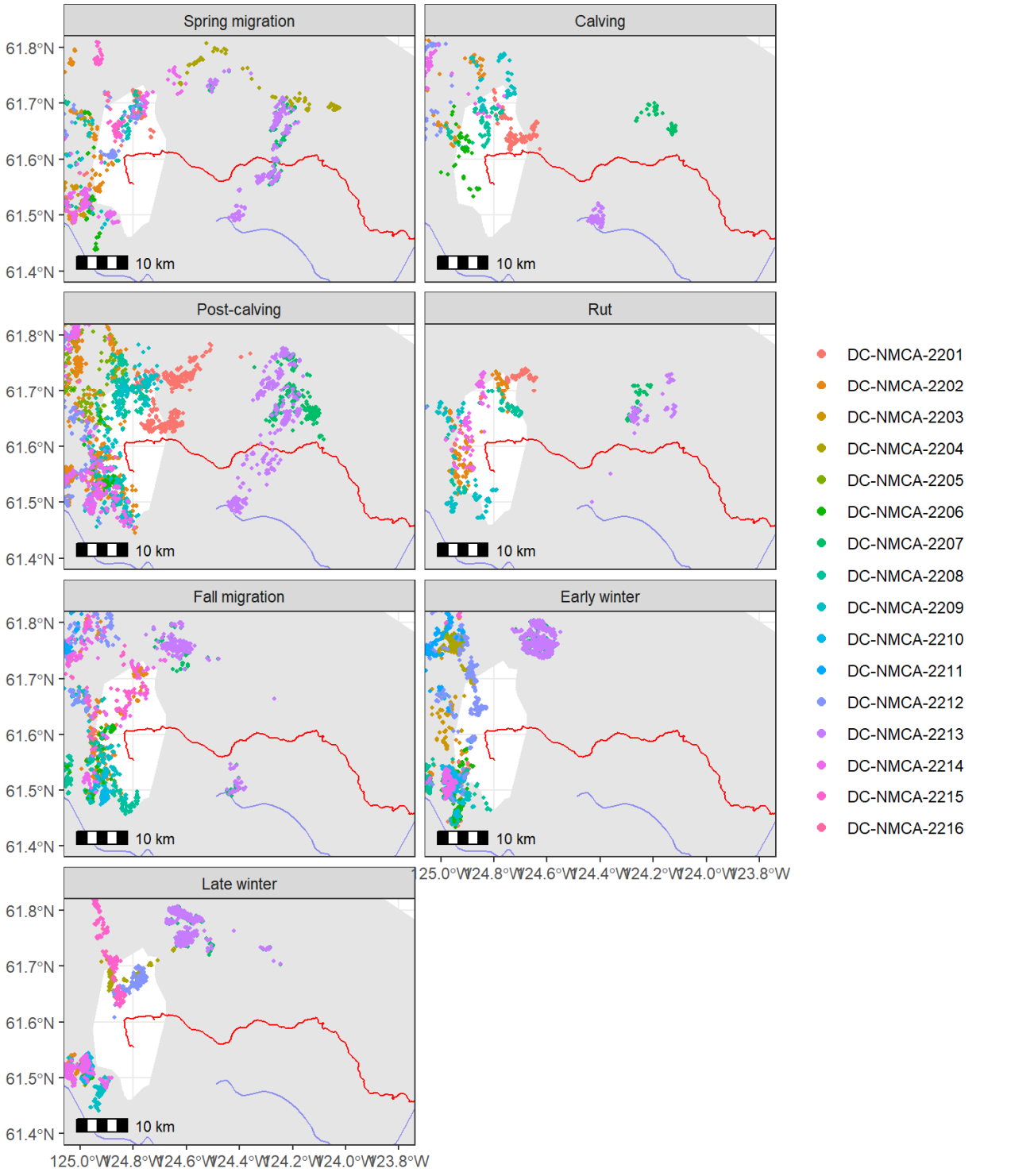


4.2 Caribou Locations by Season

4.2.1 Full Extent



4.2.2 Near Road

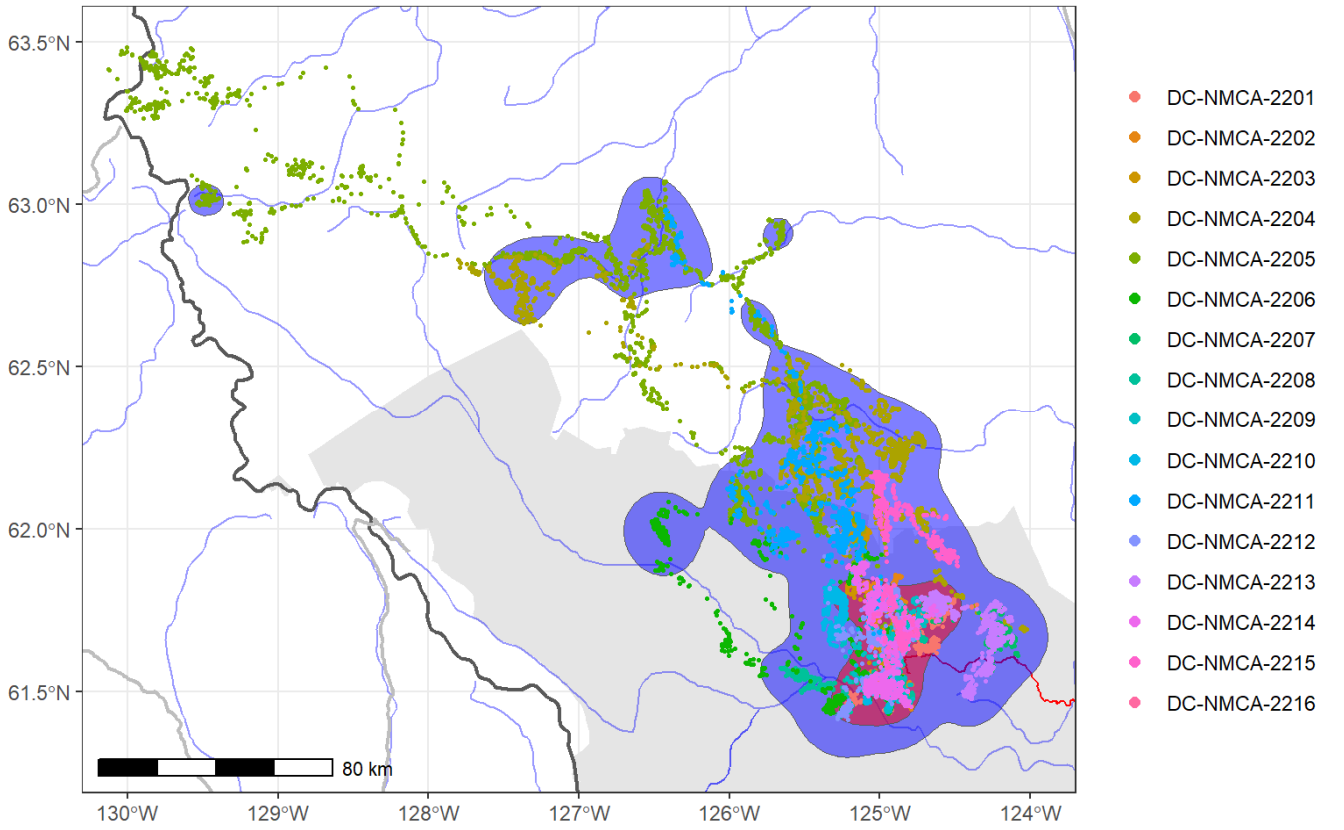


5.0 SPACE USE

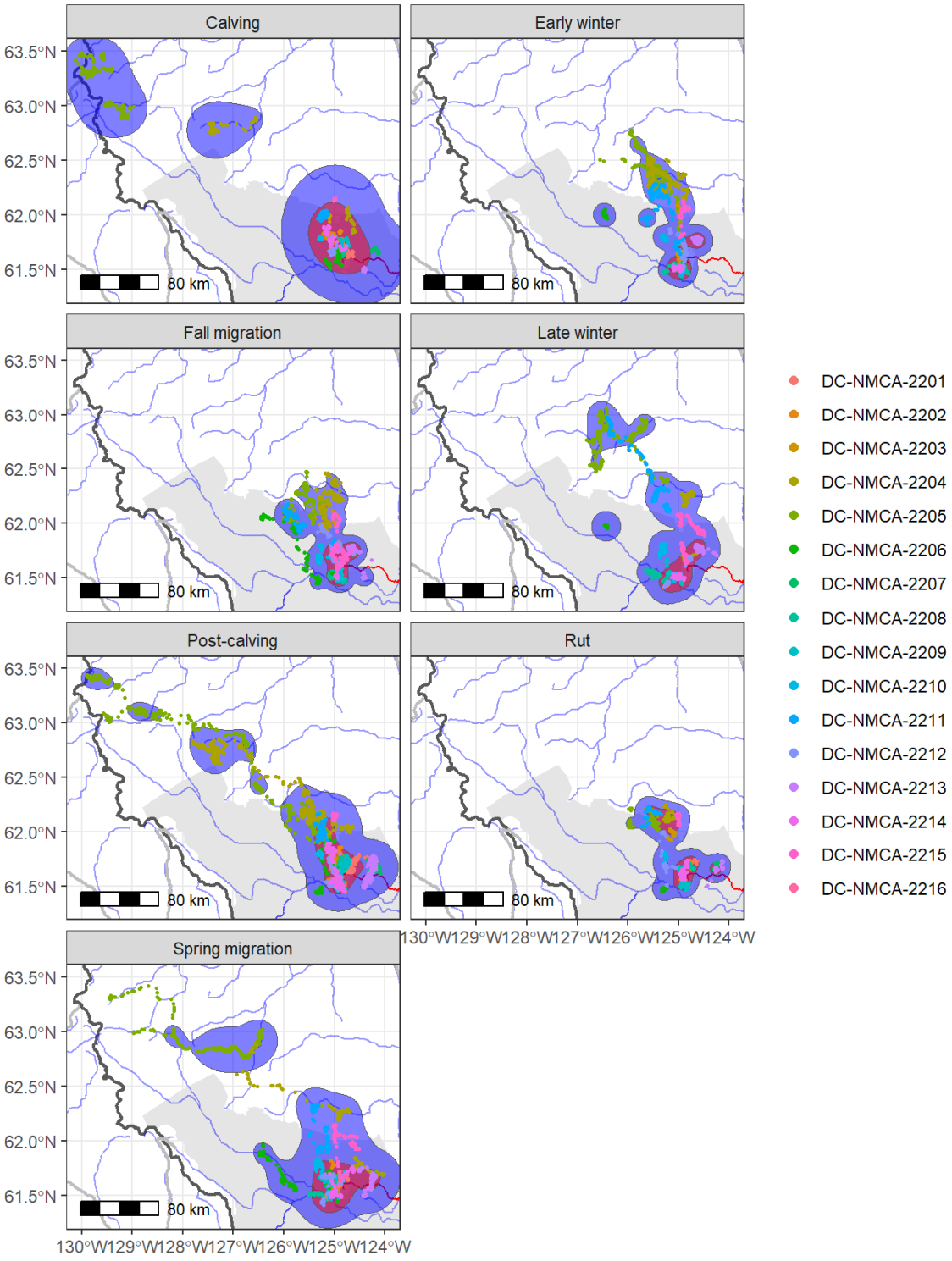
Kernel density estimation (KDE) was used to visualize the spatial distribution and density of caribou collar locations. KDE (and various modifications of KDE) are commonly used to identify home ranges for individuals or groups. The analysis conducted here is not specifically intended to estimate home ranges, rather to visualize the potential for caribou occurrence by season and in relation to the ASR, based on data collected to date.

The blue polygons are the 95% contours of the utilization distribution (encompassing 95% of collar locations). The red polygons are the 50% contours of the utilization distribution (encompassing 50% of collar locations) and may be interpreted as “core areas” or areas with highest potential for collared caribou.

