APPENDIX D – WOLF MOVEMENT ANALYSIS

GNWT WOLF MOVEMENT ANALYSIS

Summary Report - Draft

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1.0 INTRODUCTION

To support the recovery of the Bathurst and Bluenose East barren-ground caribou herds, GPS collars were deployed on wolves within the herds' ranges to better understand caribou-wolf dynamics in these areas. The goal of this project was to complete an exploratory analysis of the wolf telemetry data with the following objectives:

- Develop annual movement profiles for barren-ground caribou and wolves to determine if there are any commonalities and to explore seasonal changes in wolf movement behaviours;
- Generate occupancy models from wolf telemetry data to explore annual and seasonal space-use patterns; and,
- Conduct a sensitivity analysis that provides guidance (justification) on an appropriate number of wolf collars to have deployed across these three herds.

2.0 DATA

Telemetry locations for March to November 2020 were acquired to explore wolf movement patterns relative to barren-ground caribou movements and seasonal distributions. Collars were deployed on both male and female wolves and collected locations across a range of frequencies. Table 1 summarizes the number of locations collected by each collar by month. During May, all collars collected locations at four-hour intervals; however, from June to November four collars collected locations at eight-hour intervals and seven collars collected locations at 12-hour intervals. To account for differences in collection frequencies between collars, three datasets were generated for the analyses: a daily dataset where all data were resampled to 24-hour intervals, an eight hour dataset, and a 12 hour dataset. The two subdaily datasets contained only the collars that collected data at the corresponding intervals. Maps of the individual collar locations are available in Appendix A.

Table 1. Wolf collar telemetry data summary. The values presented in the table represent the number of locations collected for each month.

Collar ID	Gender	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
WF-NS20-01	M		20	158	87	87	89	90	93	90
WF-NS20-02	F		14	101	70	89	93	90	93	90
WF-NS20-12	M	54	120	172	90	78				
WF-NS20-13	F	44								
WF-NS20-18	M	49	120	169	90	89	8			
WF-NS20-19	M	49	72							
WF-NS20-21	F		88	165	60	55	60	60	62	60
WF-NS20-22	F		13	155	57	42	55	51		
WF-NS20-23	F		4	42	59	60	61	59	62	59
WF-NS20-26	M	37	90	165	60	54	60	27		
WF-NS20-27	M	46	90	166	60	59	60	60	62	60
WF-NS20-29	F	55	89	114	59	58	61	60	62	60
WF-NS20-30	M	43	90	165	59	59	61	60	62	60

Telemetry data for the three barren-ground caribou herds (i.e., Bluenose East, Bathurst, and Beverly Ahiak) with ranges that overlapped the wolf distributions were also obtained, as the objective of these analyses was to explore wolf movement patterns relative to barren-ground caribou. To account for differences in collection frequencies between collars, all data were resampled to daily locations. Collars that had no herd designation were excluded from the analysis. Data were further restricted to include only collars that had at least ten locations per month. These restrictions ensure that only collars that had a representative sample of locations for a given month were being used to characterize range use and movement patterns. Table 2 summarizes the number of collars used in the analysis by herd and month.

Table 2. Barren-ground caribou collar summary. The values presented in the table represent the number of collars used in the analyses by month.

Herd	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
Bathurst	45	59	59	56	56	54	52	50	49
Beverly Ahiak	30	22	22	22	22	22	19	19	19
Bluenose East	66	58	56	55	54	54	52	50	48

3.0 MOVEMENT ANALYSES

To explore wolf movement patterns relative to barren-ground caribou, variation in seasonal movement for each species were characterized using daily movement rate. Daily movement rate represents the total straight-line distance moved over a 24- hour period. For both species, the daily movement rate was calculated using the daily datasets rather than the subdaily data, so the straight-line distance represents the displacement between two successive locations and not the cumulative distances between all locations collected within the same 24-hour period. To remove any biases due to missing fixes, only displacements for 23 to 25 hours were included in the analysis. For the caribou, daily movement rate was calculated at the individual level but then averaged across individuals belonging to the same herd to provide a herd level estimate of seasonal movement patterns. For the wolf analysis, we assumed that all the collared animals were moving as separate individuals, so the daily displacement values were calculated only at the individual level.

To further characterize seasonal patterns of wolf movement, the net-squared displacement (NSD) for each individual was also calculated. Net-squared displacement (NSD) is calculated as the squared displacement between a location in a trajectory and the first location in that trajectory (Figure 1). As the displacements are measured relative to the origin of the trajectory, it is a useful metric for distinguishing periods of spatially restricted movement from periods of dispersal or migration. Since NSD is a relative metric, it was not appropriate for use in characterizing the herd level seasonal movement patterns for the caribou.

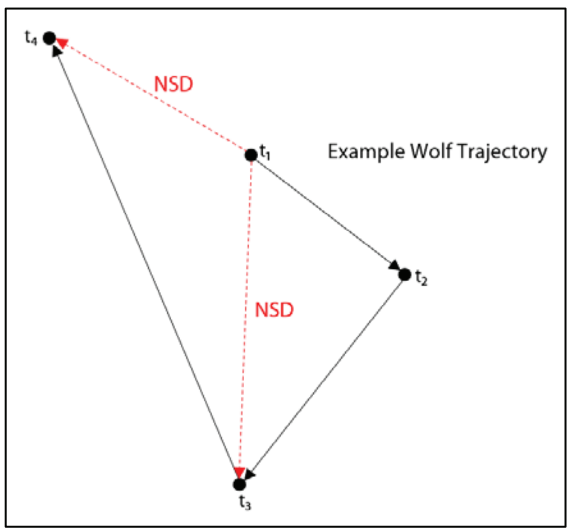

Figure 1. Example of net-squared displacement (NSD). The black line represents an example wolf movement trajectory. The red lines represent the NSD distance. For t_1 NSD= 0 as there is no relative movement. For t_2 NSD is the squared displacement between t_1 and t_2.

4.0 OCCUPANCY MODELS

To explore seasonal space-use patterns by wolves relative to barren-ground caribou, two approaches for developing occupancy models were applied: Brownian bridge movement models and grid cell counts. These two approaches were selected as they characterize space-use at two different spatial scales and could be used to inform different aspects of caribou-wolf interactions. The Brownian bridge approach provides a fine-scale description of space-use appropriate to exploring individual wolf-caribou interactions; while the grid cell count approach provides a regional scale description more appropriate to herd level wolf-caribou interactions.

4.1.1 Brownian Bridge Occupancy Models

Brownian bridge movement models (BBMM) are a continuous time approach to modelling wildlife movement and space-use where the probability of an animal using a particular area are determined according to the start and end location of each movement, the time between those two locations, and the speed of that movement (Horne et al. 2007). While BBMM produces a utilization distribution (UD), similar to a kernel density approach, the UD differs from that of a kernel density in that the sequence of the telemetry points was taken into account when the probabilities were calculated. The resulting surface represents the relative UD for an individual that highlights areas of high use representing spatially restricted movements and areas of low use that could indicate movement corridors or areas of dispersal. For this project, we are interested in wolf space-use in relation to caribou from an occupancy perspective. As such, we will be using the term occupancy model (BBOM) rather than movement model (BBMM).

Since BBOM is conditioned on the time elapsed between locations, it is a method that benefits from using subdaily telemetry data. As such, the eight-hour and 12-hour datasets were used for this analysis. Two parameters are required to calculate a BBOM: the Brownian motion variance parameter and the standard deviation of location error for the trajectory. The motion variance parameter was calculated for each individual using the maximum-likelihood approach proposed by Horne et al. 2007 and the location error was set to 28.85 metres based on error estimates calculated for a previous telemetry study (Horne et al. 2007).

BBOM UDs were calculated for two different scales: the whole trajectory (March to November) and for four shorter time periods April 1 – May 31(Spring), June 1 – June 30 (Calving), July 1 - August 31(Summer), September 1 – November 30 (Fall). These time periods roughly match the seasonality of barren-ground caribou movement and range use patterns to examine the potential for seasonally important interactions between the two species. BBOM were only generated for the wolf data and the results compared to the location of the caribou as defined by the telemetry data.

4.1.2 Relative Herd Distributions

For the grid cell count approach, binary range use rasters were generated for individual animals of both species. Telemetry data were subdivided into months resulting in a binary use raster for each month for each animal. A one-kilometre fishnet raster was created for the study area to act as a baseline surface. The one-kilometre resolution was too fine to be a useful analysis unit; however, it provided an appropriate base resolution that could be aggregated across a variety of spatial scales. The baseline fishnet was iteratively intersected with each of the individual collar datasets. If a cell intersected with a telemetry location it was assigned a value of one, cells that did not intersect with any locations were assigned a value of zero. If multiple locations fell within the same cell, the cell was still assigned a value of one; intensity of use within each cell was not considered.

The initial one kilometre binary use rasters were aggregated to a 10 kilometre grid to match with a previous seasonal range use analysis performed for the Bathurst, Bluenose East, and Beverly Ahiak herds (Nishi *et al.* 2020). A 10 kilometre cell size was selected for that analysis based on a sensitivity analysis that compared grid cell count results for caribou across a range of resolutions: 5 kilometres, 10 kilometres, 15 kilometres and 20 kilometres. Once aggregated, 10 kilometre raster cells with a value greater than zero were reclassified to a value of one to convert them back into binary surfaces. Cells with a value equal to zero remained unchanged. To distinguish range use between caribou and wolves, binary rasters were according to species and herd designation (if caribou). The coding scheme applied to the use rasters is outlined in Table 3. Finally, the binary rasters were combined to generate a cumulative surface representing relative monthly space use by caribou and wolves and any areas of concurrent use by the two species.

Table 3. Relative distribution classes

Weighted Cumulative Value	Monthly Range Use
0	No recorded use
1	Beverly Ahiak only
10	Bathurst only
100	Bluenose East only
1000	Wolf use

5.0 RESULTS

5.1 Movement Analysis

Characterizing movement patterns for wolves using daily movement rate revealed no apparent seasonal trends. Movement rate varied between successive days providing no indication of seasonal changes in movement behaviours (i.e., denning or dispersal). Some wolves (e.g., WF-NS20-01, WF-NS20-26) had periods of low movement rates April through June indicating spatially restricted movements possibly associated with denning; however, the pattern was not consistent across collars, so was not considered to be an indication of a biological season.

Characterizing movement patterns for wolves using NSD was a more appropriate metric for capturing changes in movement behaviour. When the NSD values were graphed for each collar, almost every collar showed periods of area restricted movement (i.e., plateaus) and periods of high movement (i.e., sharp increases or decreases and high variability). While no consistent patterns were evident between collars, NSD plateaus in April through June could be linked to denning and shorter plateaus in July through November could indicate caribou kills or hunting. Daily average movement rate and NSD graphs for all collars are available in Appendix B.

Examining the NSD profiles for each collar in combination with the collar movement maps allowed for the identification of three general movement groups: north-south movers, east-west movers, and stationary wolves (Table 4). The north-south movers were generally characterized by north-south movements occurring from March to November, interactions with only one barren-ground caribou herd, area restricted movement March to June, and a return south in September/October matching the return of the caribou to their winter ranges. East-west movers displayed periods of clustered movements connected by east-west dispersals. Unlike the north-south group, these east-west dispersals had the potential for interactions with multiple caribou herds. The stationary wolves displayed no seasonal movement and remained in the same area March through to November. These collars generally were located south of the Bathurst range.

Table 4. General wolf movement groupings

North – South	East-West	Stationary
WF-NS20-01	WF-NS20-12	WF-NS20-02
WF-NS20-18	WF-NS20-21	WF-NS20-23
WF-NS20-19	WF-NS20-27	WF-NS20-29
WF-NS20-22	WF-NS20-30	
WF-NS20-26		

Characterizing movement patterns for barren-ground caribou using daily movement rate captured the expected changes in seasonal movement behaviours associated with annual caribou life cycles. Increases in movement rates were present in May and September/October indicating the beginning of the spring and fall migrations, respectively. Beverly Ahiak did not show strong changes in movement rate associated with the start and end of spring migration. Another increase in movement rate was present in July possibly corresponding to higher movements associated with insect avoidance. Low movement rates were present in March, April, and November characteristic of winter range use. A complete set of barren-ground caribou movement profiles are available in Appendix C.

5.2 Brownian Bridge Occupancy Models

The Brownian bridge occupancy models successfully distinguished areas of high, medium, and low use from the wolf telemetry data. Visualizing the BBOM UD for the whole trajectory provided a broad scale characterization of space use for each of the wolves; while the seasonal BBOMs provided a much finer characterization of both space use and movement patterns. At the trajectory level, the BBOM UDs are another tool for comparing the general movement groups identified using the NSD profiles and movement maps. Figure 2 shows the BBOM UD for north-south mover WS-N20-01 with pockets of high use spread across three different areas in a north-south direction. Figure 3 shows the BBOM UD for east-west mover WS-N20-27 with two major areas of high use connected by east-west movements; and Figure 4 shows the BBOM UD for stationary wolf WS-N20-02 with only one major area of high use. Visualizing the occupancy models at such a high level allows for the differentiation of annual space-use strategies adopted by wolves within barren-caribou ranges. Identifying these strategies is a first-step exploratory tool that can be used to understand the spatial distribution of potential wolf-caribou interactions and prioritize and inform further analyses.

At the seasonal level, the BBOMs again highlight areas of high, medium, and low use but at a much finer temporal and spatial scale. Since these models were calculated from a subset of the wolf telemetry data, they enable a more direct comparison of seasonal wolf and caribou distributions. When visualized seasonally, wolves from all three movement groups displayed clustered movements and space-use for both the spring and calving subsets. There appears to be the potential for caribou interaction, specifically with individuals from Bluenose East, for wolves WF-NS20-01 and WF-NS20-27 in the spring (Figure 5). However, the potential for interaction decreases during the calving period as the caribou move further away from the location of the clustered wolf distributions (Figure 6).

During the summer period, there was a dramatic shift in space-use and movement patterns by the non-stationary wolves away from spatially restricted movements to long dispersal movements followed by areas of high intensity use that overlapped with summer caribou distributions (Figure 7). For example, WF-NS20-01 travelled directly north with high use areas overlapping with collared Bluenose East caribou; while WF-NS20-27, travelled directly east with high use areas overlapping with collared Bathurst caribou. For stationary wolf WF-NS20-02, there was also a shift in use patterns with the large contiguous high use area observed during the spring and calving seasons splitting into multiple smaller clusters.

Wolf space-use patterns for the fall continued to be more variable than those observed during the spring and calving periods (Figure 8). Again, the non-stationary wolves followed a pattern of travelling between high use areas which overlapped with collared caribou distributions. WF-NS20-01 appeared to follow the Bluenose East caribou down from the summer range to their winter range and WF-NS20-27 travelled west returning from the Bathurst summer range to interact with Bluenose East. Interestingly, the timing of wolf WF-NS20-27 travelling west corresponds to the timing of collared Bathurst individuals leaving the area around Lupin and movement south by Bluenose East individuals returning to their winter range.