5.1.1 All Seasons



5.1.2 By Season

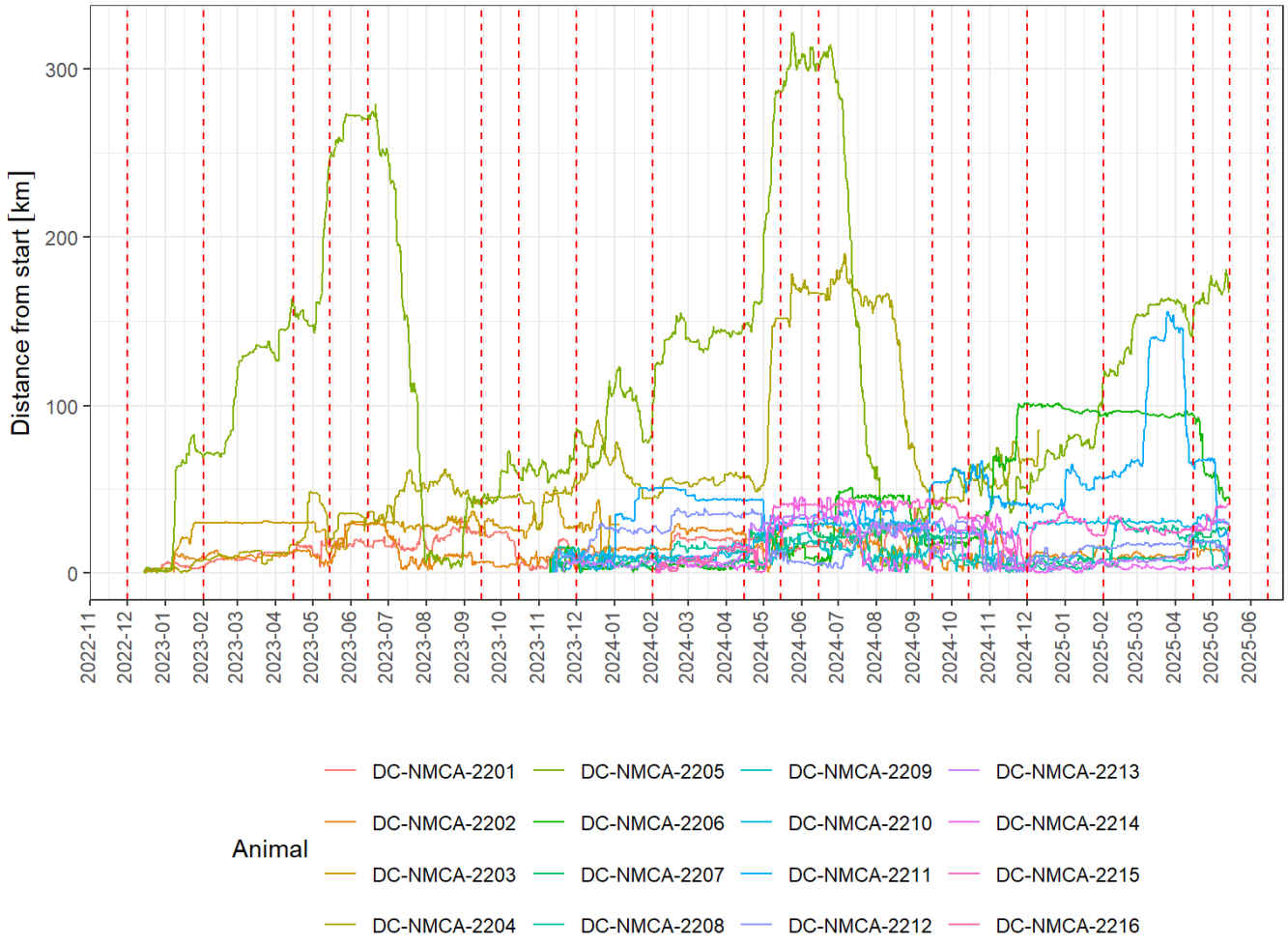


6.0 SEASONAL MOVEMENTS

The following figures show caribou movements over time in relation to 1) displacement of each collared caribou location relative to its capture location, 2) movement speed, and 3) elevation.

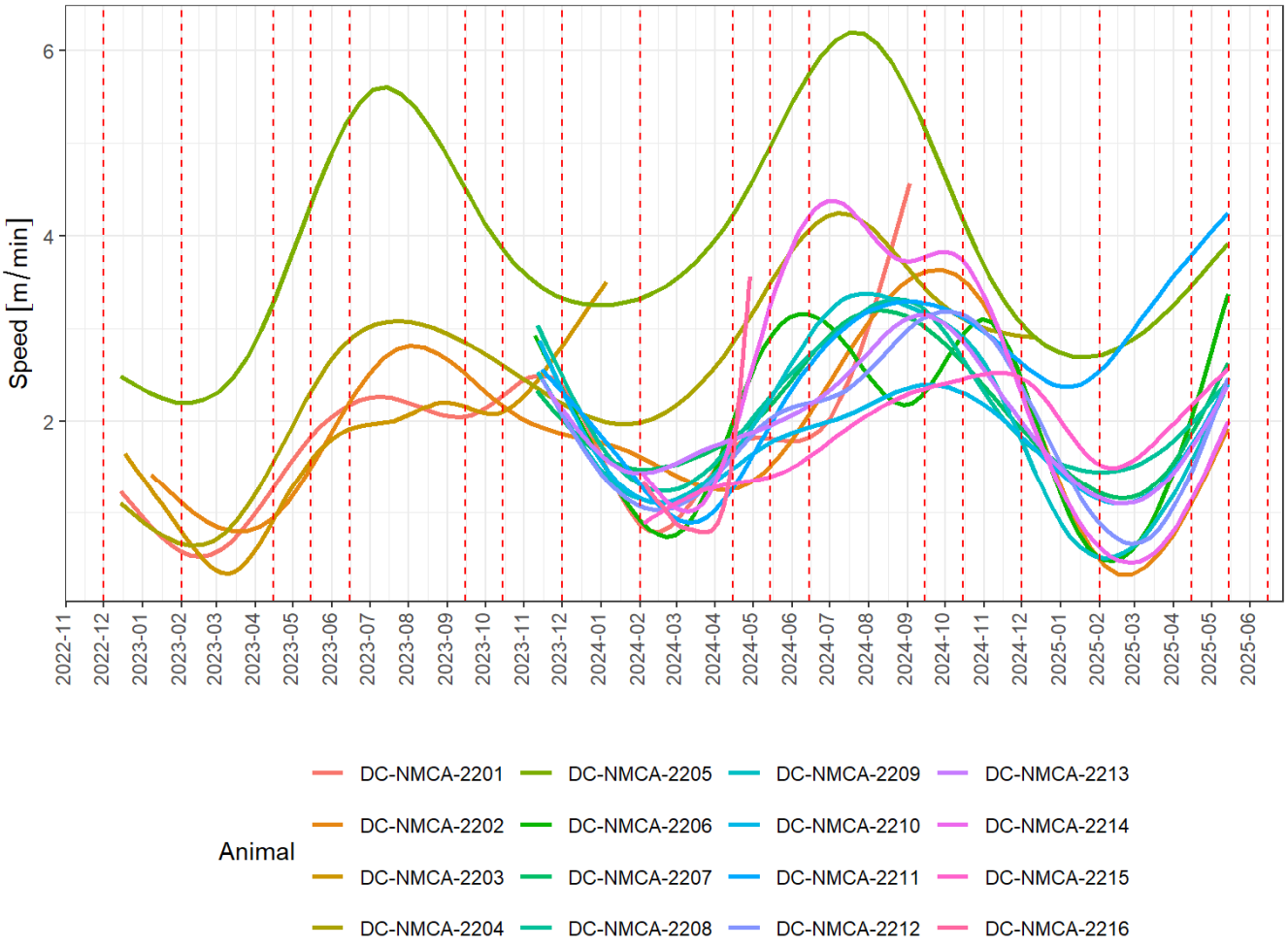
Vertical red dashed lines are the beginning day of each caribou season defined in Section 2.0.