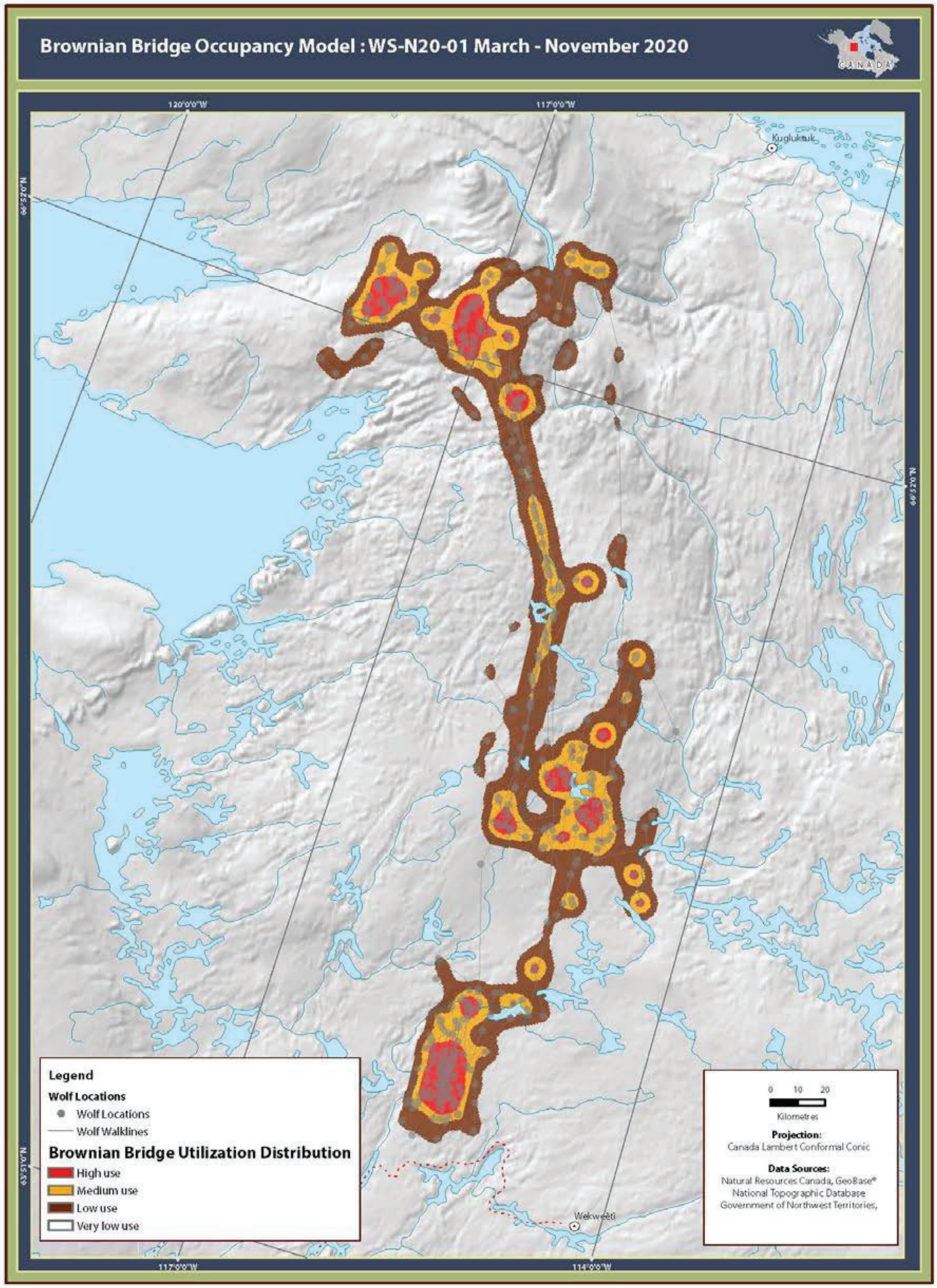

Figure 2. Brownian bridge utilization distribution for WF-NS20-01

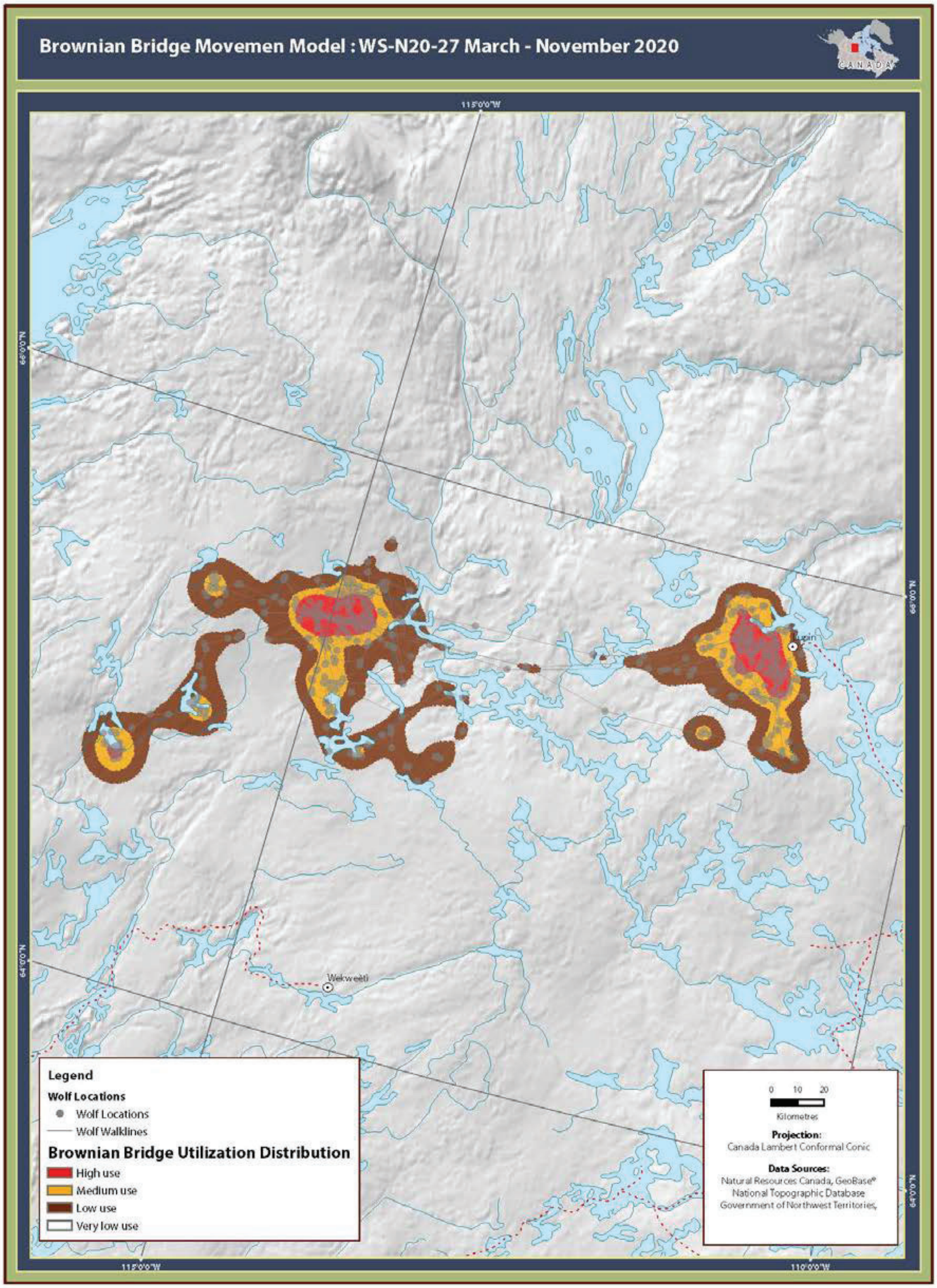

Figure 3. Brownian bridge utilization distribution for WF-NS20-27

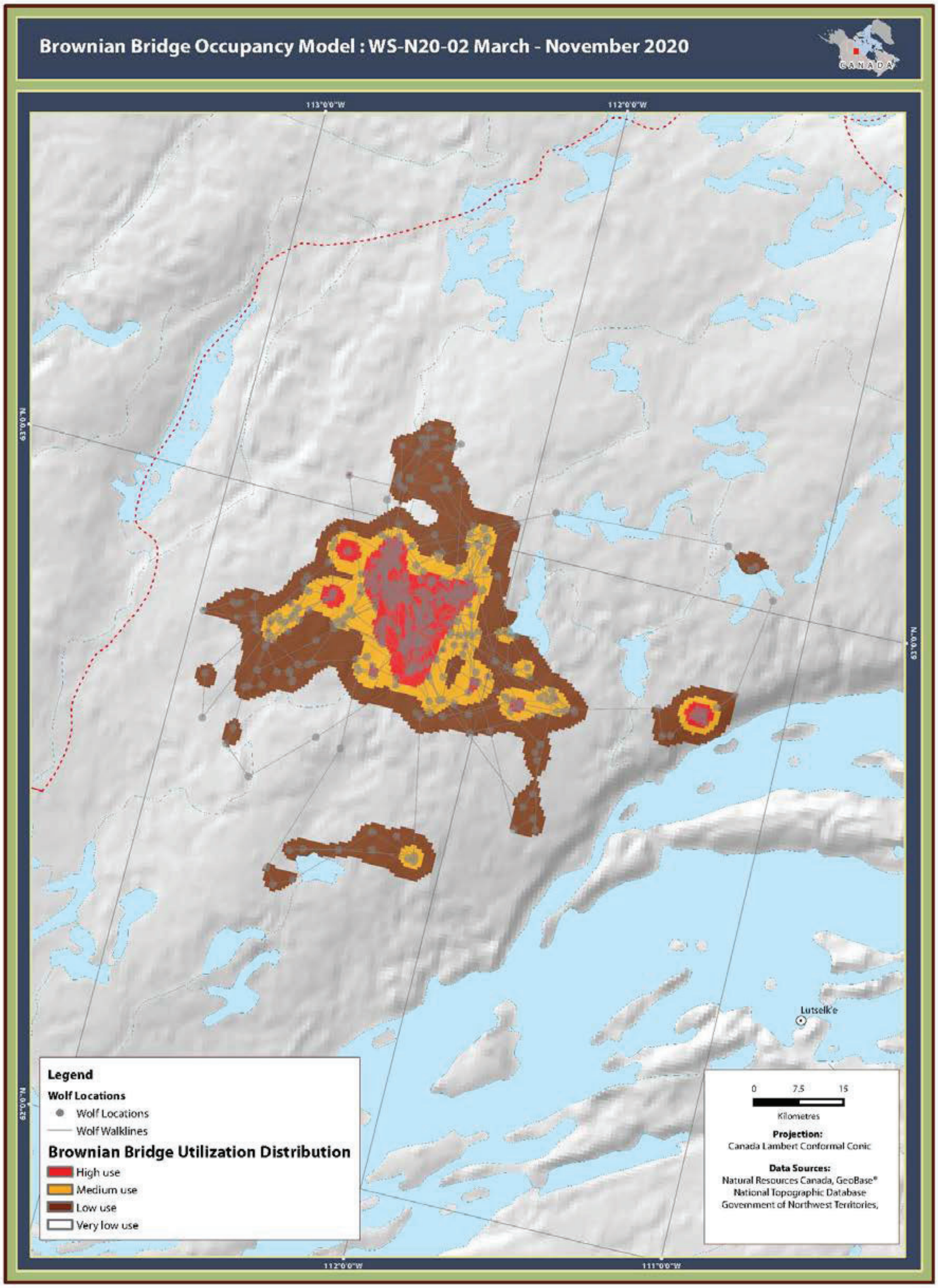

Figure 4. Brownian bridge utilization distribution for WF-NS20-02

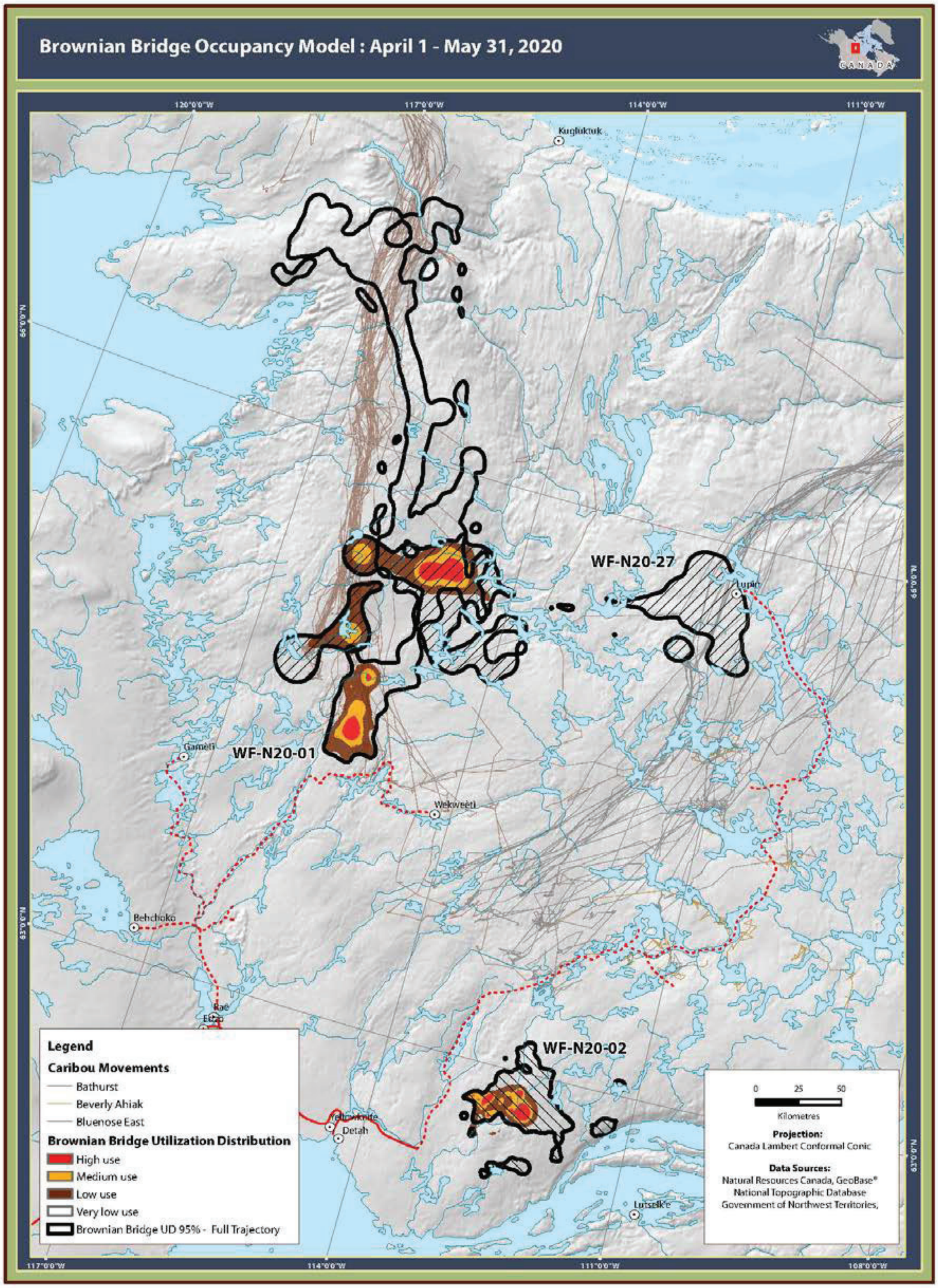

Figure 5. Brownian bridge utilization distribution for the spring period. Caribou movement for the same date range have been mapped to explore the location of the caribou relative the high use wolf areas.