6.1 Displacement from Initial Capture Location

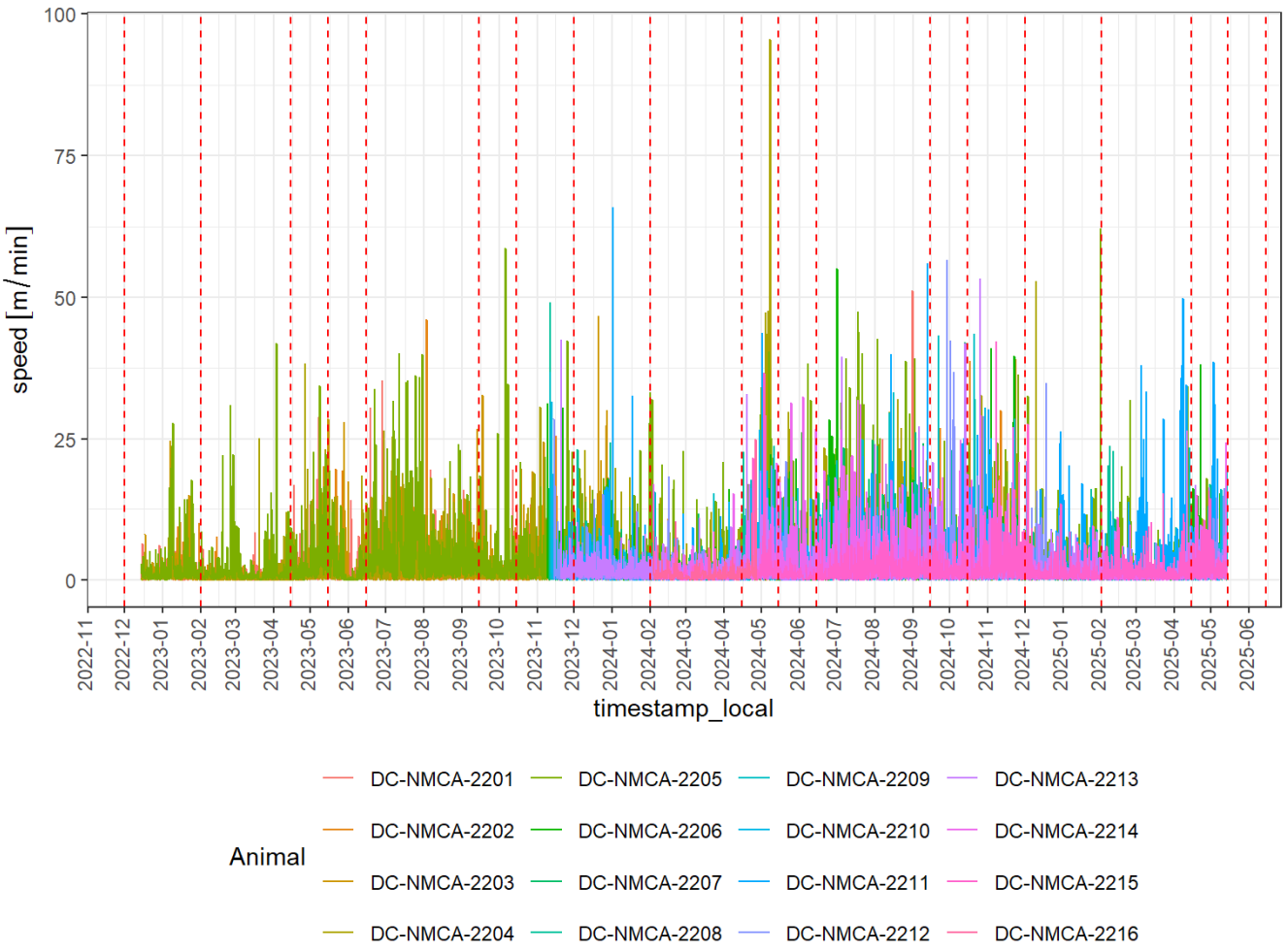


6.2 Speed

6.2.1 Smoothed Speed

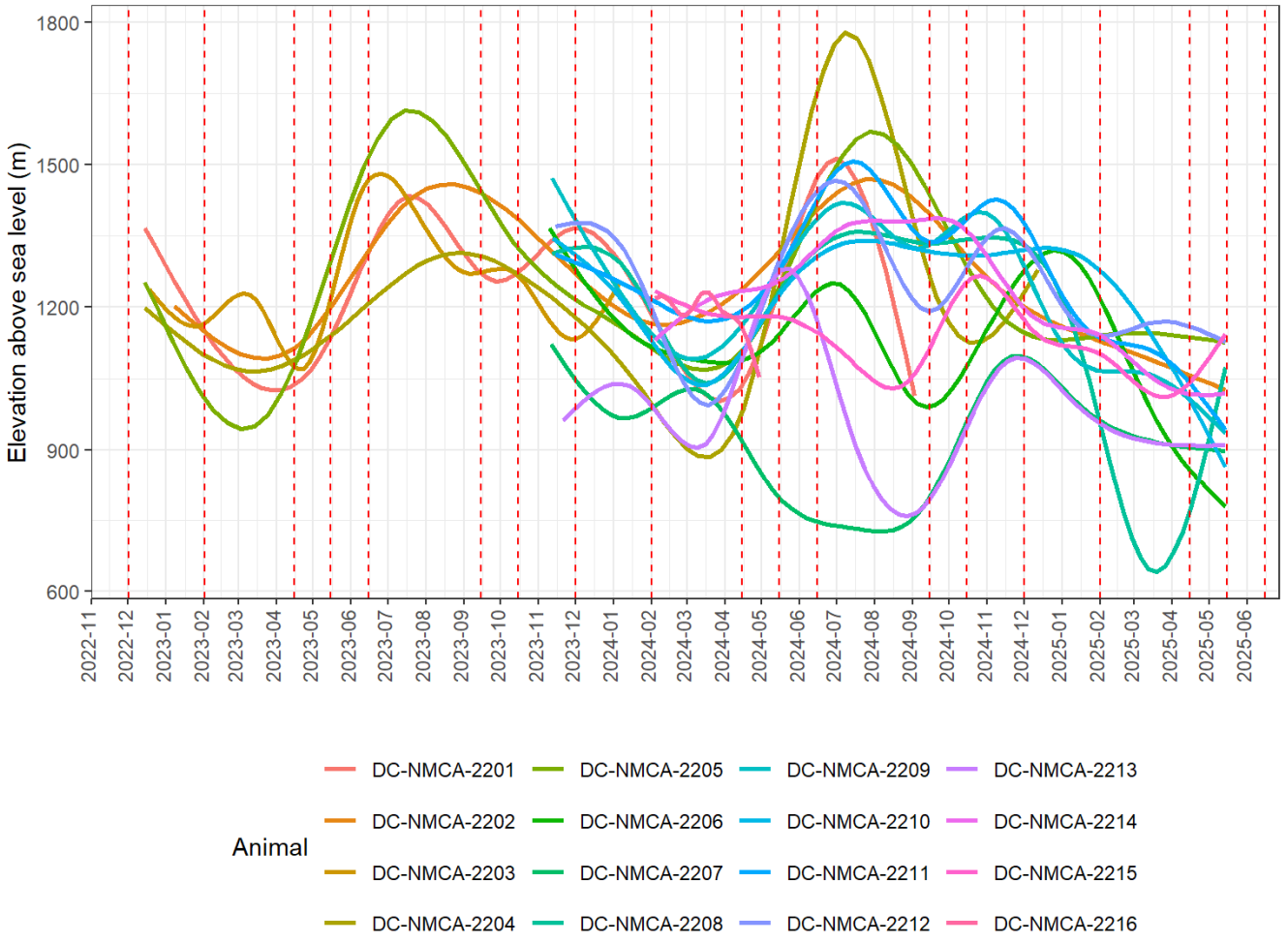


6.2.2 Raw Speed

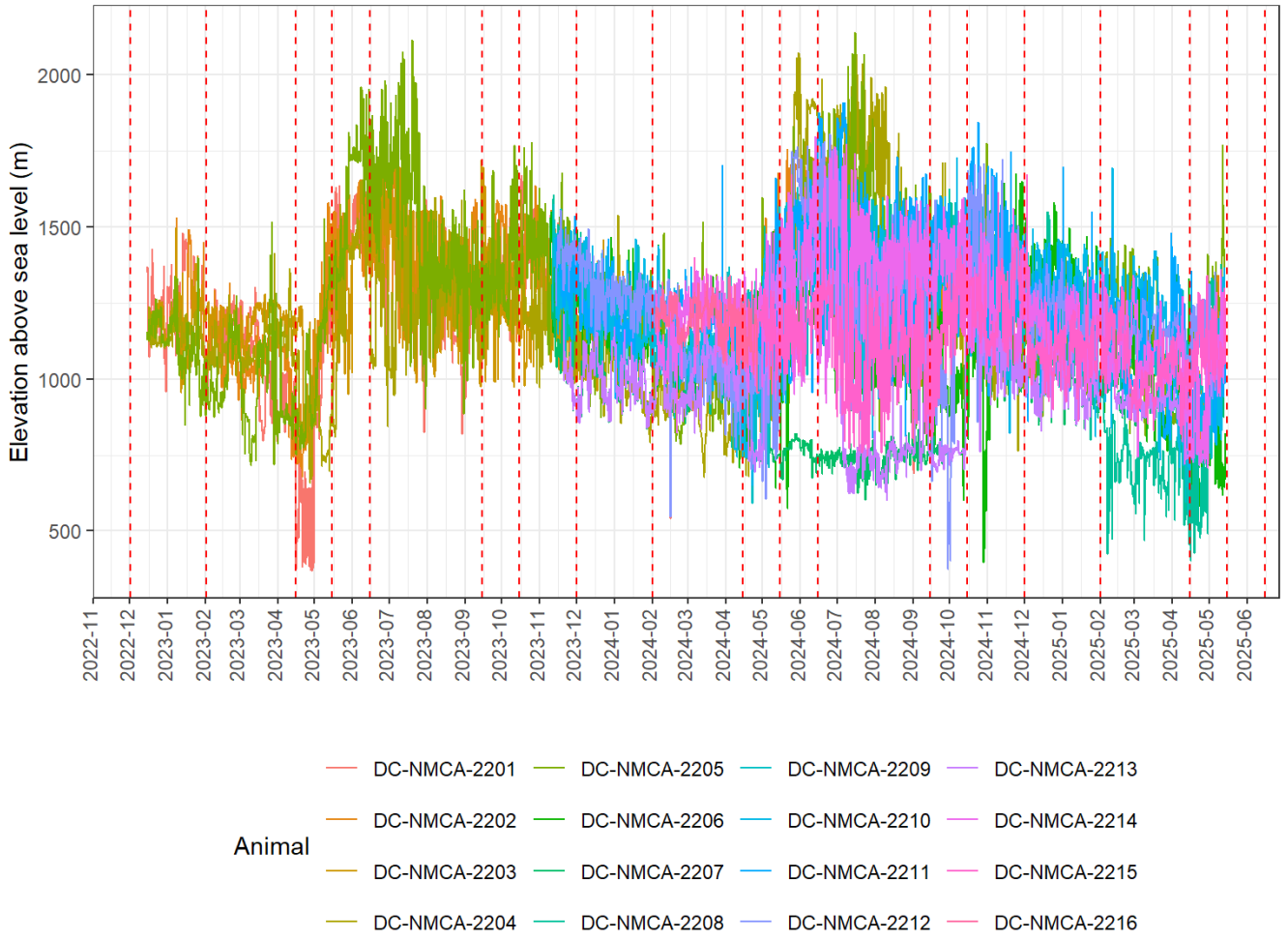


6.3 Elevation

6.3.1 Smoothed Elevation



6.3.2 Raw Elevation



7.0 CALVING SEASON

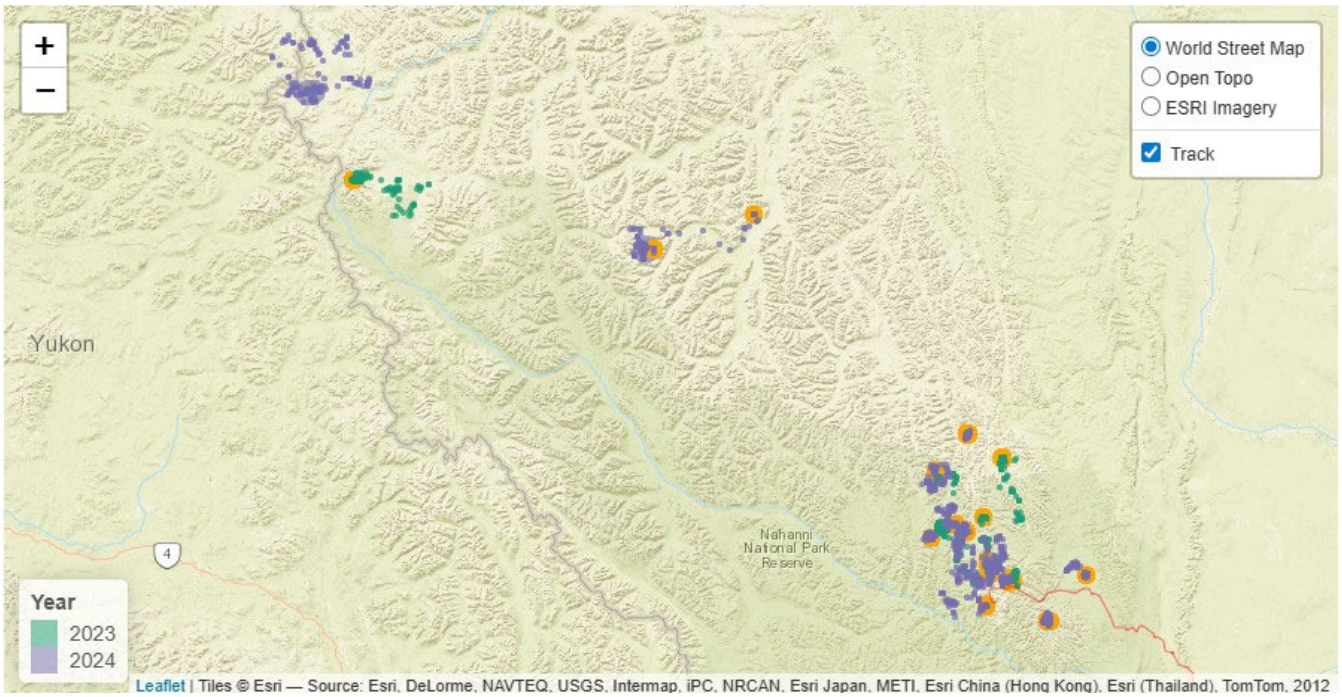
The following maps show caribou collar locations during the calving season. Possible calving locations were predicted in two complementary ways.

Kernel Density Estimation – KDE was used to visualize the spatial distribution and density of caribou collar locations during the calving season. The polygons in the map below are the 25% contours of the utilization distribution (encompassing the densest 25% of collar locations; shown as dots given the map scale below). These are general areas with the highest calving potential for each of the collared caribou. Results showing the KDE polygons for each collared caribou are also provided in Appendix A.

Location Clusters – A cluster of locations by an individual caribou during the calving period indicates very slow movement speed and that they remained in an area for an extended period. This could indicate calving at that location. These locations represent possible calving locations only. It is also possible that calving occurred elsewhere or not at all in that year.

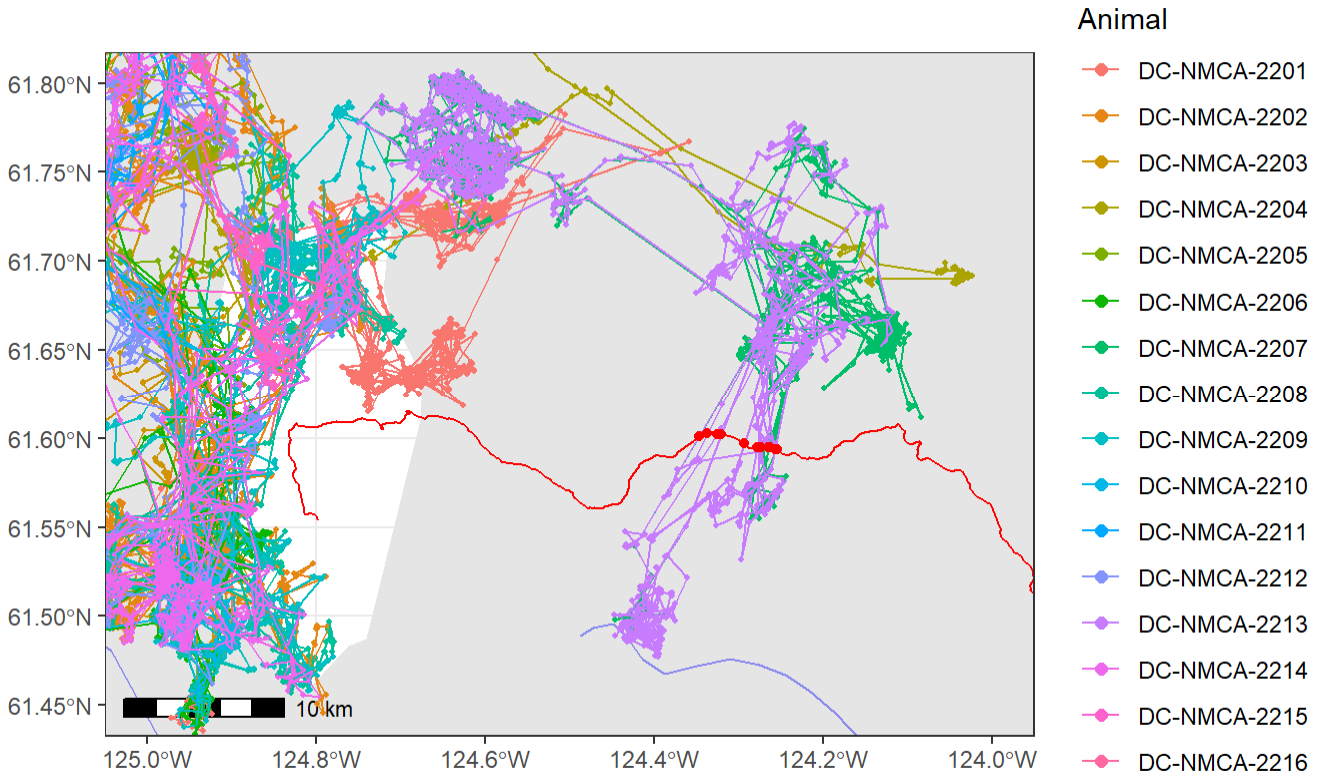
The R package ‘dbscan’ (Hahsler et al. 2024) was used to identify clusters of points. The dbscan algorithm is a density-based clustering algorithm that groups together points that are close to each other based on a distance metric and a minimum number of points required to form a cluster. Ten location points within 75 m were used to form a cluster. Ten locations represent about two days of reported positions. The clustering was completed separately for each caribou in each year. Identified clusters are shown in orange in the map below, as well as in Appendix A.