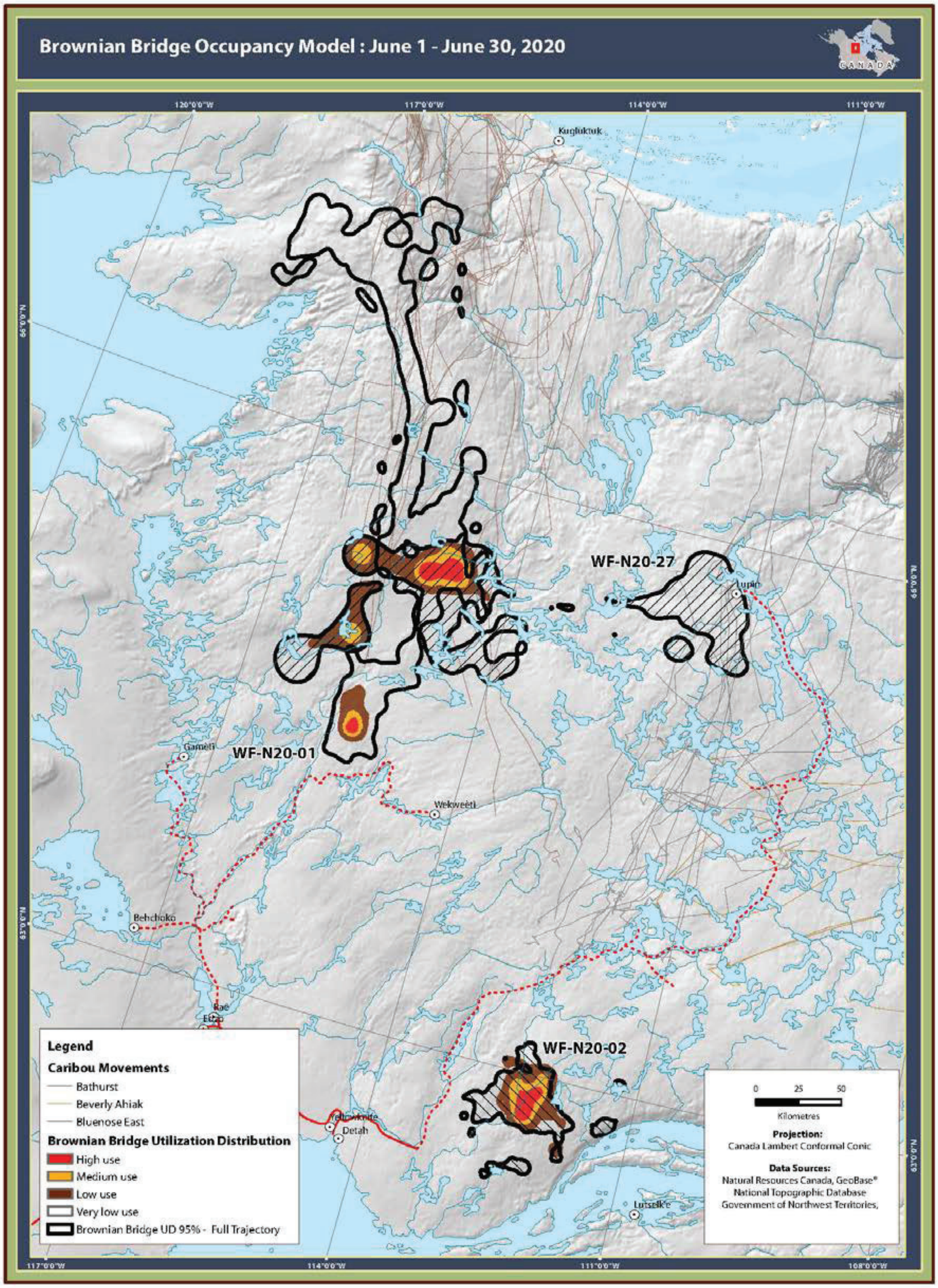

Figure 6. Brownian bridge utilization distribution for the calving period. Caribou movement for the same date range have been mapped to explore the location of the caribou relative the high use wolf areas.

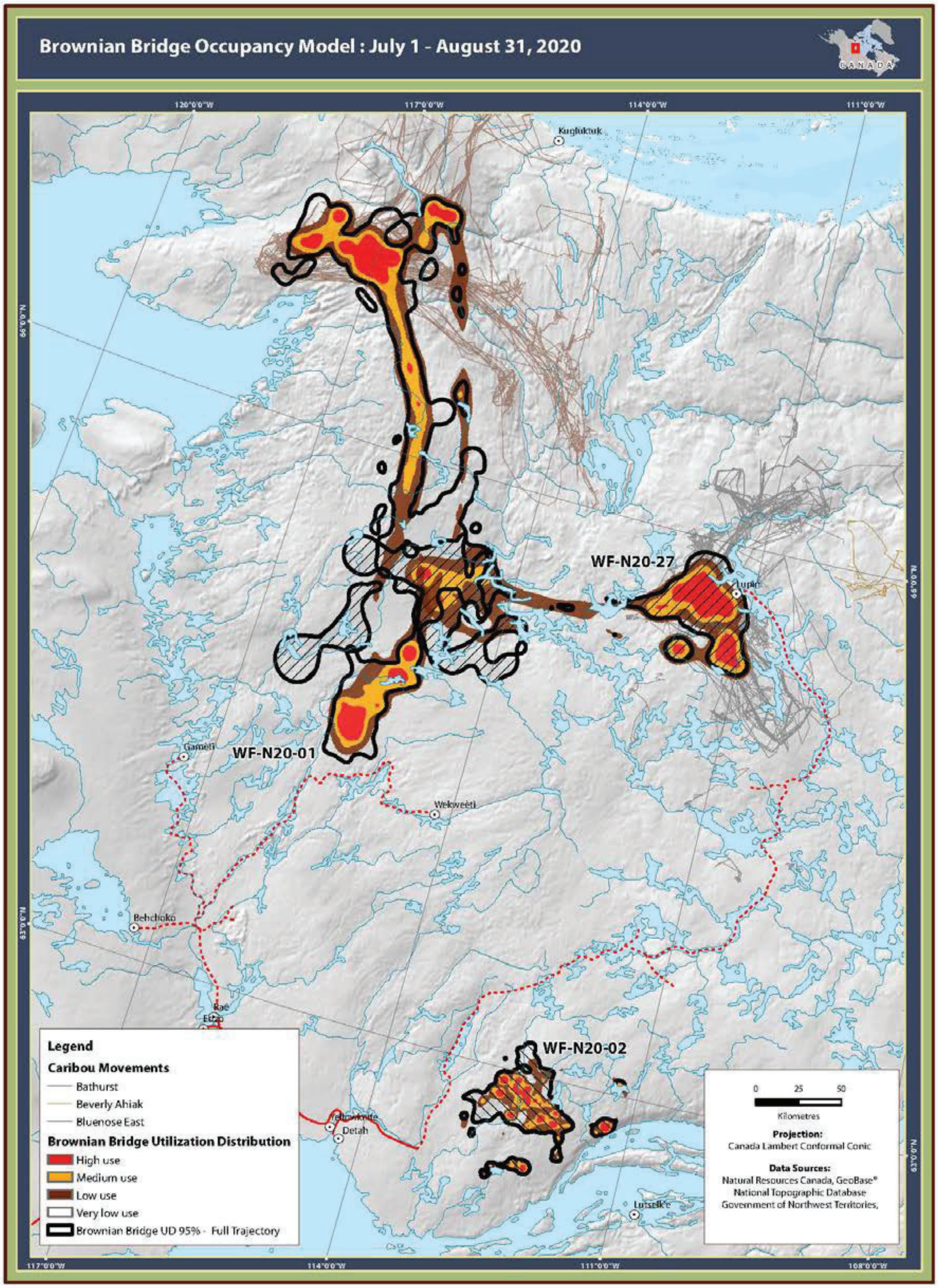

Figure 7. Brownian bridge utilization distribution for the summer period. Caribou movement for the same date range have been mapped to explore the location of the caribou relative the high use wolf areas.

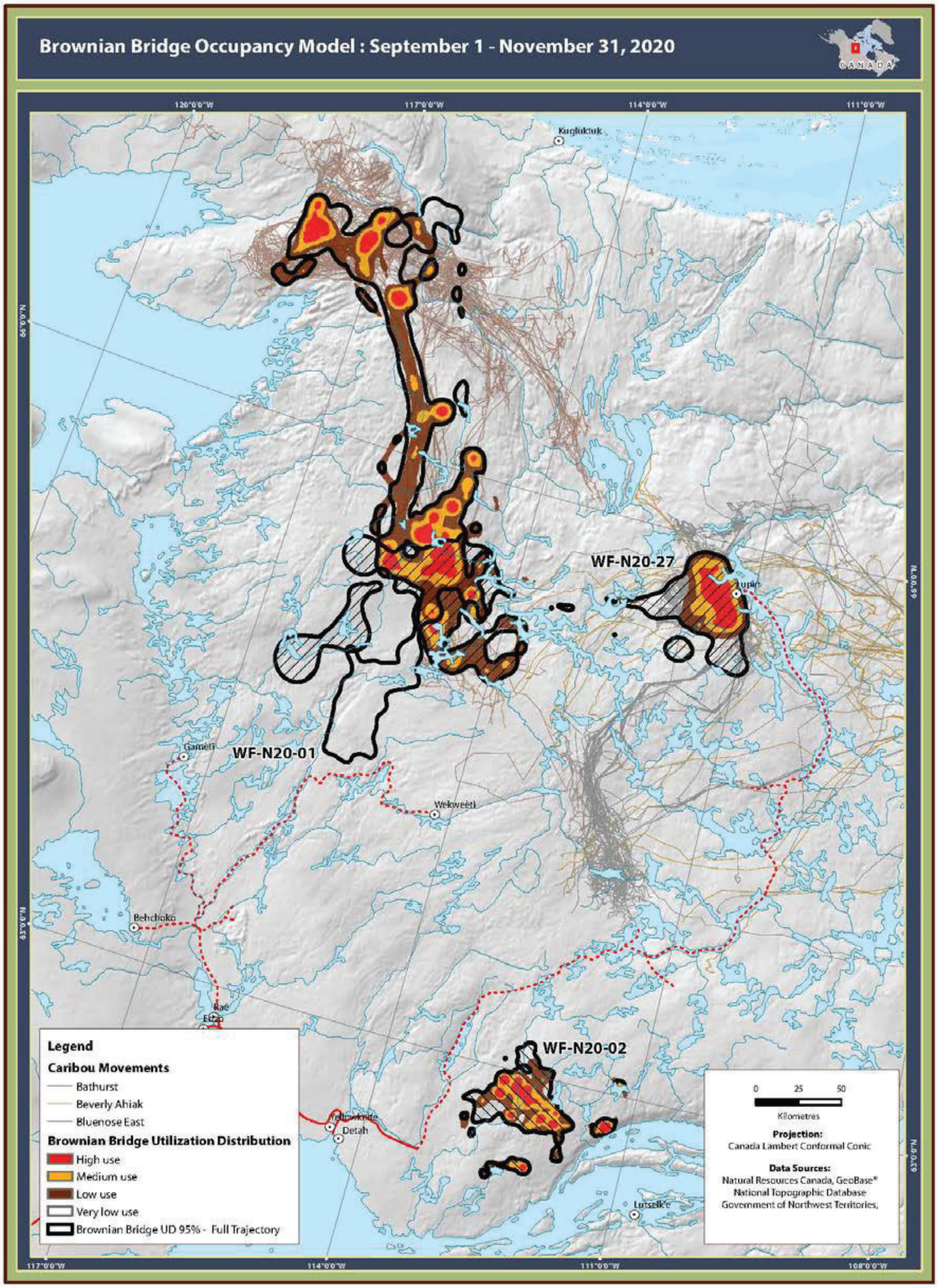

Figure 8. Brownian bridge utilization distribution for the fall period. Caribou movement for the same date range have been mapped to explore the location of the caribou relative the high use wolf areas.

Developing occupancy models at the seasonal level represents a spatially explicit method for quantifying wolf occupancy that is easily compared to caribou movement patterns and distributions. If the wolf data subsets were informed using wolf movement NSD profiles, this method could potentially be used to identify high use areas associated with denning or for assigning wolves to specific caribou herds for management purposes. However, this approach is limited by the quality of data collected by each collar and the size of the data subsets used. Data subsets must be large enough to be biologically relevant and the quality of data (i.e., presence of missing fixes) must be sufficiently high to ensure that the motion variance parameter estimated from the data is representative of actual movement patterns.

5.3 Grid Cell Counts

The grid cell approach provided a regional scale characterization highlighting wolf-caribou interactions at the herd level rather than at the individual level. Areas of concurrent use by wolf and caribou were present in each month of the analysis. For the winter months (March, April, November), areas of potential wolf-caribou interactions were primarily located in areas of overlap between caribou herds. For example, in November, wolf-caribou shared use areas were concentrated in the region north-east of Wekweètì where the three barren-ground caribou herds were mixing on winter ranges (Figure 9). In contrast, during the summer months, potential wolf-caribou interactions appeared to be tied to individual herd distributions rather than areas of herd overlap. For example, in July, one set of wolf-caribou shared use areas were located within the Bluenose East summer distribution and another within the Bathurst summer distribution (Figure 10). A complete set of grid cell count maps are available in Appendix D.

The regional grid cell count approach is a useful analysis tool as its data requirements are far more flexible than those of the BBOM. Using data collected at a daily intervals the grid cell counts can be used to quickly identify data gaps, visualize changes in distribution through time, and summarize large amounts of data efficiently. For example, when the monthly grid cell counts are reviewed as a time series, no shared wolf-caribou use is recorded for the Beverly Ahiak herd. This probably indicates a gap in the wolf telemetry data given the relationship observed between collared wolves and the Bluenose East and Bathurst herds. Identifying data gaps in the wolf collaring data spatially could be used to inform future collaring programs and deployments.

As the grid cell count approach uses a consistent grid for analysis, occupancy models can be easily developed for any new data collected and integrated into the existing analysis. Since the analysis results are easily updatable this approach lends itself to modelling potential wolf-caribou interactions over a longer period. Exploring space-time variation in these interactions could be used to support management planning, determine the effectiveness of any management actions, and characterize any long-term trends for the population dynamics between the species.

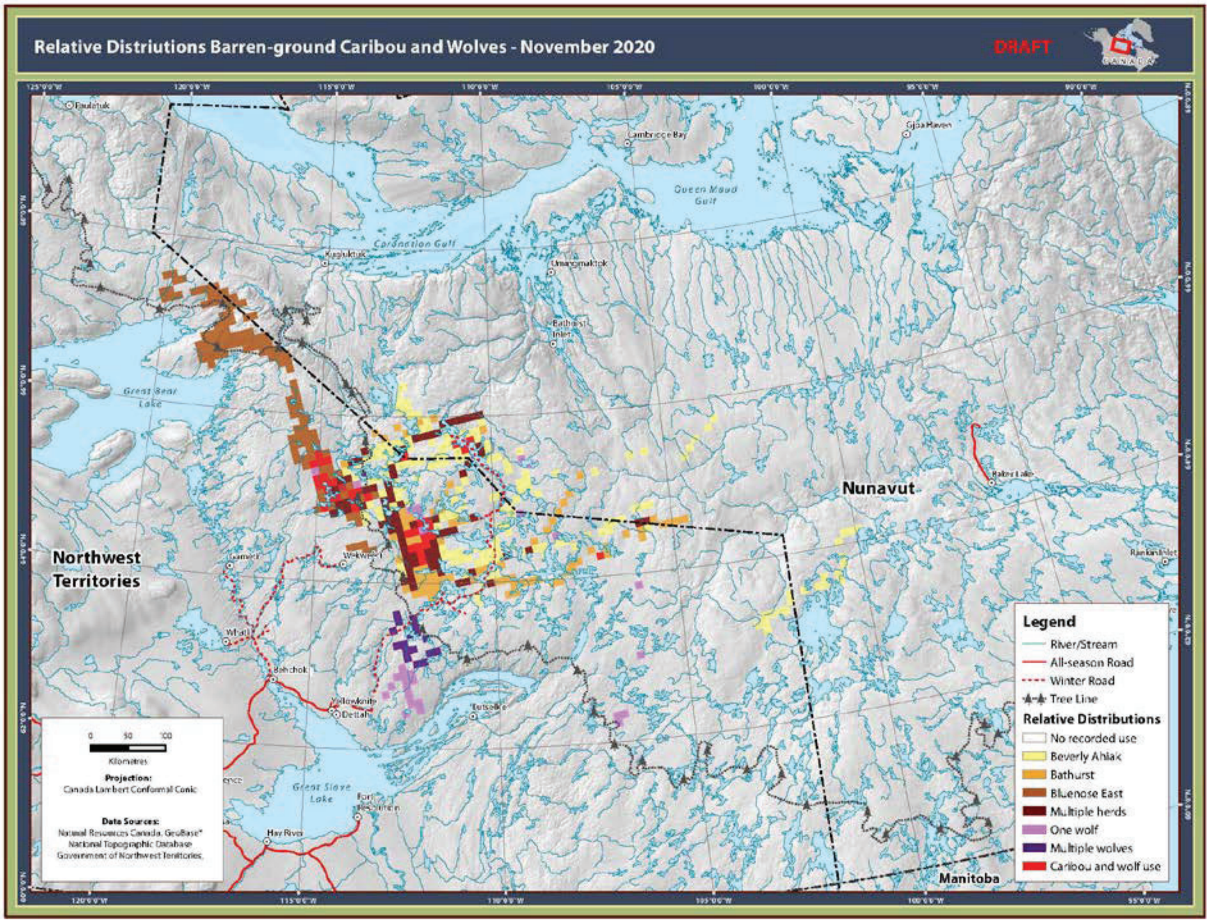

Figure 9. Grid cell count results for November showing concurrent wolf-caribou use in areas of caribou range overlap.

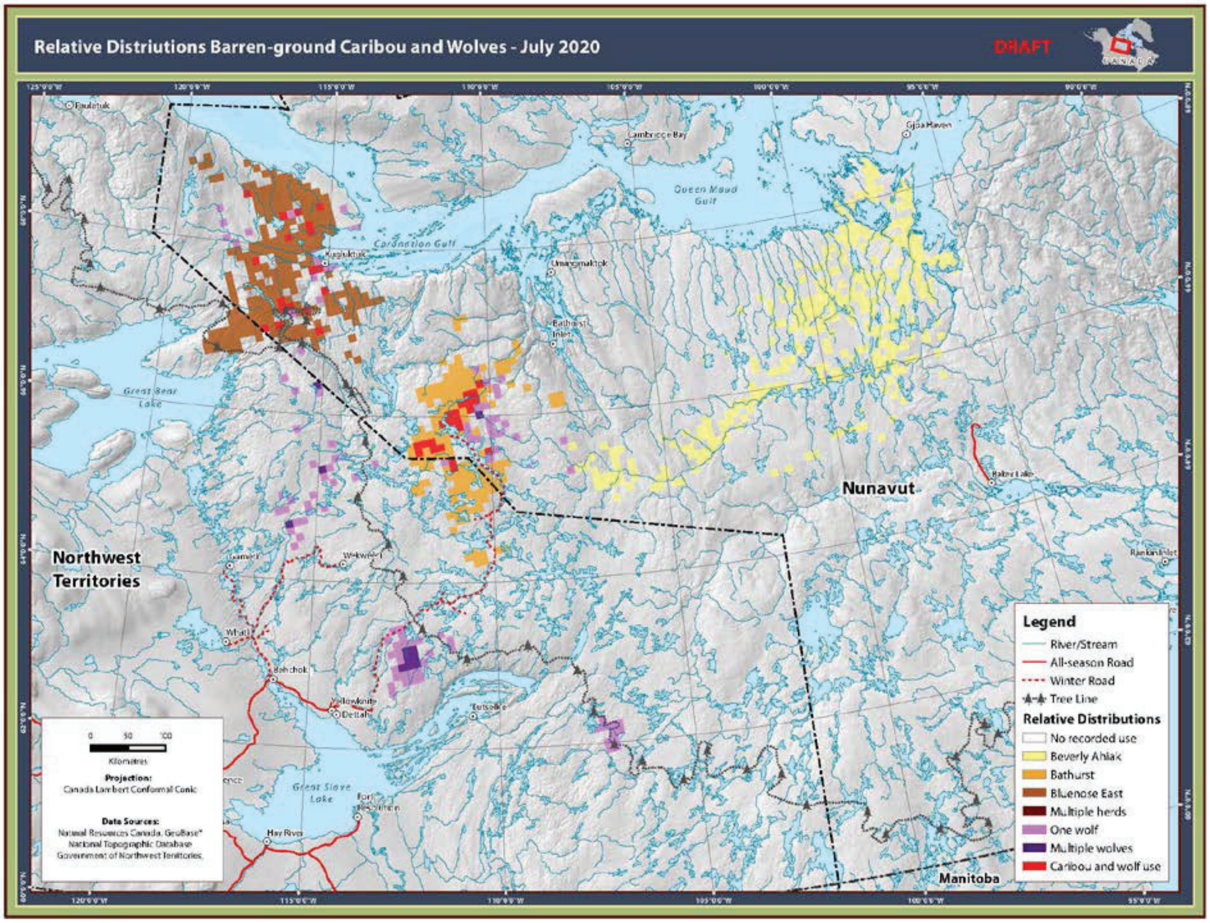

Figure 10. Grid cell count results for July showing concurrent wolf-caribou use tied to individual herds.

6.0 RECOMMENDATIONS

Based on the results of these exploratory analyses, we have the following recommendations.

6.1 Future Analyses

Incorporating the wolf telemetry data for November 2020 to March 2021 into the existing analysis would provide a complete annual characterization of wolf movement and space-use patterns. Incorporating these months would be particularly interesting for the occupancy models as the gird cell analysis highlighted areas of concurrent wolf and caribou use in November primarily in regions where there was intermixing between herds. As the three barren-ground caribou herds have overlapping winter ranges, exploring patterns of potential wolf-caribou interactions would be critical during these months. Expanding the BBOM analysis to include new data would add further detail, as finer scale space-use patterns by wolves in the areas of winter range overlap could be quantified and potentially used to inform management program planning for the following year. For example, a the BBOM generated for December 2020 – April 2021 (i.e., the barren-ground caribou winter season) would provide a characterization of both wolf movement and space use patterns during a season when we would expect caribou movement to be relatively low. It would be interesting to determine if wolf movement was correspondingly low with BBOM UDs appearing as large contiguous areas of high use, or if wolf movement was more varied with wolves alternating between travelling and area restricted movements.

With seven collars still active on the landscape, there will be the opportunity to look at spatial-temporal patterns of wolf movement and space-use between 2020 and 2021. Examining inter-annual variation in wolf movement patterns will provide information on the degree of fidelity these wolves display in their space-use patterns and caribou herds. For example, WF-NS20-01 appeared to follow a north-south movement pattern that was related to the movement of the Bluenose East caribou; while WF-NS20-27 followed an east-west movement pattern that brought it into contact with both the Bluenose East and Bathurst herds. As both these wolves are active in roughly the same region, will they adopt similar strategies in 2021 or will there be a shift in movement patterns and space-use?

6.2 Data Structure

The two occupancy modelling approaches explored in this project represent methods with different data requirements. The BBOM is a data intensive method that requires sub-daily telemetry data with very few missing locations, while the grid cell count method is suited to coarser data resolutions. If the goal of future analyses is to look at finer scale movement patterns by wolves, then collecting data at sub-daily frequencies is required. In the BBOM analysis, there was not much difference in the models generated from the eight and twelve-hour datasets. However, as the time between locations increases so does the uncertainty built into the BBOM UDs. As a result, the UD surfaces are more generalized leading to a probability of use surface that may not be appropriate to inform management decisions at finer spatial scales. For example, identifying how wolf movement may vary relative to human related disturbance, identifying den sites, or delineation of travel corridors. However, collecting data at high frequencies will reduce collar life and impact the feasibility of quantifying variation in wolf movement patterns through time. These spatial-temporal analyses would inform long term dynamics between wolf and caribou and would be a valuable tool for developing population management strategies. If a fine scale examination of wolf space-use and movement patterns is required by the project, then collecting data at the eight-hour fix rate would be ideal. Collecting data at a 12-hour fix rate would represent an increase in uncertainty in fine scale patterns; however, may present a balance between increased data collection and collar life span.

The grid cell count approach has more flexible data requirements but can only be used to examine wolf-caribou space-use patterns at a regional scale. Collecting coarser data (i.e., daily data) likely make for a dataset that spanned multiple years and would be suited to quantifying fidelity in both annual seasonal wolf movement patterns. If the goal of the analyses is to help plan long term regional based management strategies, then collecting daily data may be sufficient for the task.

From a spatial data analysis perspective, ideal sample sizes are difficult to determine. To generate a balanced spatial characterization of wolf movement relative to the barren-ground caribou herds, wolf collars would have to be spread equally across the herds considered in the analysis. Currently, there exists a data gap for wolves active in the overlap areas between the Bathurst and Beverly Ahiak herds. Addressing this gap would provide more information about wolf movement patterns in these areas and whether wolf movement and space-use strategies differ between caribou herds. For modelling caribou ranges, we use a five collar threshold for determining if a range is representative of caribou space-use (Gunn *et al.* 2011); however, we could not find a similar precedent for barren-ground wolves. A brief literature review revealed that sample sizes from between four to thirty collars have been used to ask questions pertaining to wolf caribou dynamics in the past (Hayes and Russel 1998; James 1999; Walton *et al.* 2001; Courbin *et al.* 2009; Latham et al. 2011; Hansen 2013). If the goal of the project is to quantify wolf movement patterns relative to specific herds, then a minimum number of collars (e.g., five) associated with each herd could be used to ensure that a balanced picture of wolf-caribou dynamics is being captured. From a spatial perspective, a balanced spatial distribution of wolf collars five-7 collars per herd may be more important to the analysis than a large number of collars deployed for just one herd.

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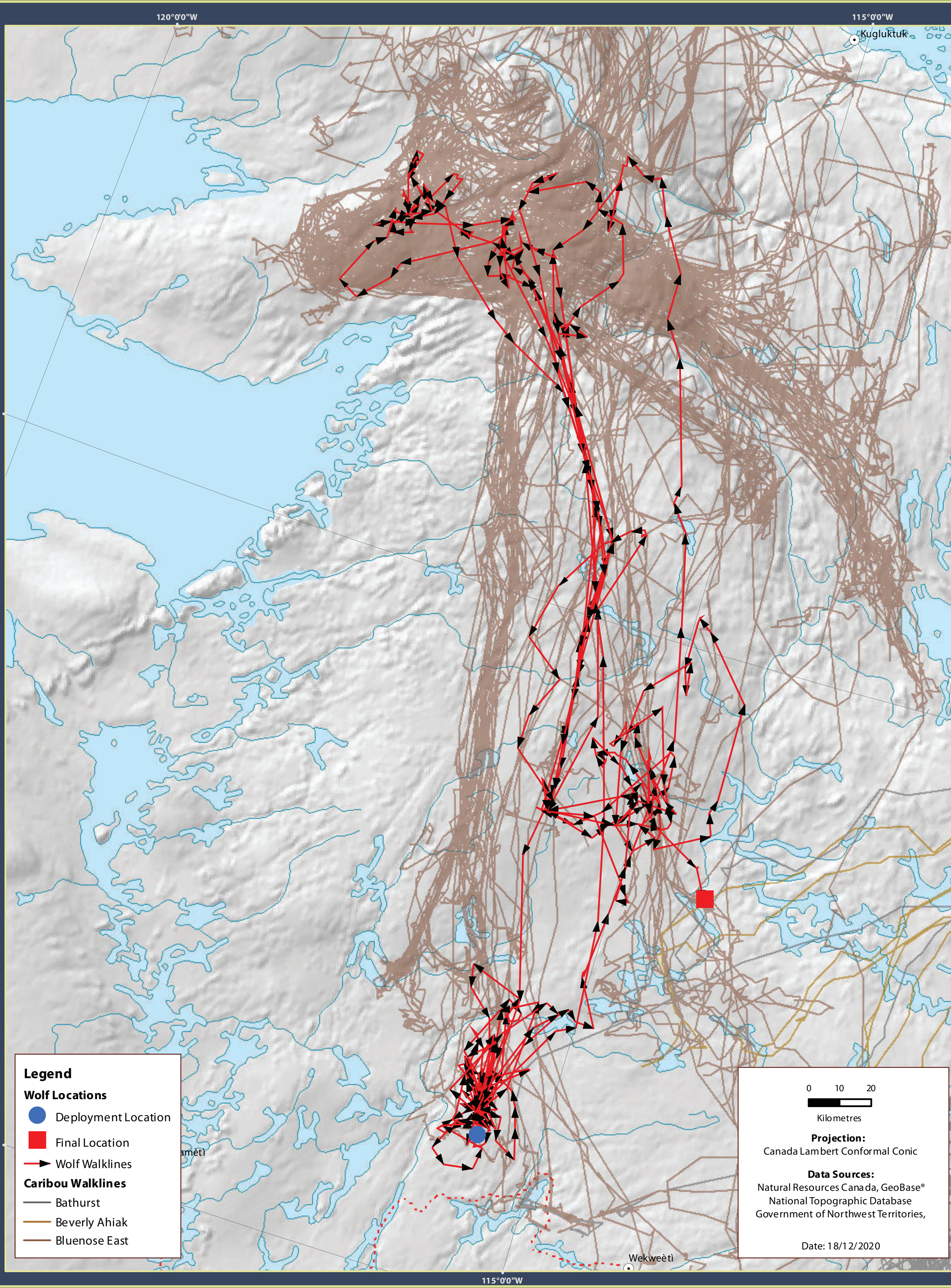
GNWT 2020 Wolf Colloring Program: WF-NS20-01