Locations of individual animals are provided in Appendix A.



8.0 MOVEMENT CORRIDORS

The red dots mark locations where caribou tracks (straight-line connections between GPS locations) intersect with the ASR.



REFERENCES

Chrysalis Ecological. 2023. Spatial Analyses for Nahanni and Nááts'įhch'oh National Park Reserve Caribou Prepared By: Chrysalis Ecological. Prepared for Parks Canada Agency. Contract #5P420-22-0147.

Hahsler M, Piekenbrock M, and Doran D. 2019. “dbscan: Fast Density-Based Clustering with R.” Journal of Statistical Software, 91(1), 1-30. doi:10.18637/jss.v091.i01 https://doi.org/10.18637/jss.v091.i01.

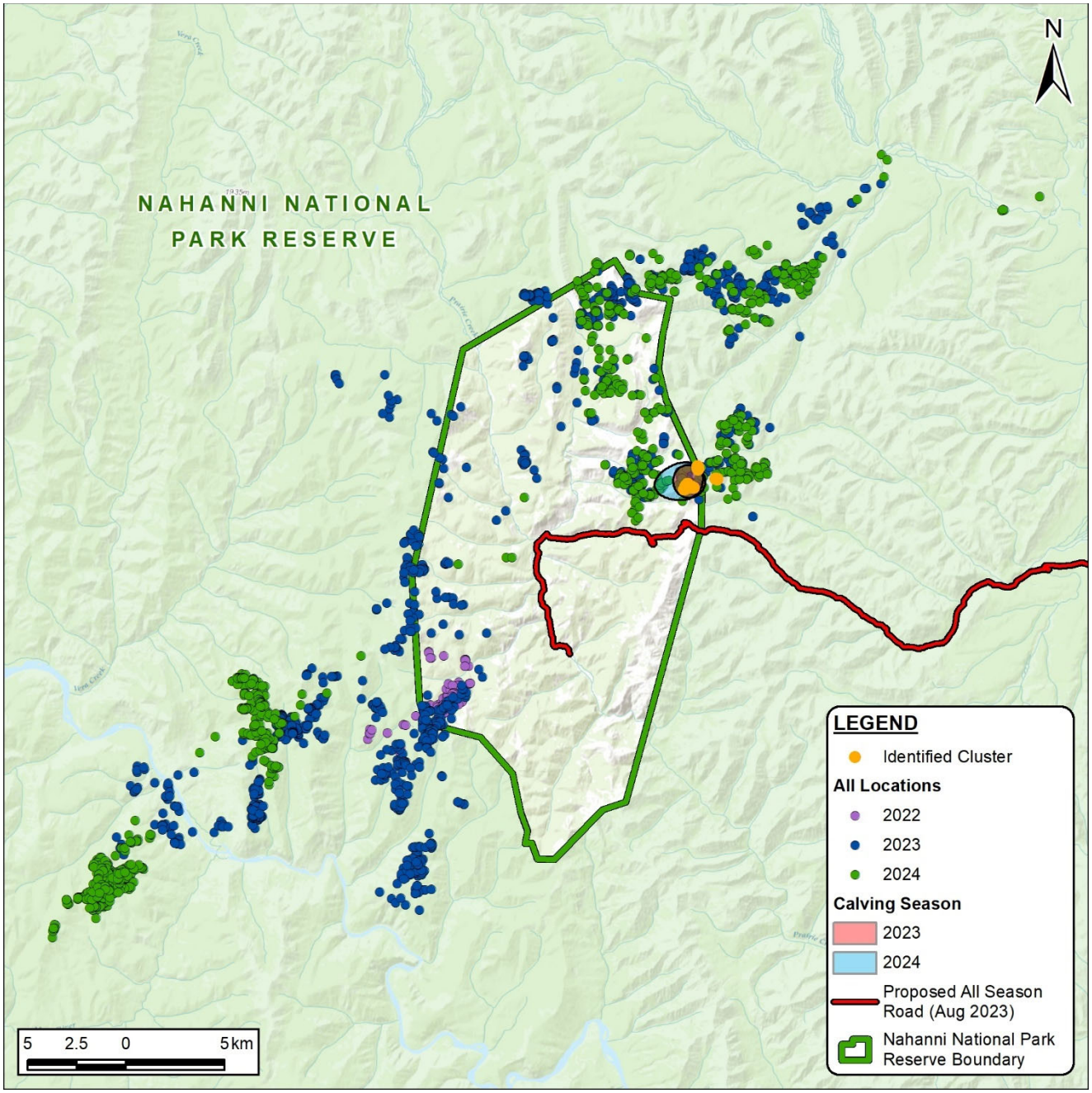
Kranstauber, B., Safi, K., and Scharf, A. K. 2024. move2: R package for processing movement data. Methods in Ecology and Evolution, n/a(n/a). https://doi.org/10.1111/2041-210X.14383.

APPENDIX A

LOCATIONS OF INDIVIDUAL CARIBOU

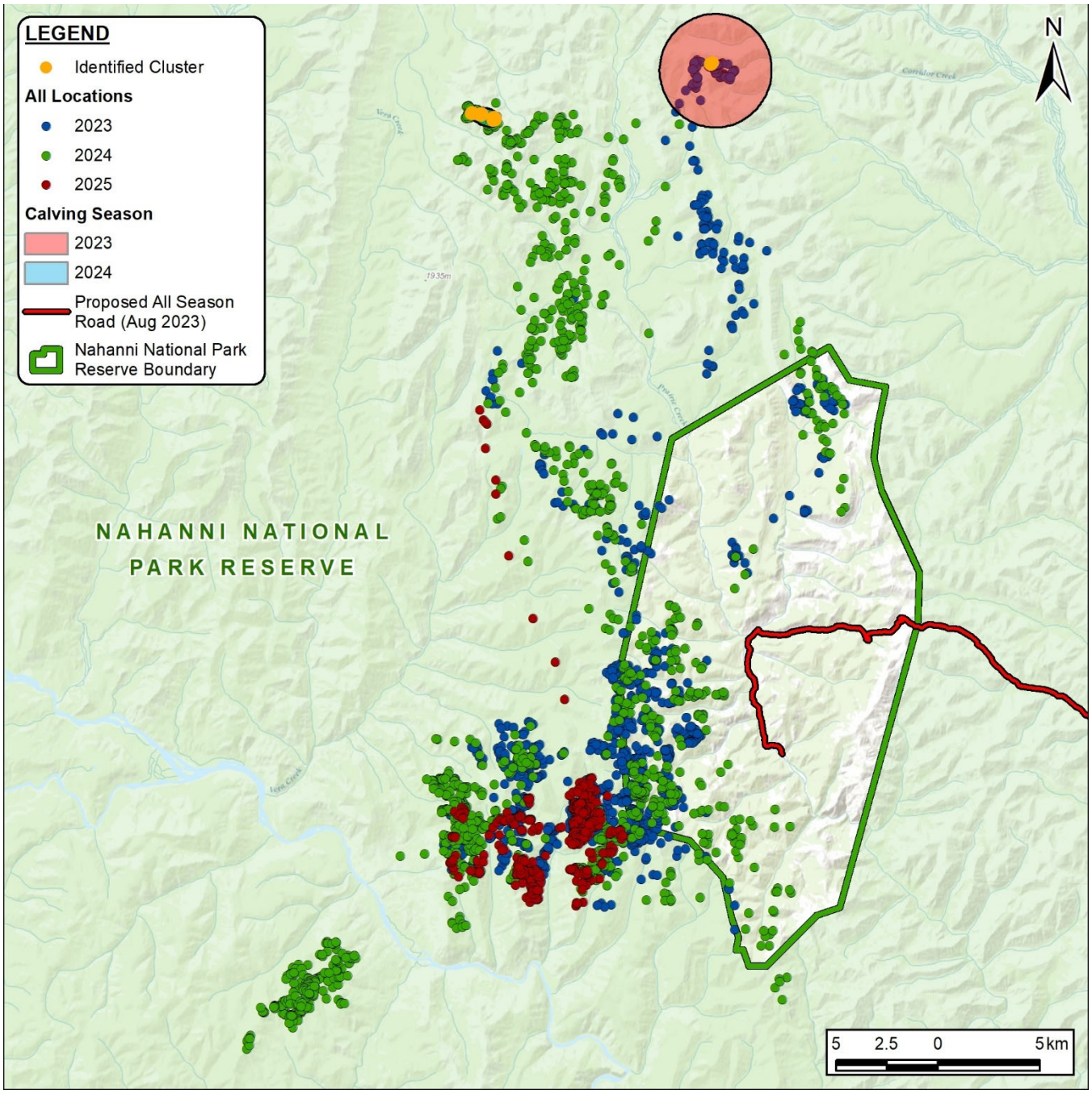
DC-NMCA-2201

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2201	6.18	2022-12-14	2024-09-02	628	1.26 (2023) 1.13 (2024)



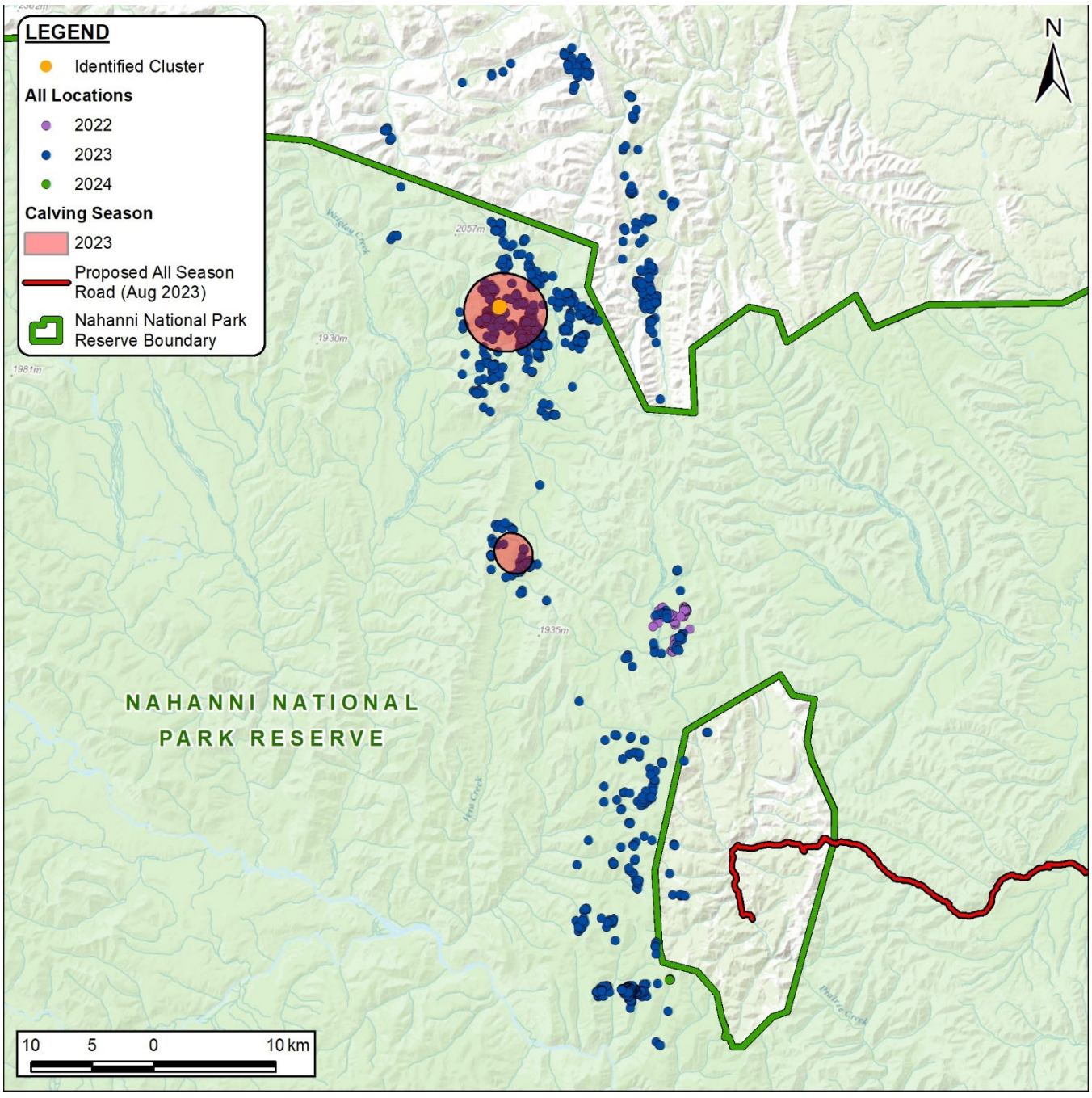
DC-NMCA-2202

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2202	1.99	2023-01-07	2025-05-14	859	24.66 (2023) 27.84 (2024)



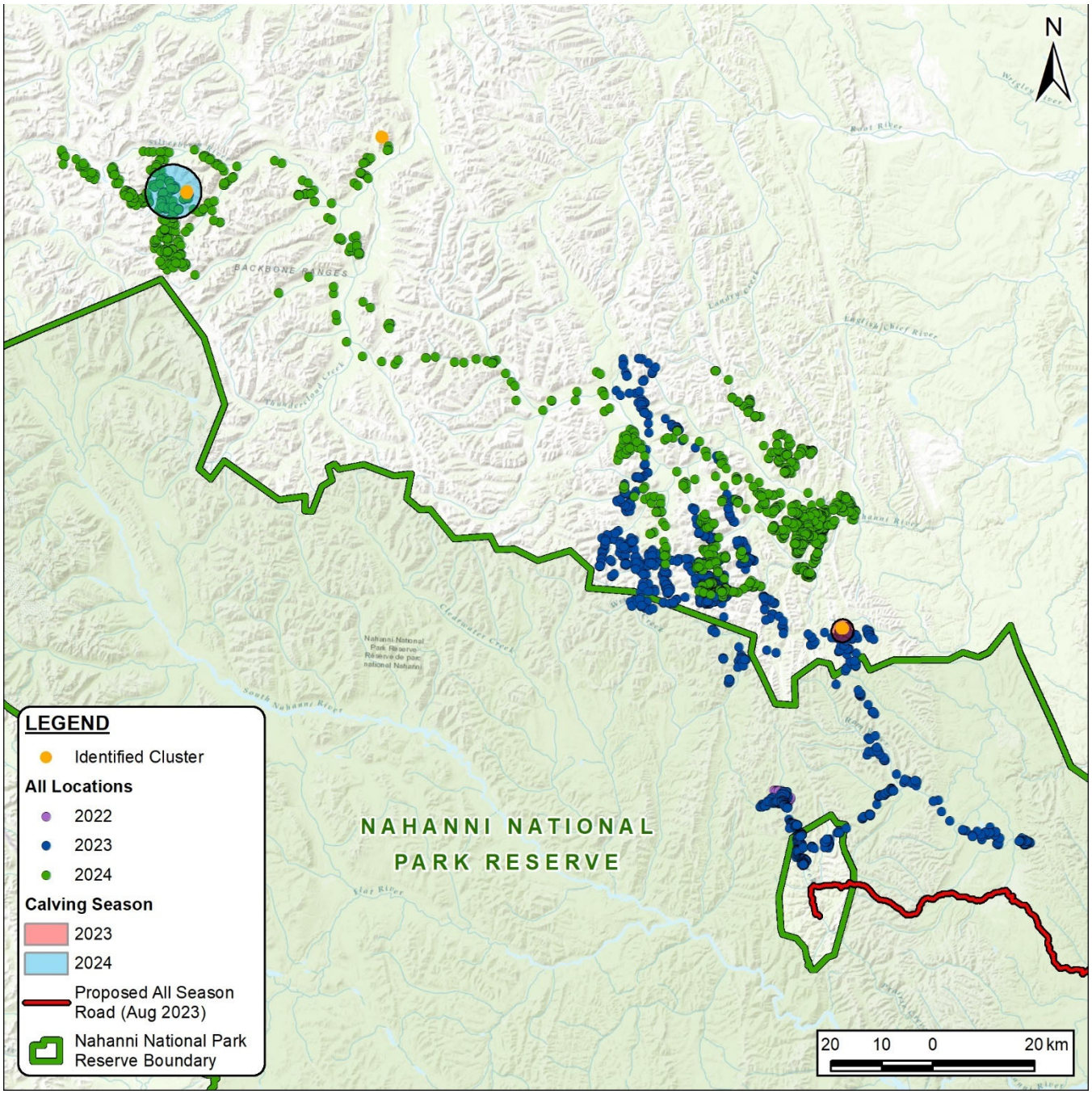
DC-NMCA-2203

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2203	18.01	2022-12-17	2024-01-05	383	28.31 (2023)



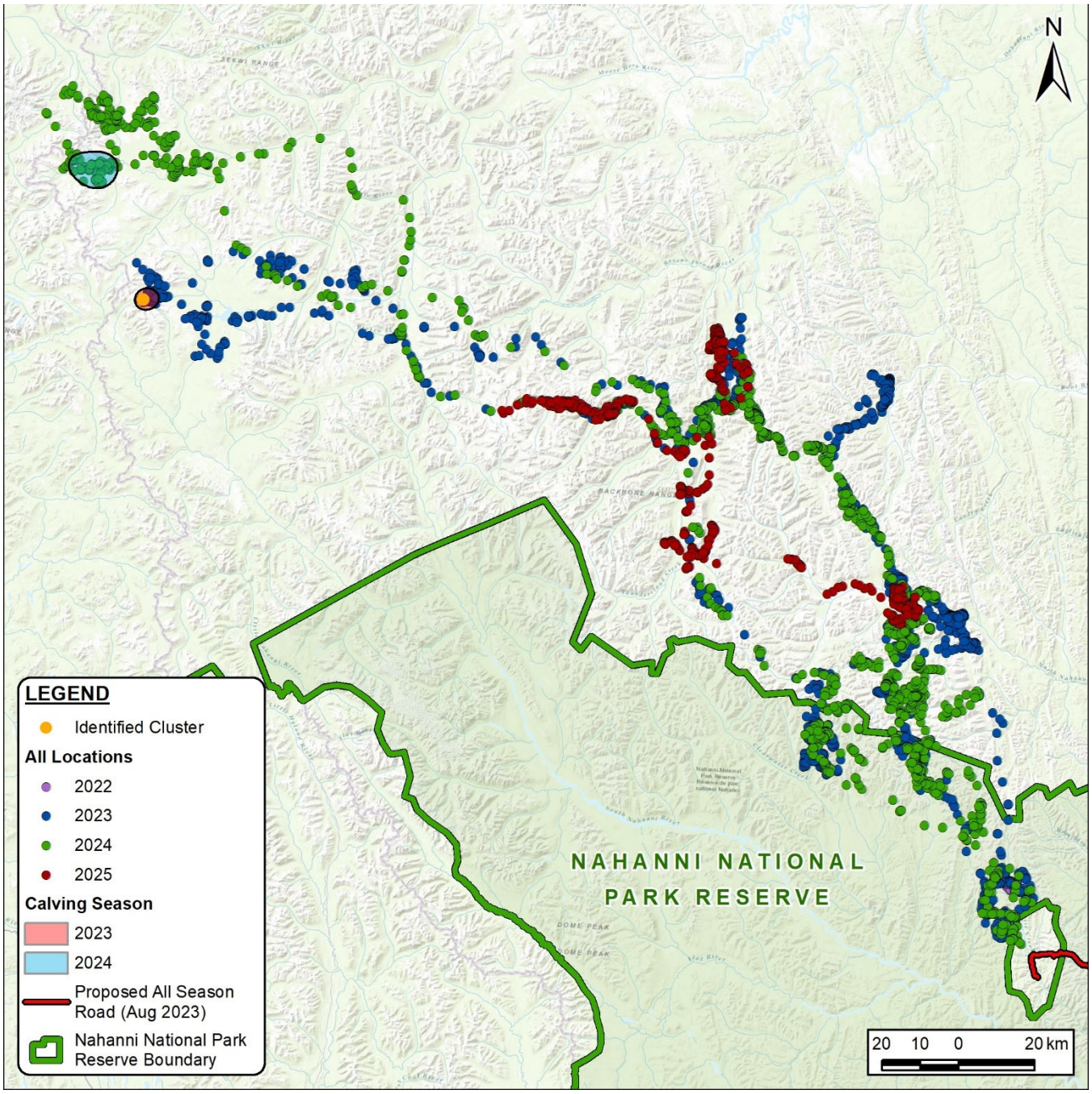
DC-NMCA-2204

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2204	17.46	2022-12-14	2024-12-11	726	47.03 (2023) 179.78 (2024)



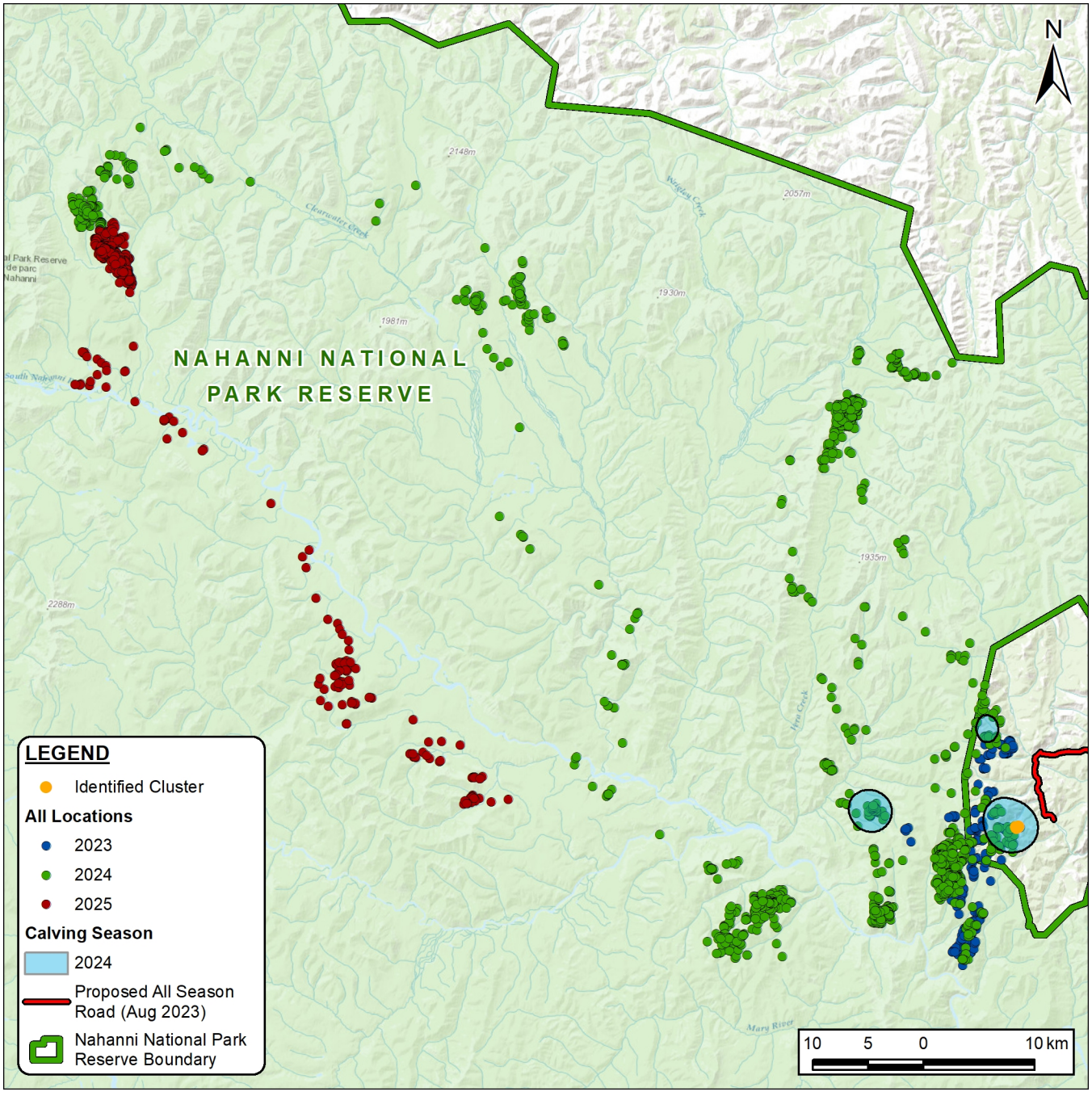
DC-NMCA-2205

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2205	18.84	2022-12-14	2025-05-14	879	285.49 (2023) 314.58 (2024)