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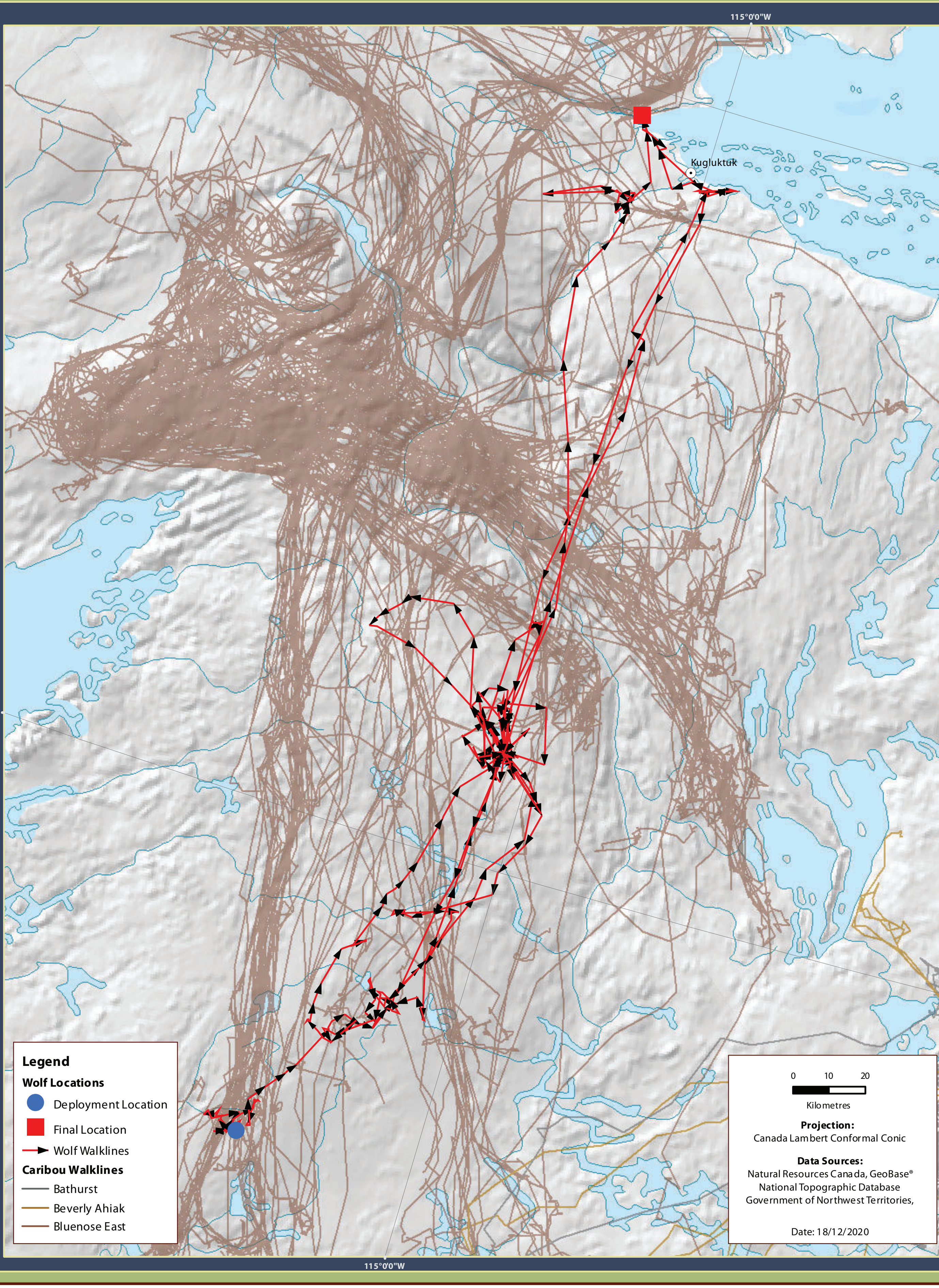

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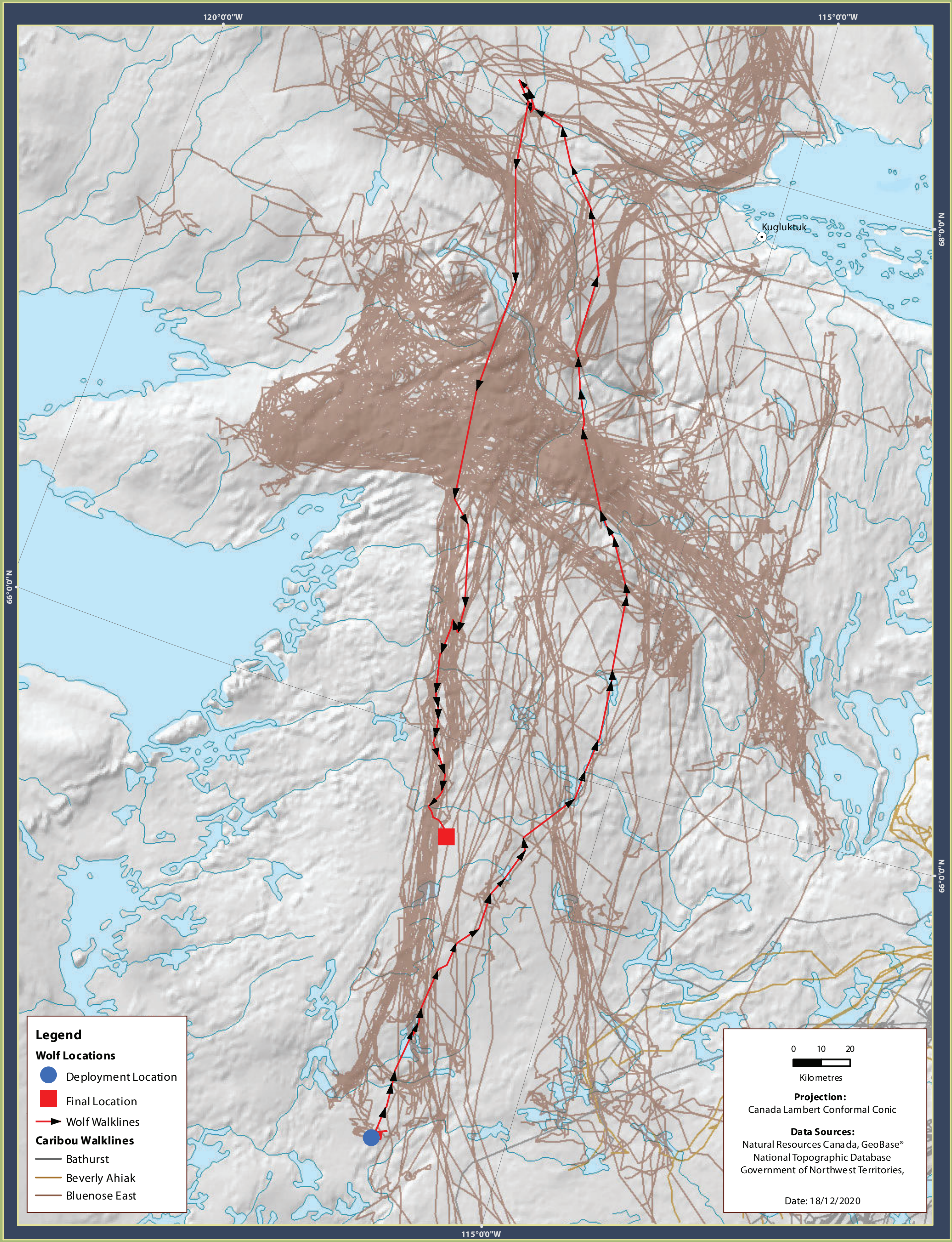
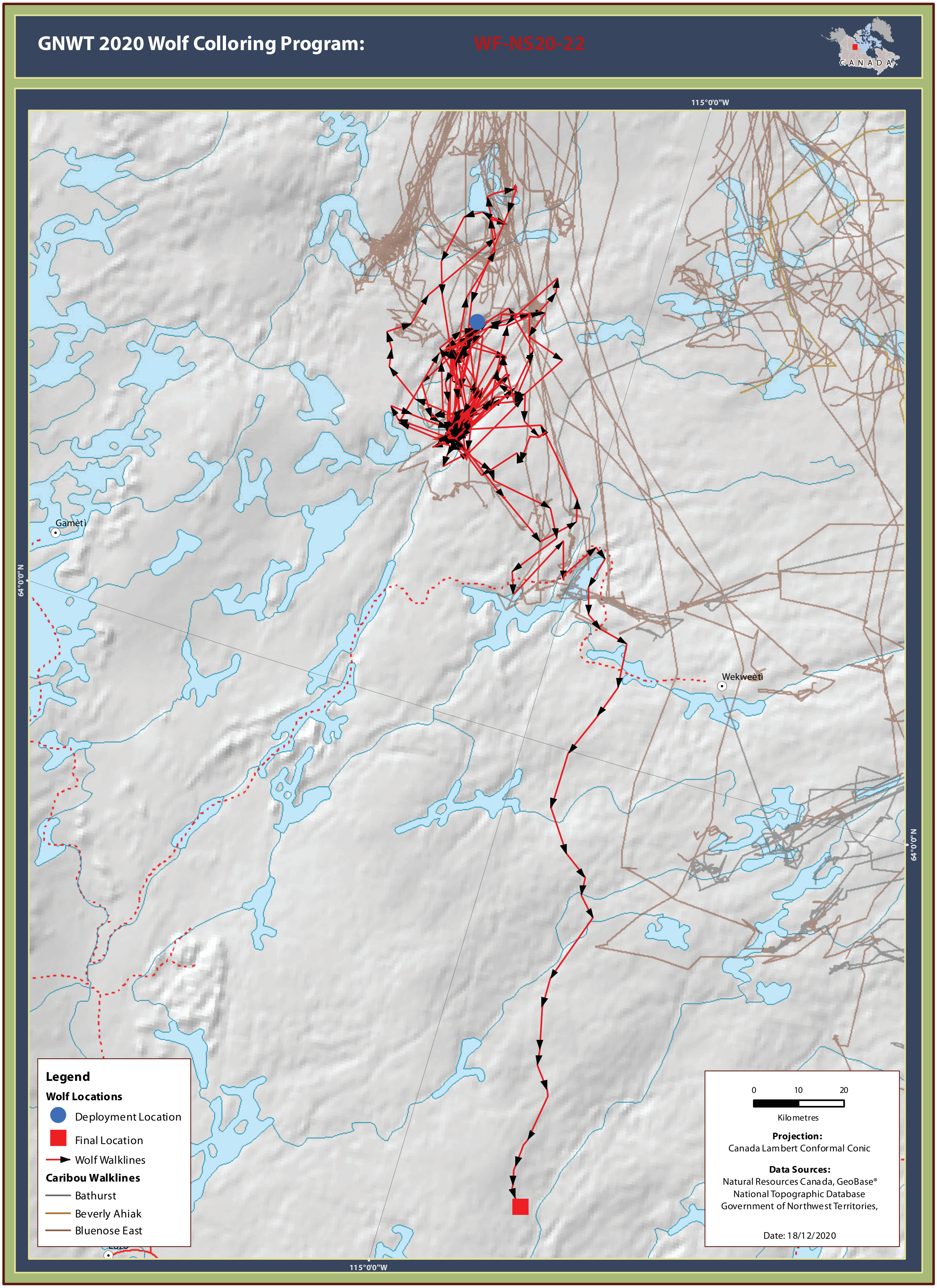
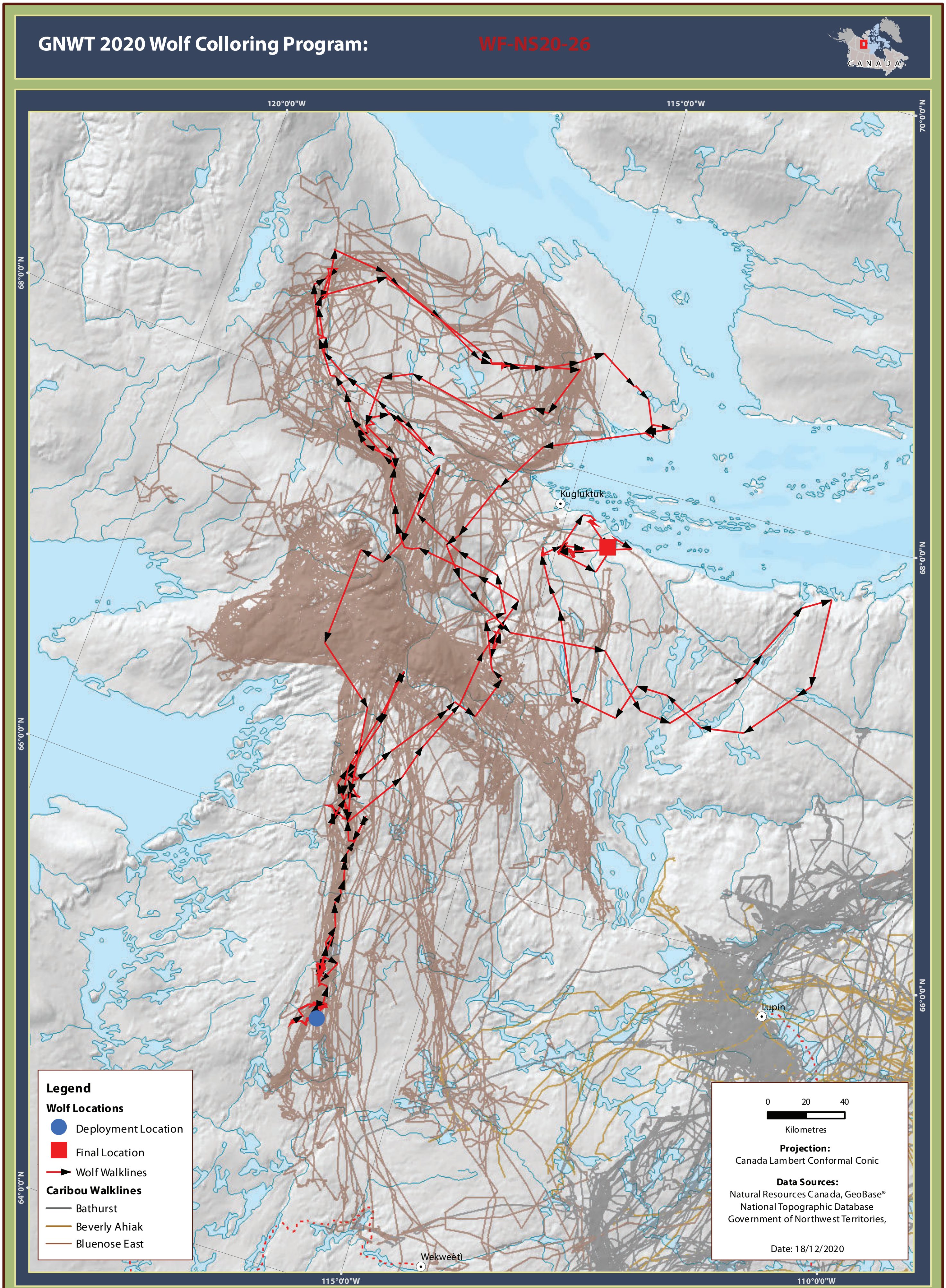