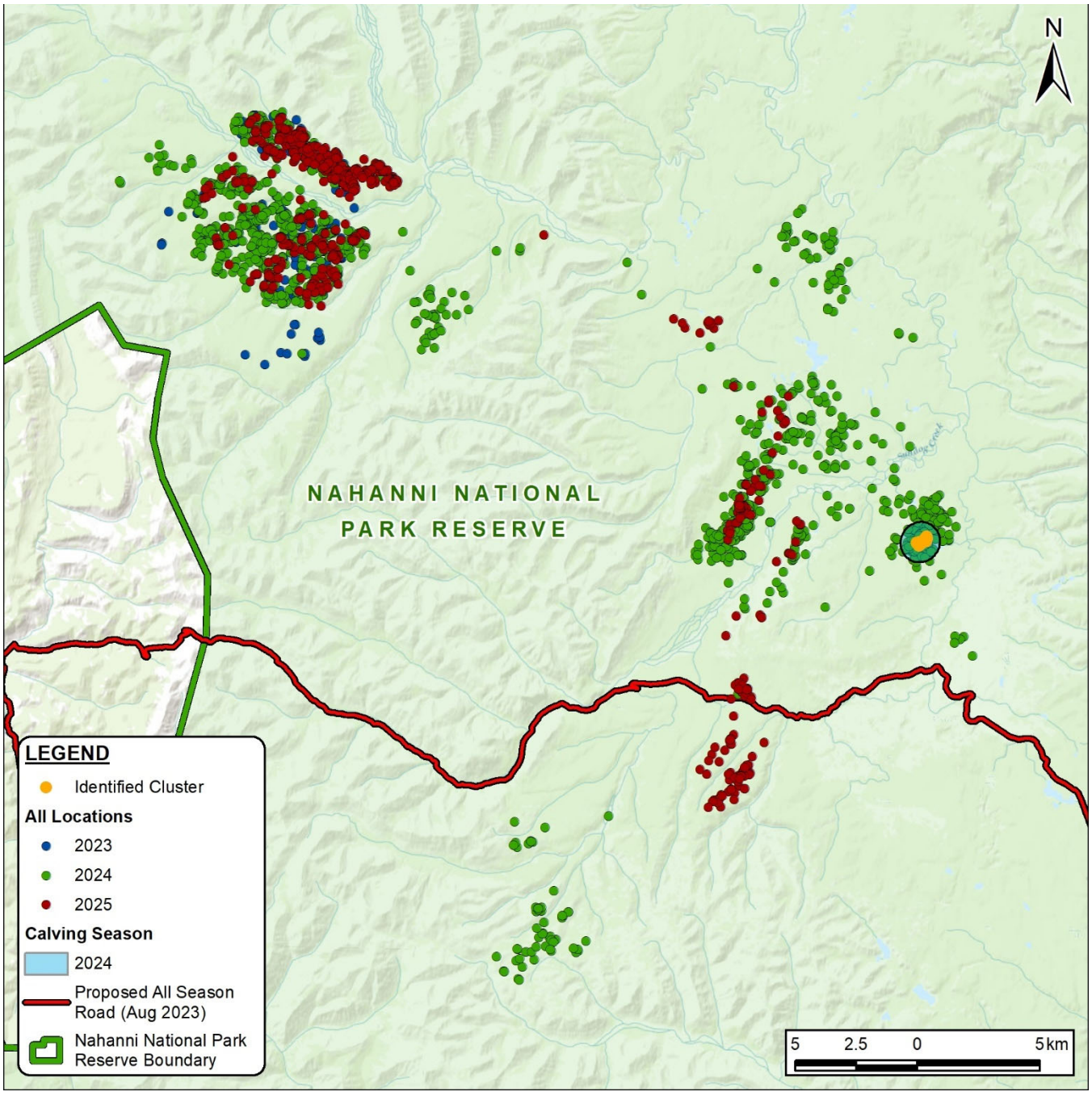
DC-NMCA-2206

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2206	11.27	2023-11-09	2025-05-14	552	0.79 (2024)



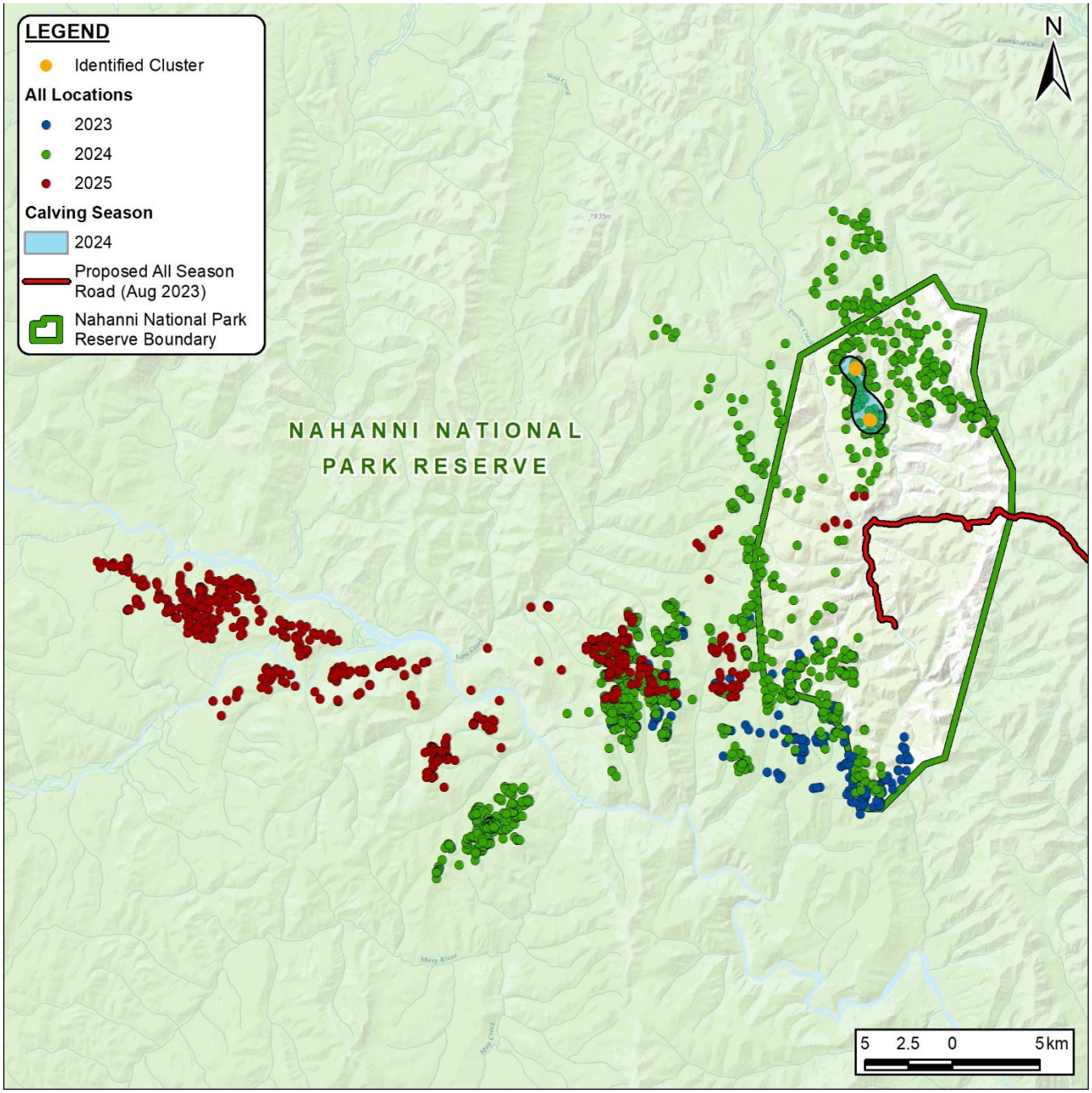
DC-NMCA-2207

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2207	11.46	2023-11-10	2025-05-14	550	4.29 (2024)



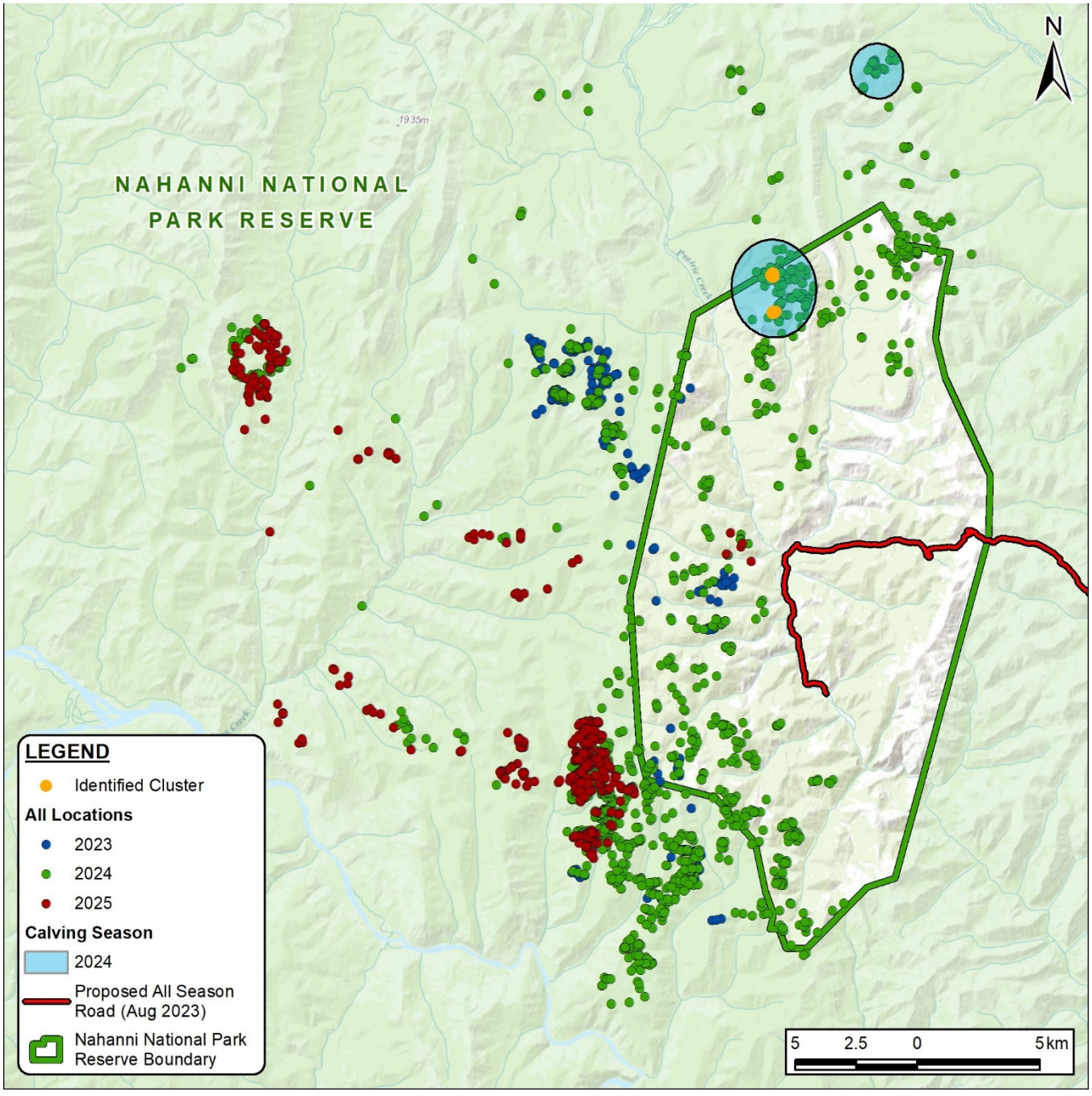
DC-NMCA-2208

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2208	12.09	2023-11-11	2025-05-14	549	4.91 (2024)



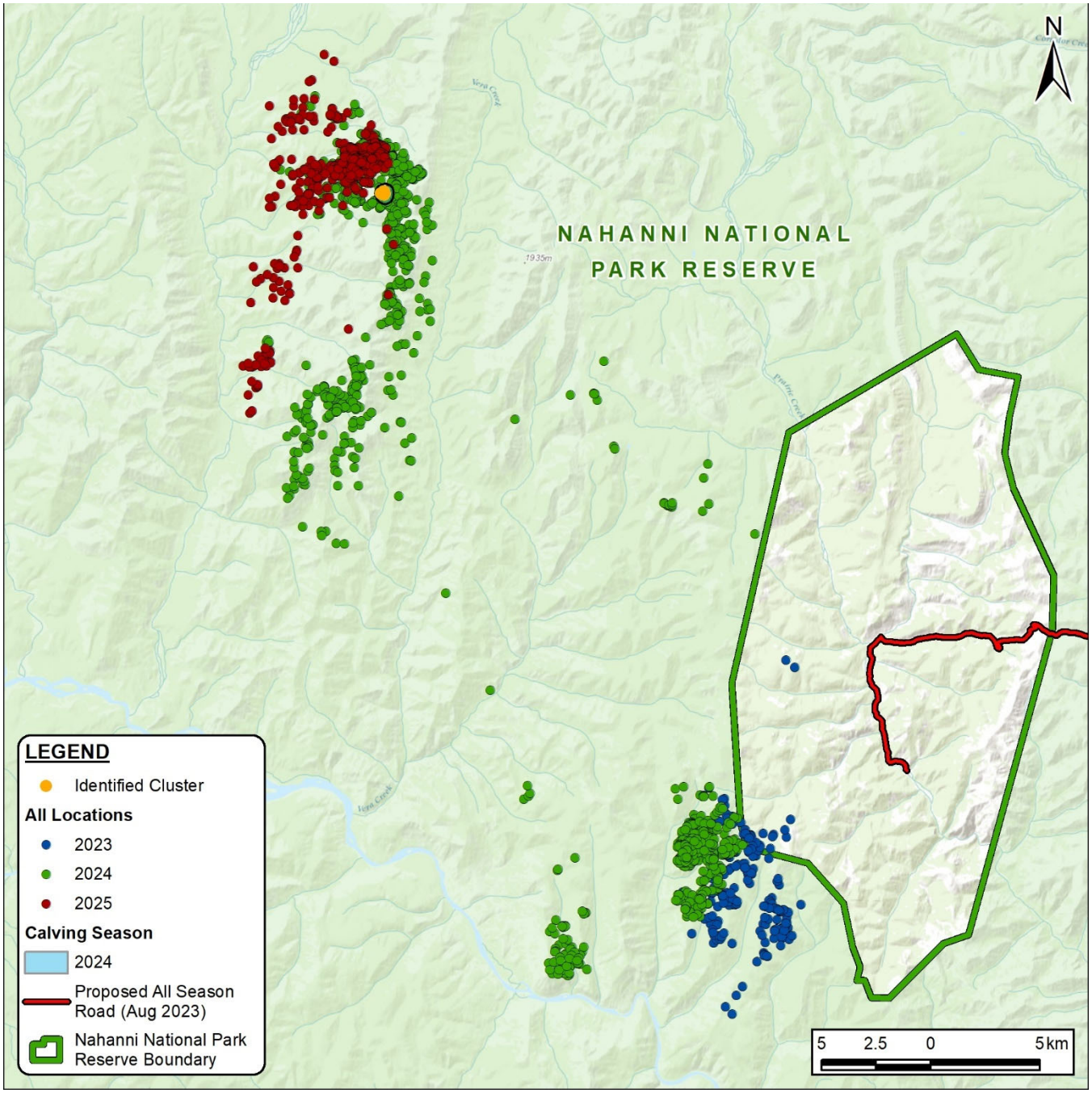
DC-NMCA-2209

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2209	5.24	2023-11-11	2025-05-14	549	8.47 (2024)



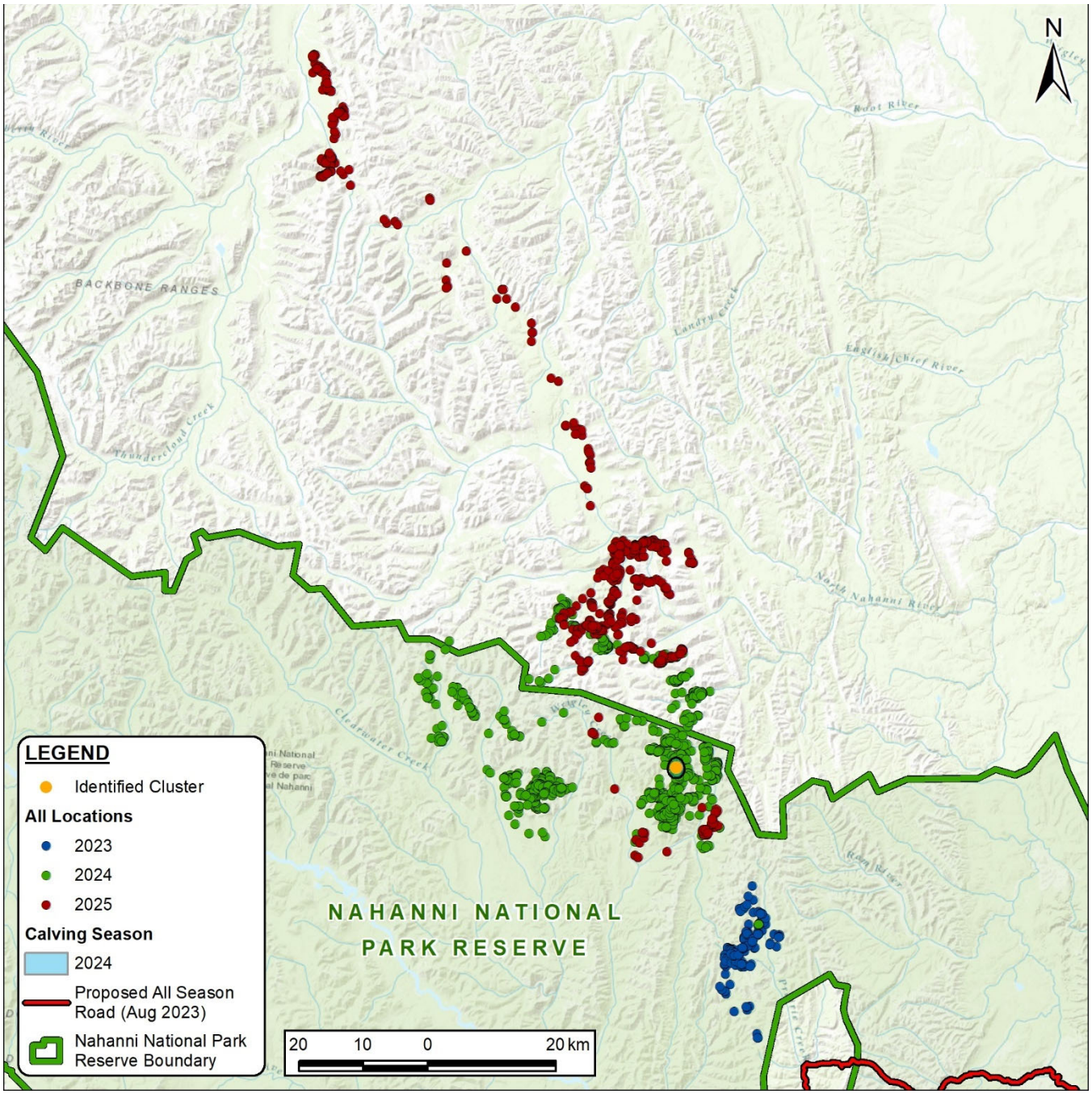
DC-NMCA-2210

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2210	3.85	2023-11-12	2025-05-14	548	29.98 (2024)



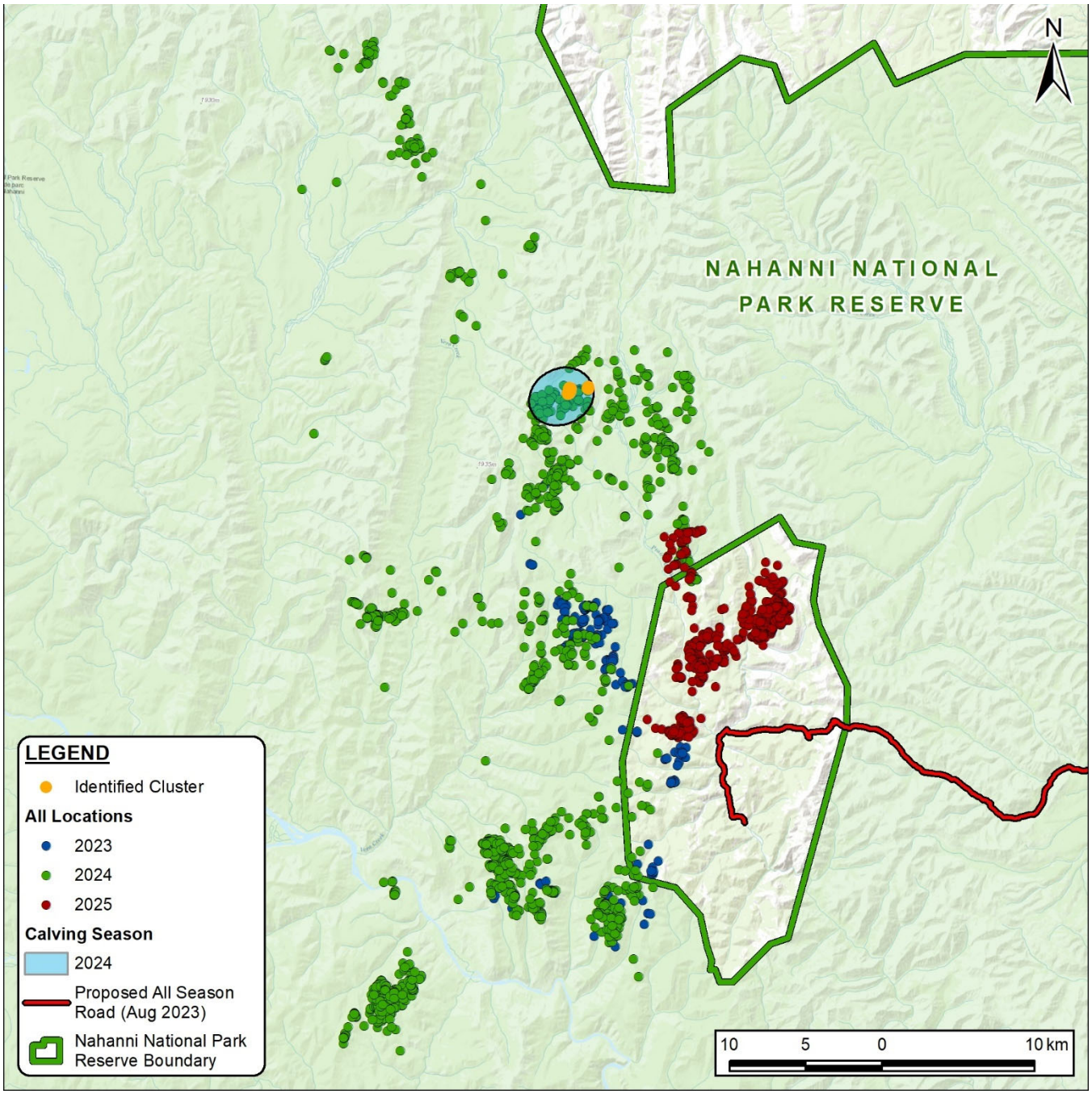
DC-NMCA-2211

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2211	18.73	2023-11-14	2025-05-14	544	48.56 (2024)