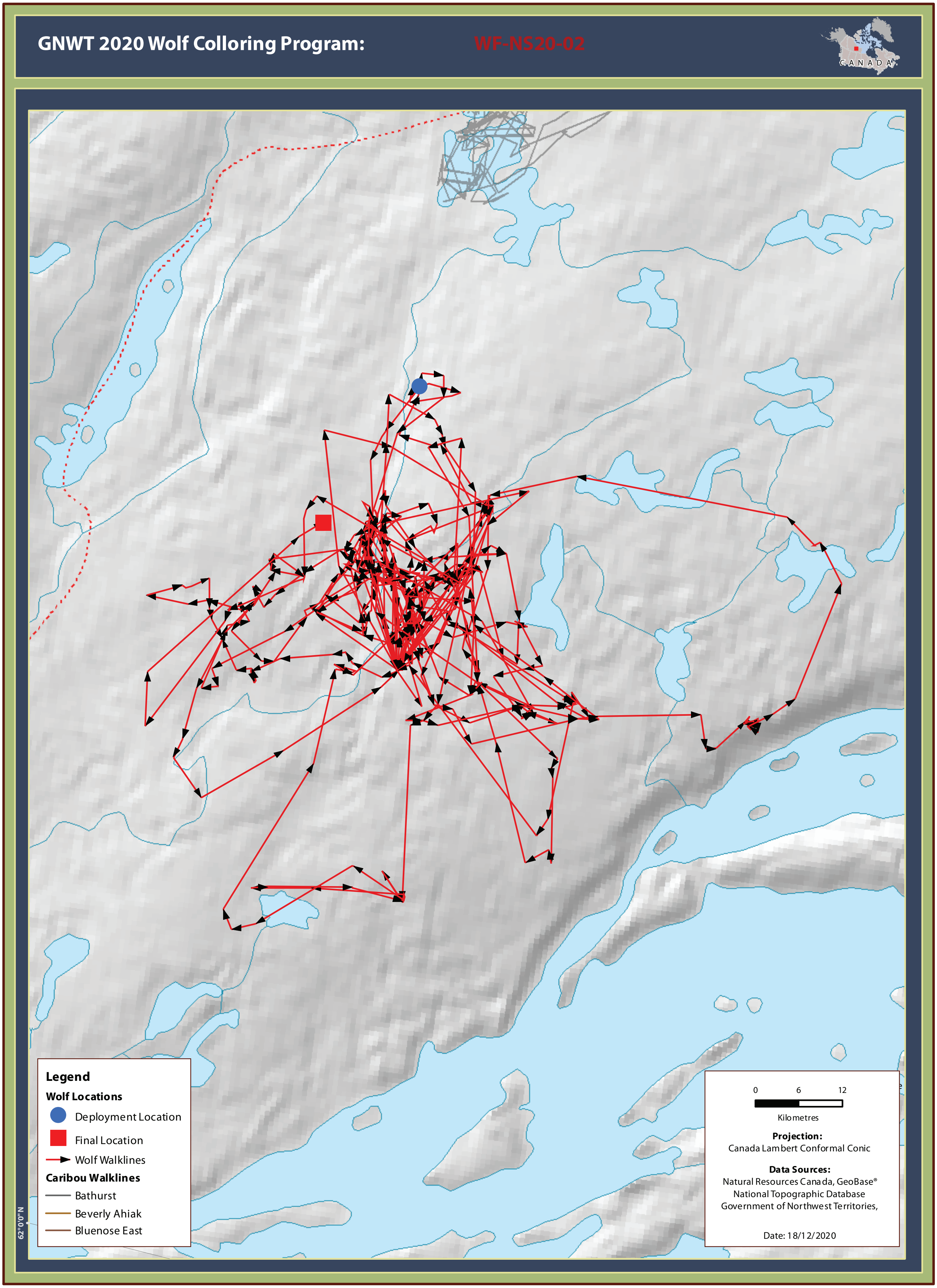
GNWT 2020 Wolf Colloring Program: WF-NS20-22



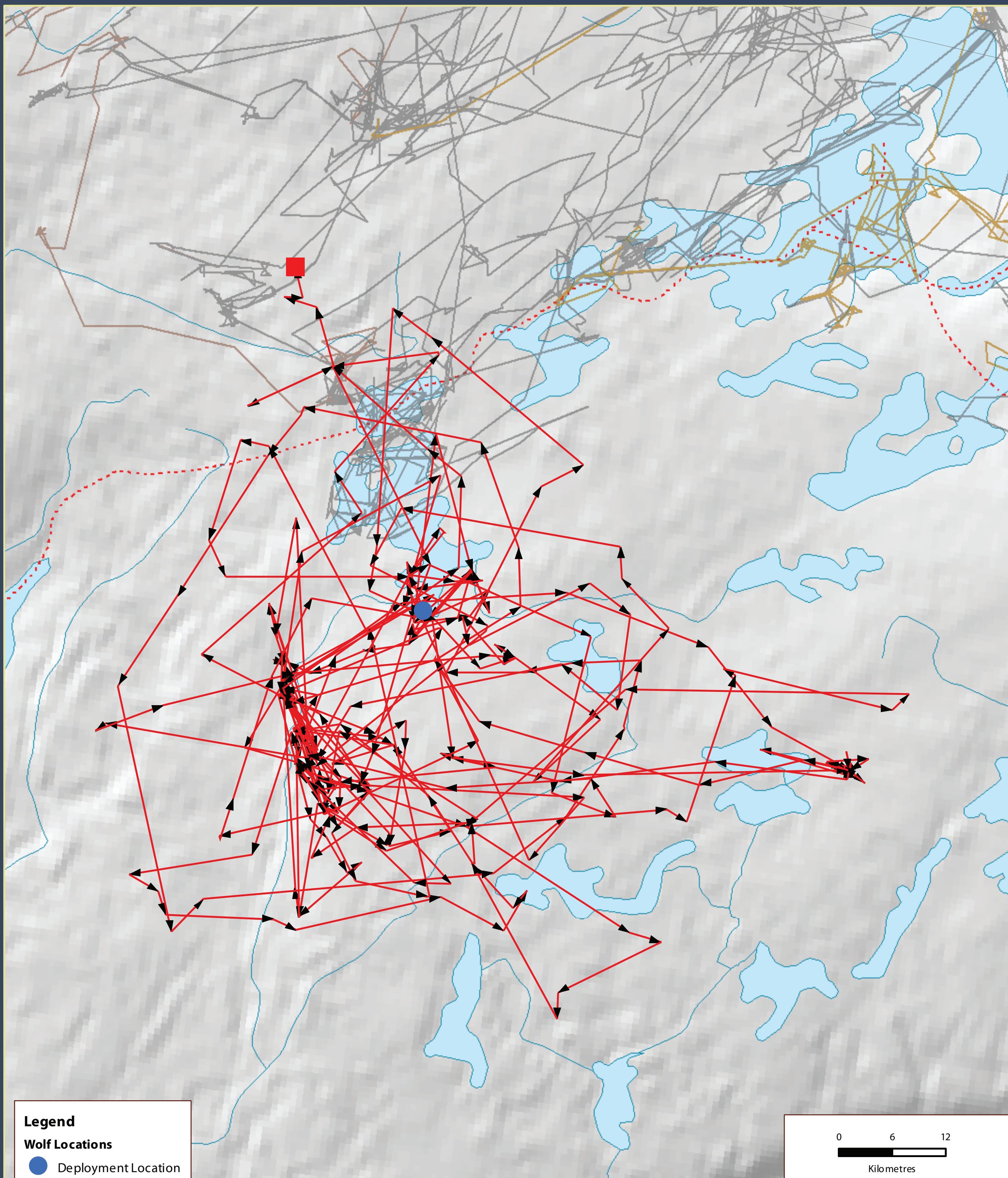
GNWT 2020 Wolf Colloring Program: WF-NS20-26



GNWT 2020 Wolf Colloring Program: WF-NS20-02



GNWT 2020 Wolf Colloring Program: WF-NS20-23



Legend

Wolf Locations

- Deployment Location
- Final Location
- Wolf Walklines

Caribou Walklines

- Bathurst
- Beverly Ahiak
- Bluenose East

0 6 12

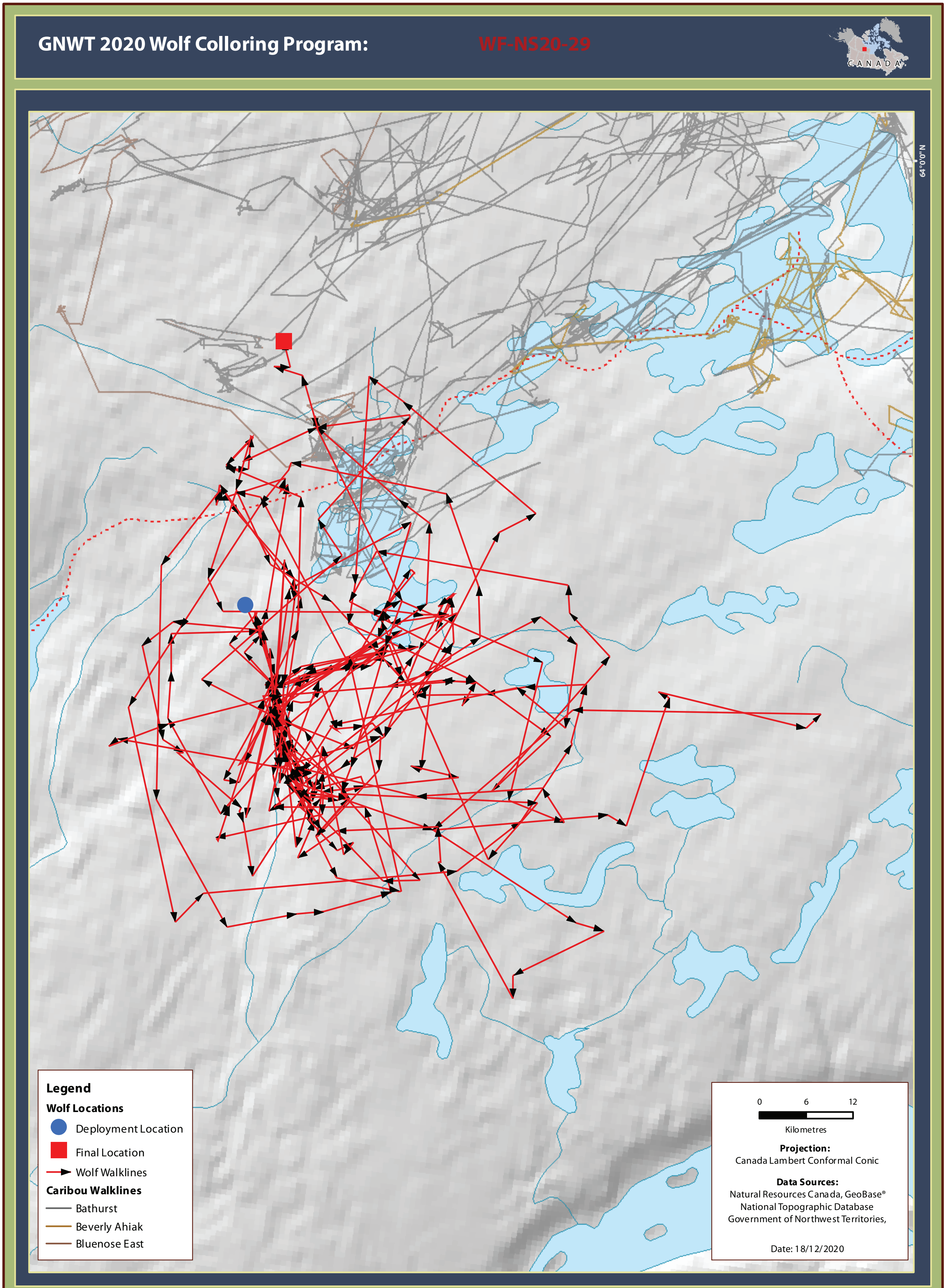
Kilometres

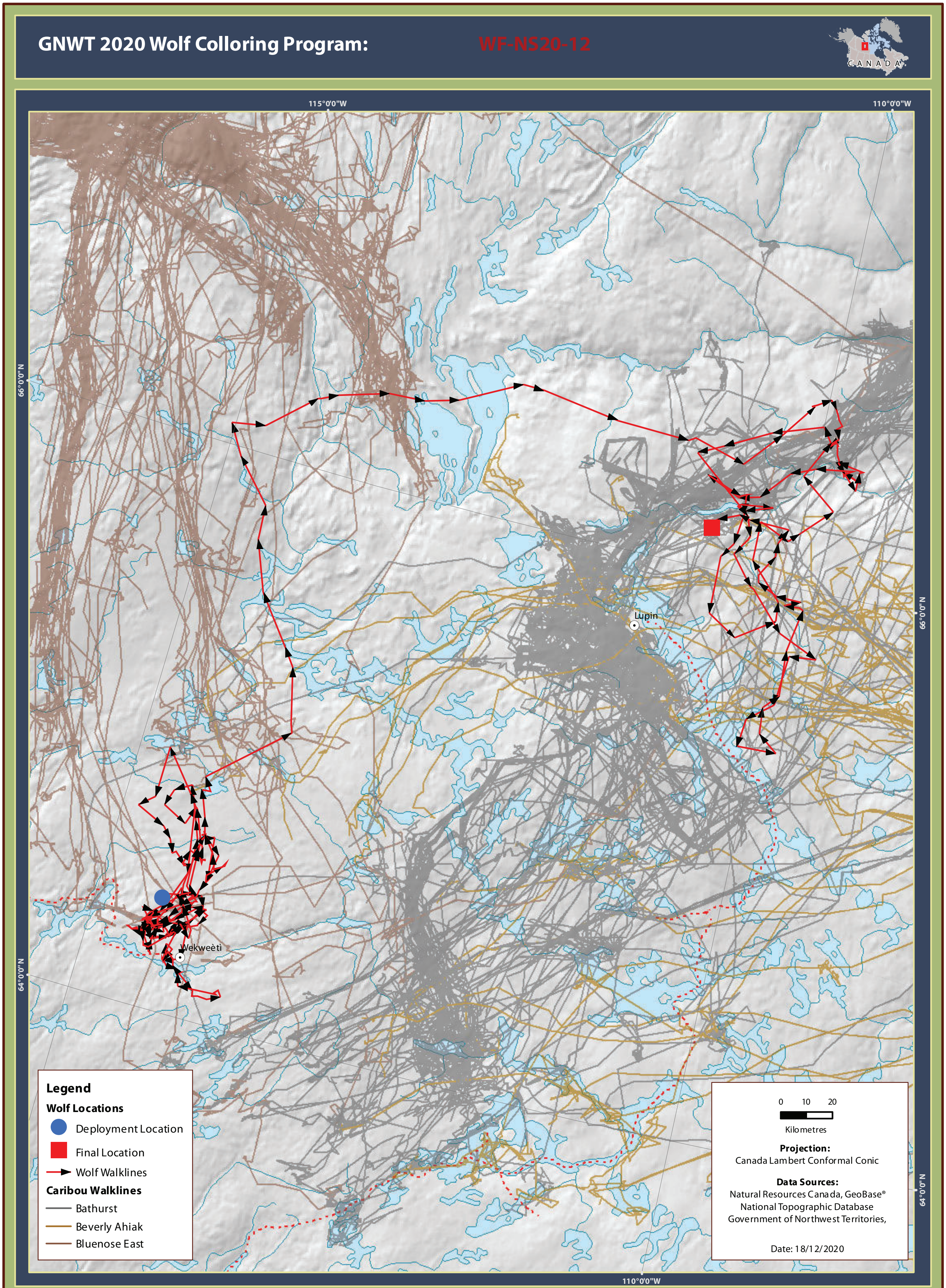
Projection:
Canada Lambert Conformal Conic

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Government of Northwest Territories,

Date: 18/12/2020

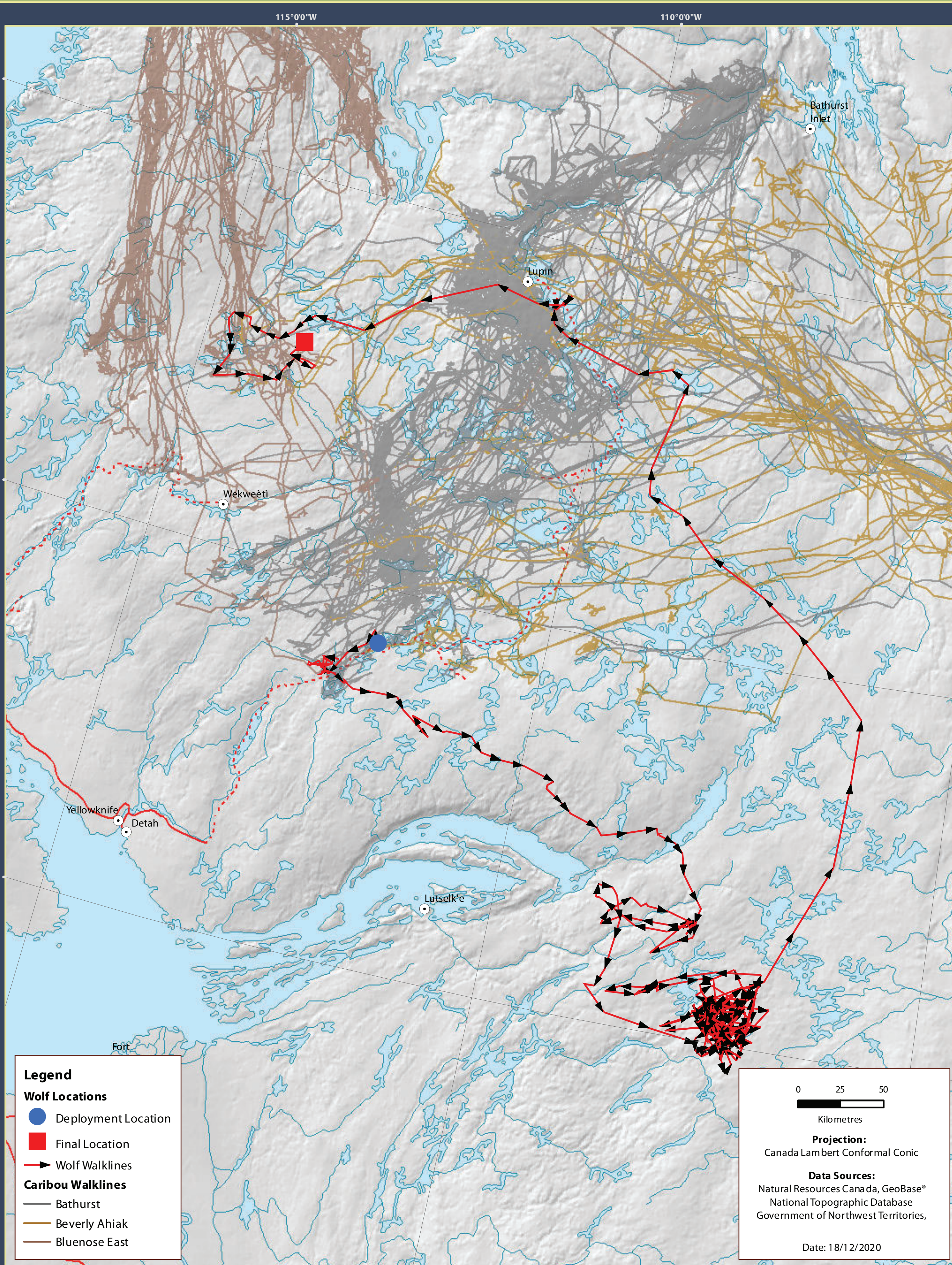
GNWT 2020 Wolf Colloring Program: WF-NS20-29



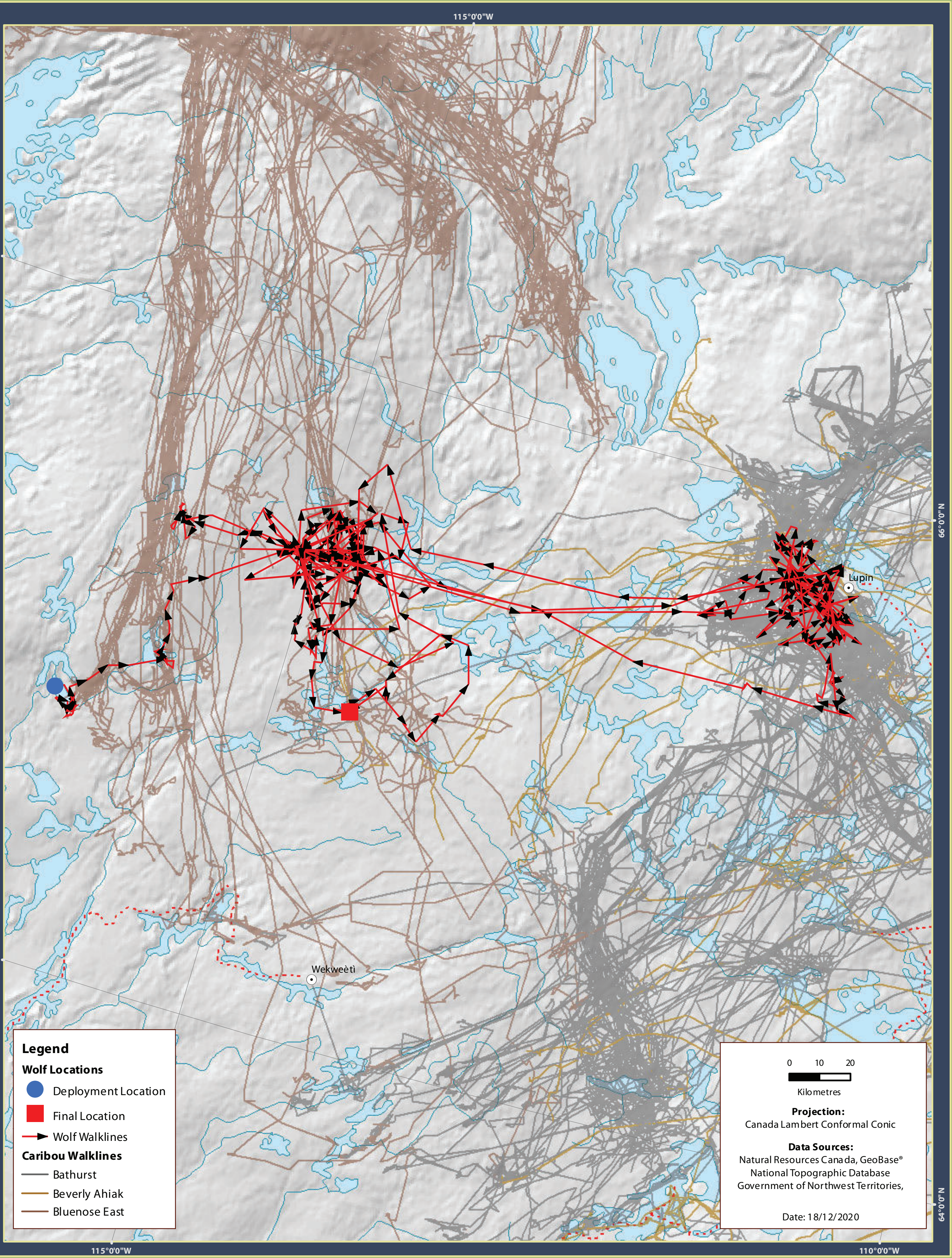


GNWT 2020 Wolf Colloring Program:
WF-NS20-12
CANADA
115°0'0"W
110°0'0"W
66°0'0"N
64°0'0"N
Lupin
Wekweètì
Legend
Wolf Locations
Deployment Location
Final Location
Wolf Walklines
Caribou Walklines
Bathurst
Beverly Ahiak
Bluenose East
0 10 20
Kilometres
Projection:
Canada Lambert Conformal Conic
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Government of Northwest Territories,
Date: 18/12/2020

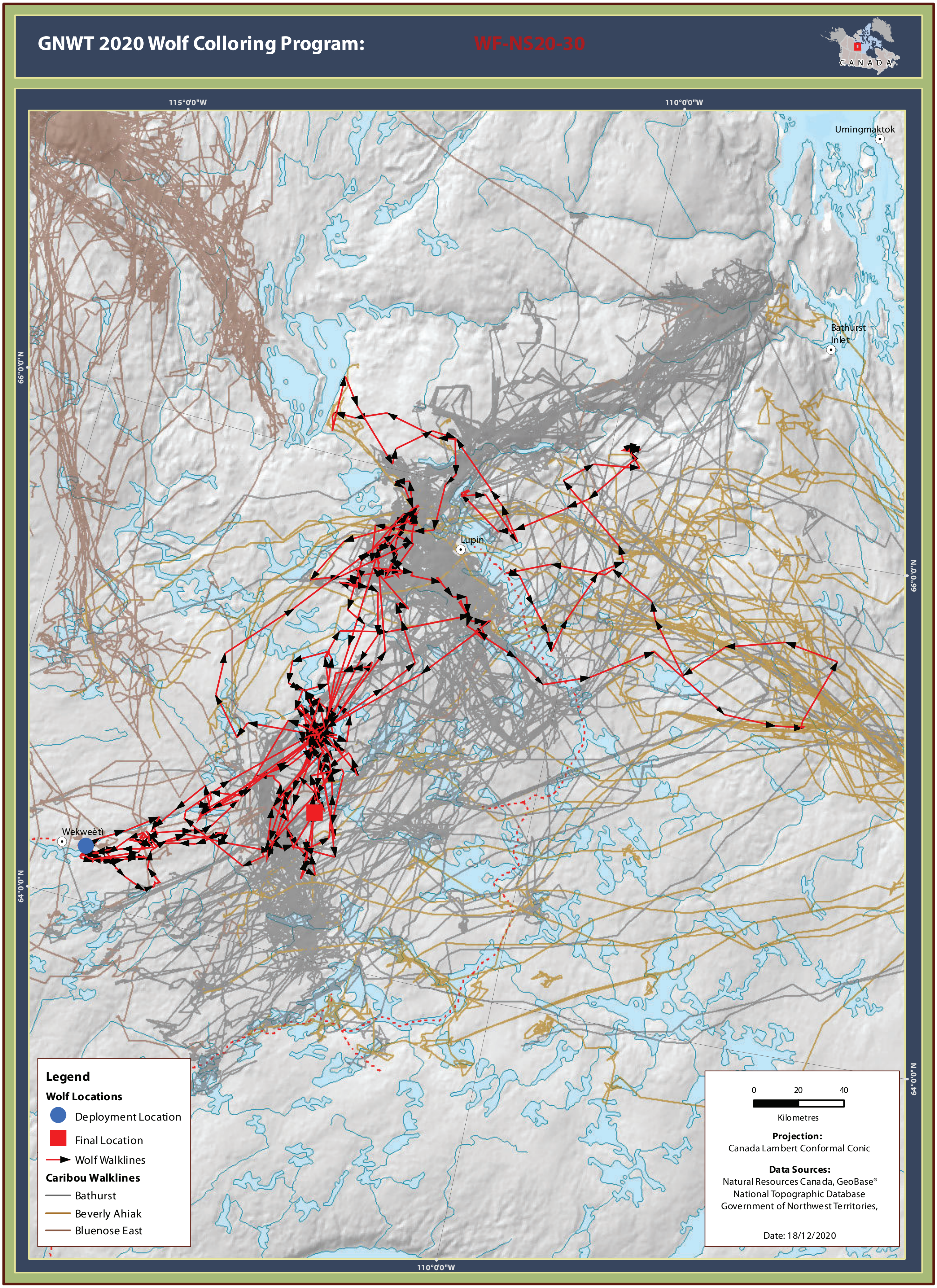
GNWT 2020 Wolf Colloring Program: WF-NS20-21