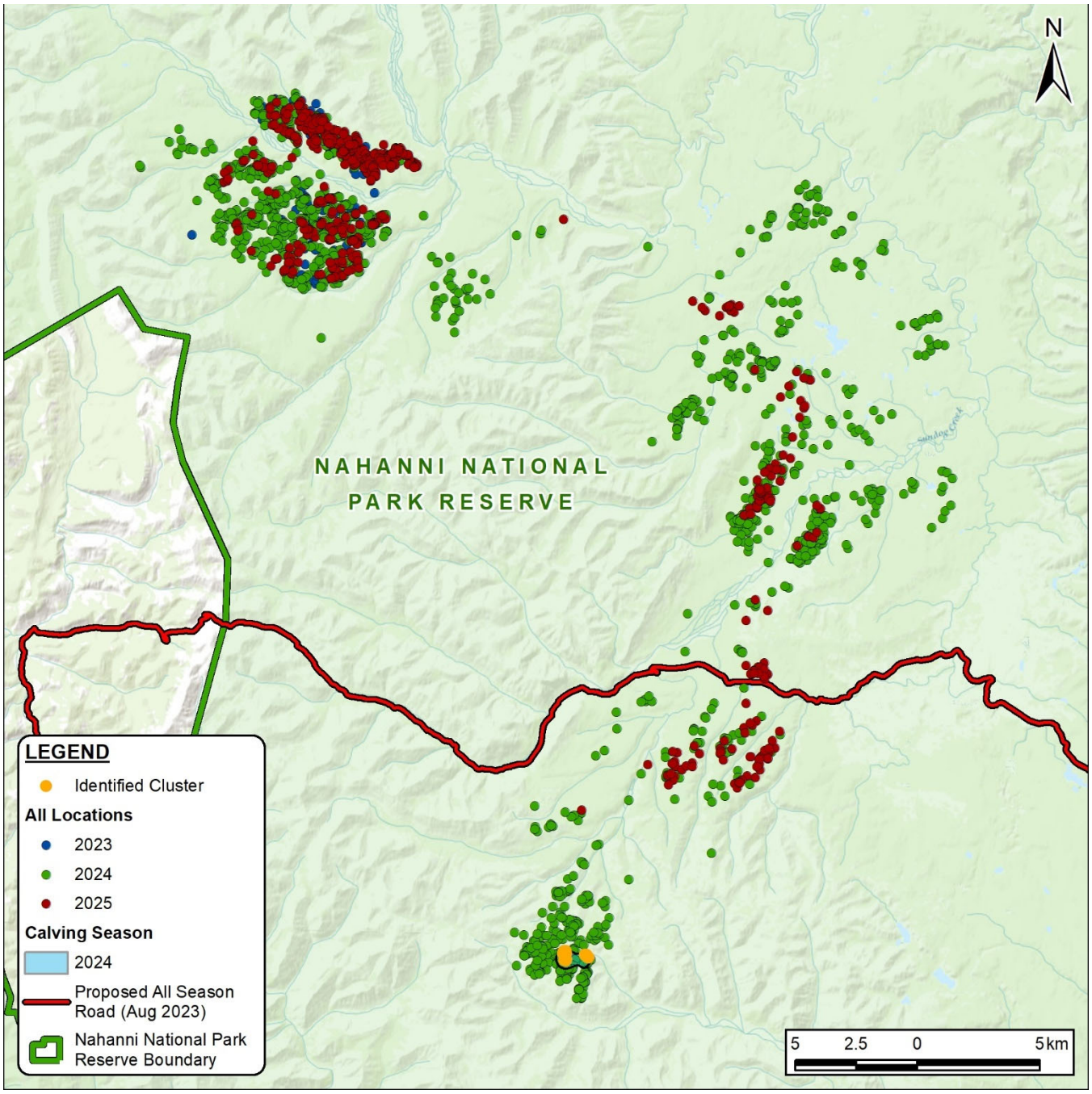
DC-NMCA-2212

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2212	19.86	2023-11-14	2025-05-14	545	22.48 (2024)



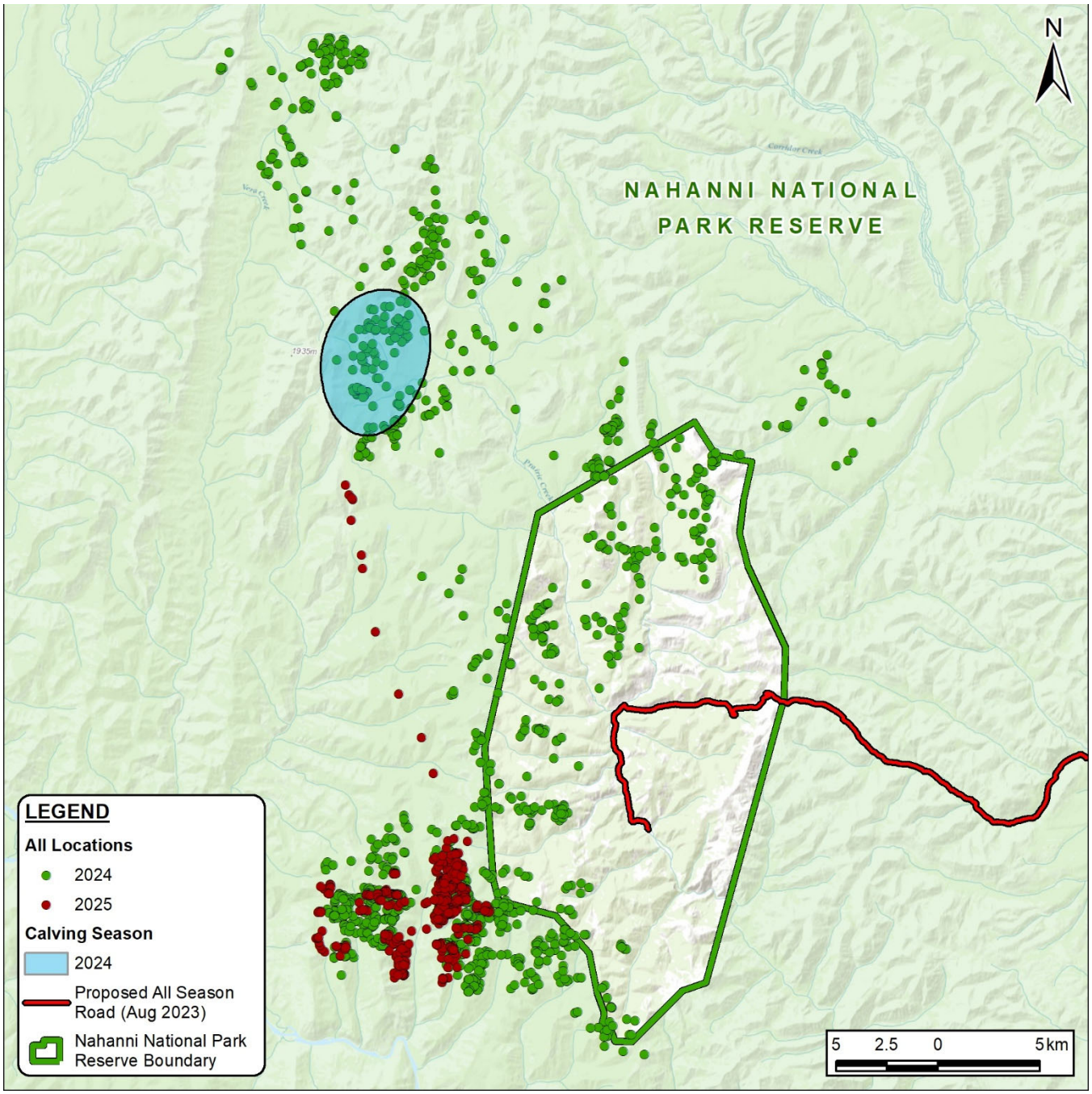
DC-NMCA-2213

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2213	15.46	2023-11-20	2025-05-14	539	7.74 (2024)



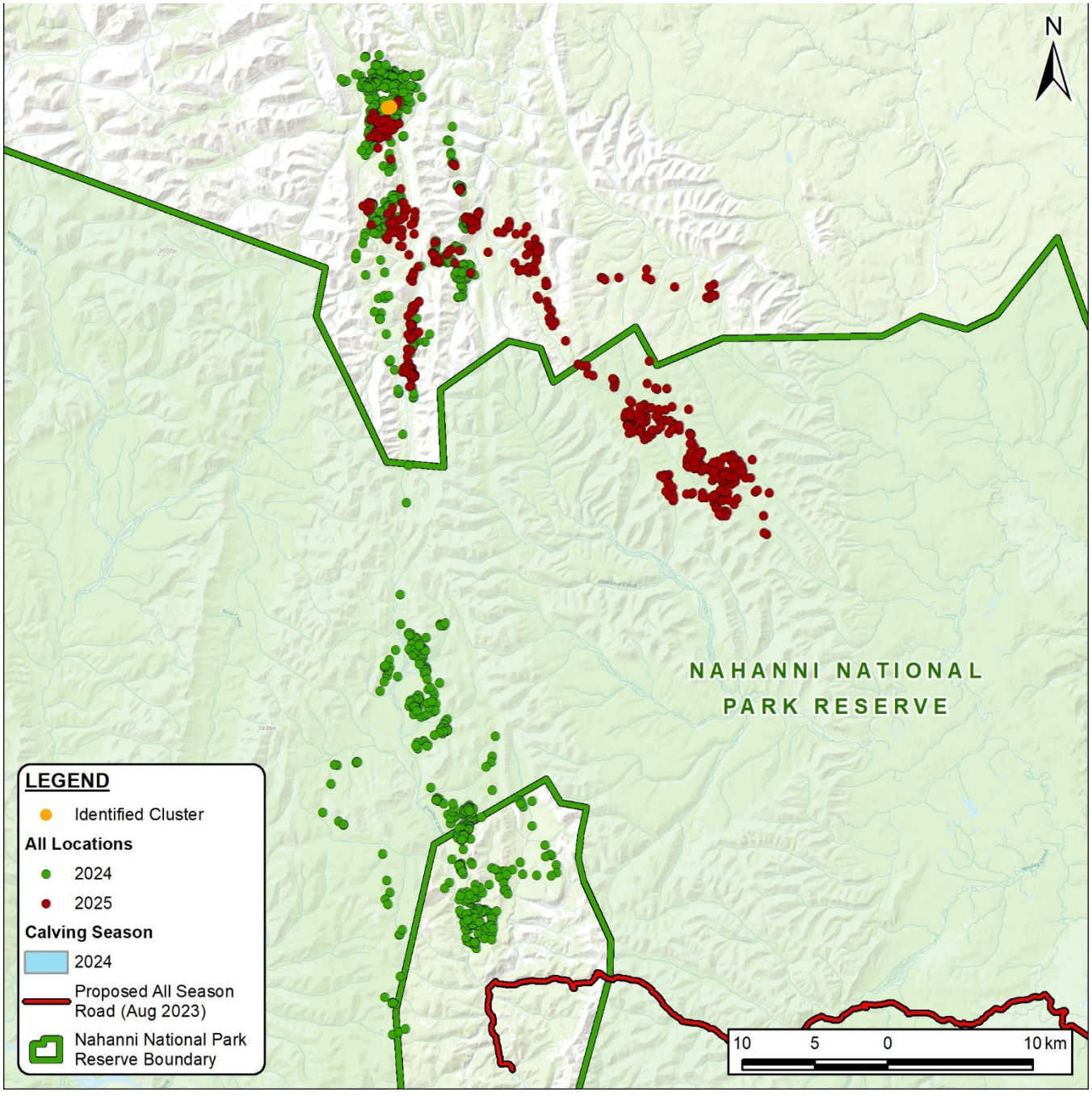
DC-NMCA-2214

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2214	10.81	2024-02-03	2025-05-14	465	17.79 (2024)



DC-NMCA-2215

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2215	19.89	2024-02-04	2025-05-14	463	60.04 (2024)



DC-NMCA-2216

Animal	Capture Dist. to ASR (km)	Start Date	Latest Date	Collar Days	Calving Season Polygon Dist. to ASR (km)
DC-NMCA-2216	18.23	2024-02-03	2024-04-28	81	Not Applicable