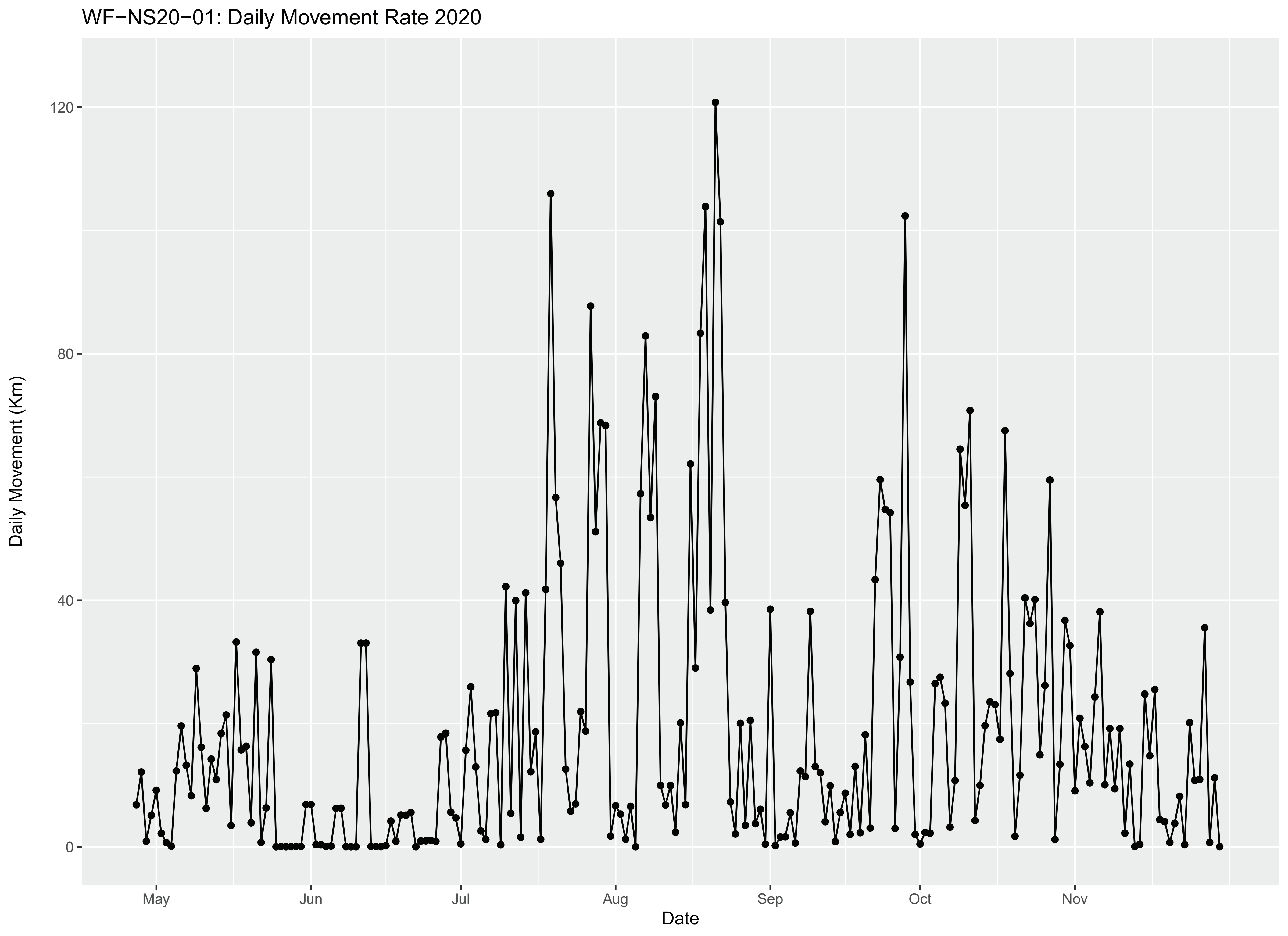


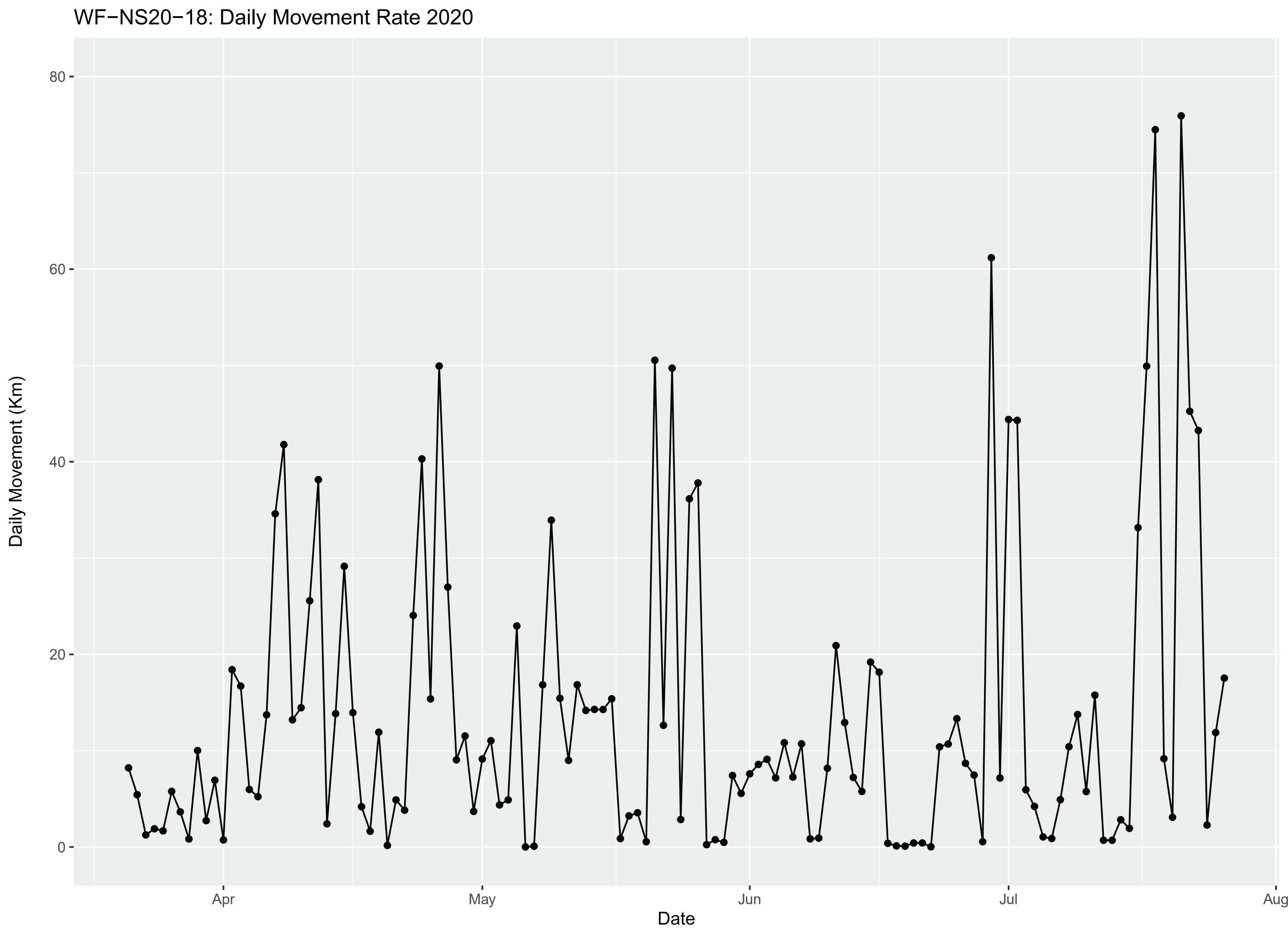
GNWT 2020 Wolf Colloring Program: WF-NS20-27



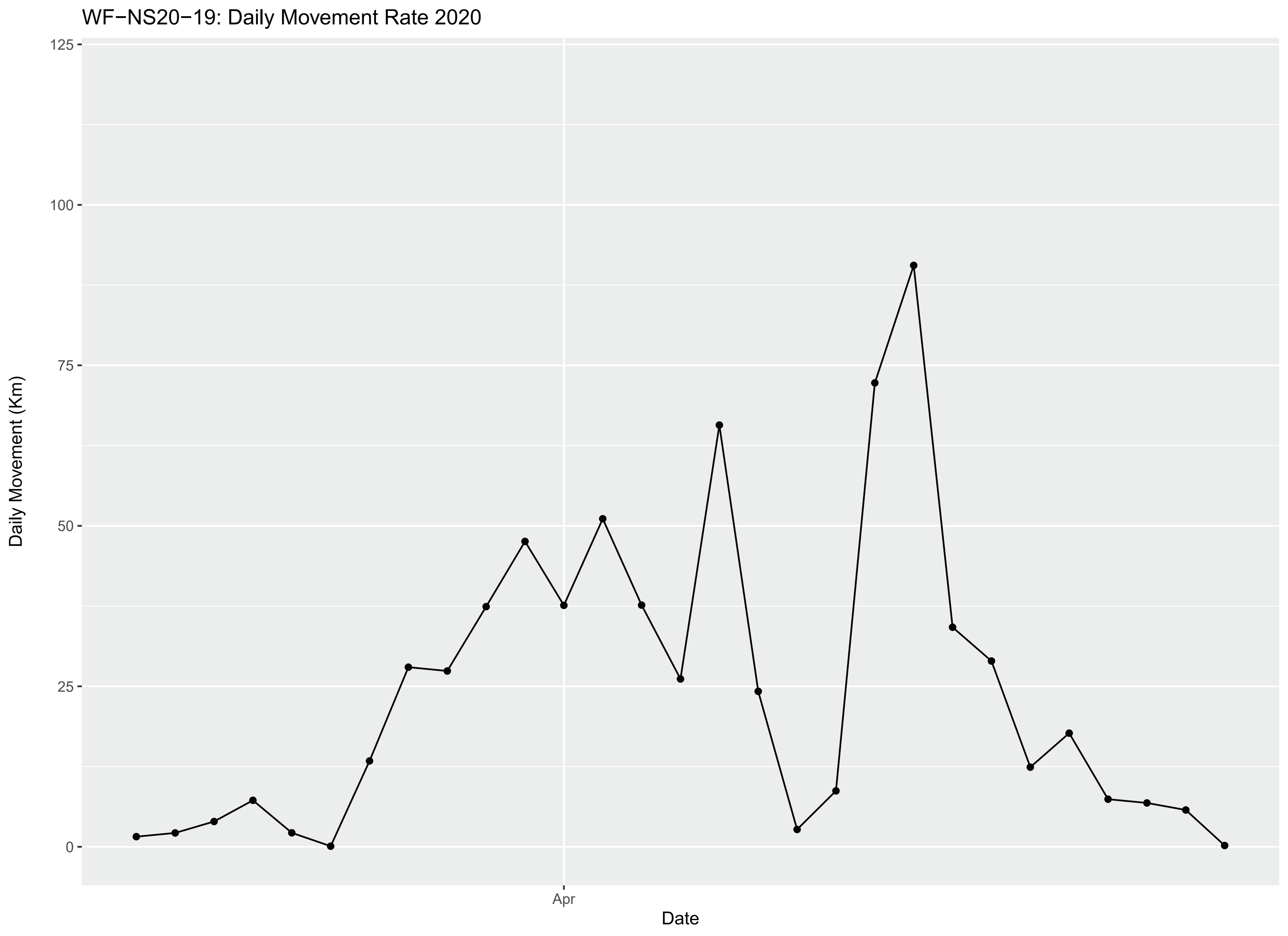
GNWT 2020 Wolf Colloring Program: WF-NS20-30



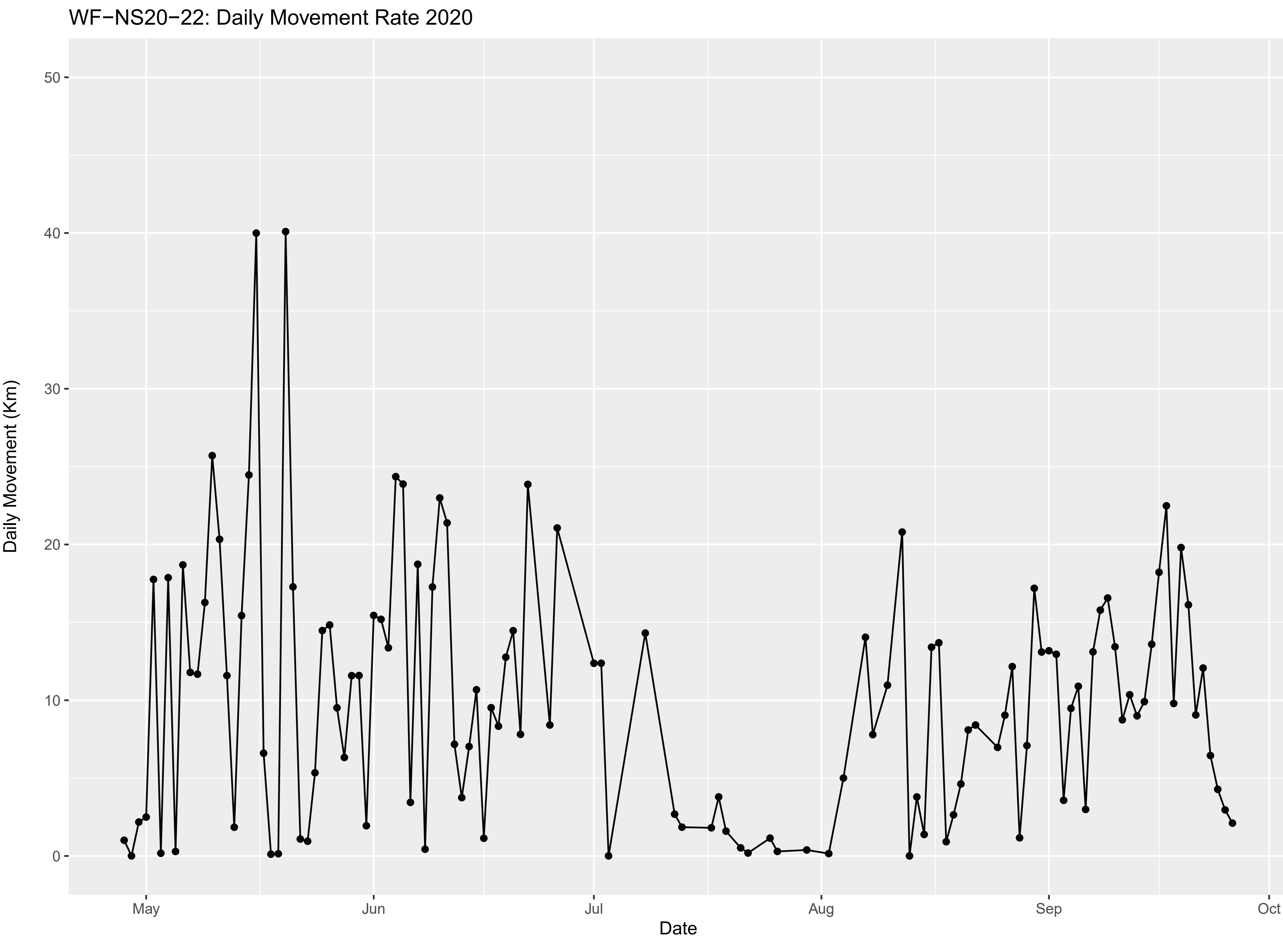

WF−NS20−01: Daily Movement Rate 2020
Daily Movement (Km)
120
80
40
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Date



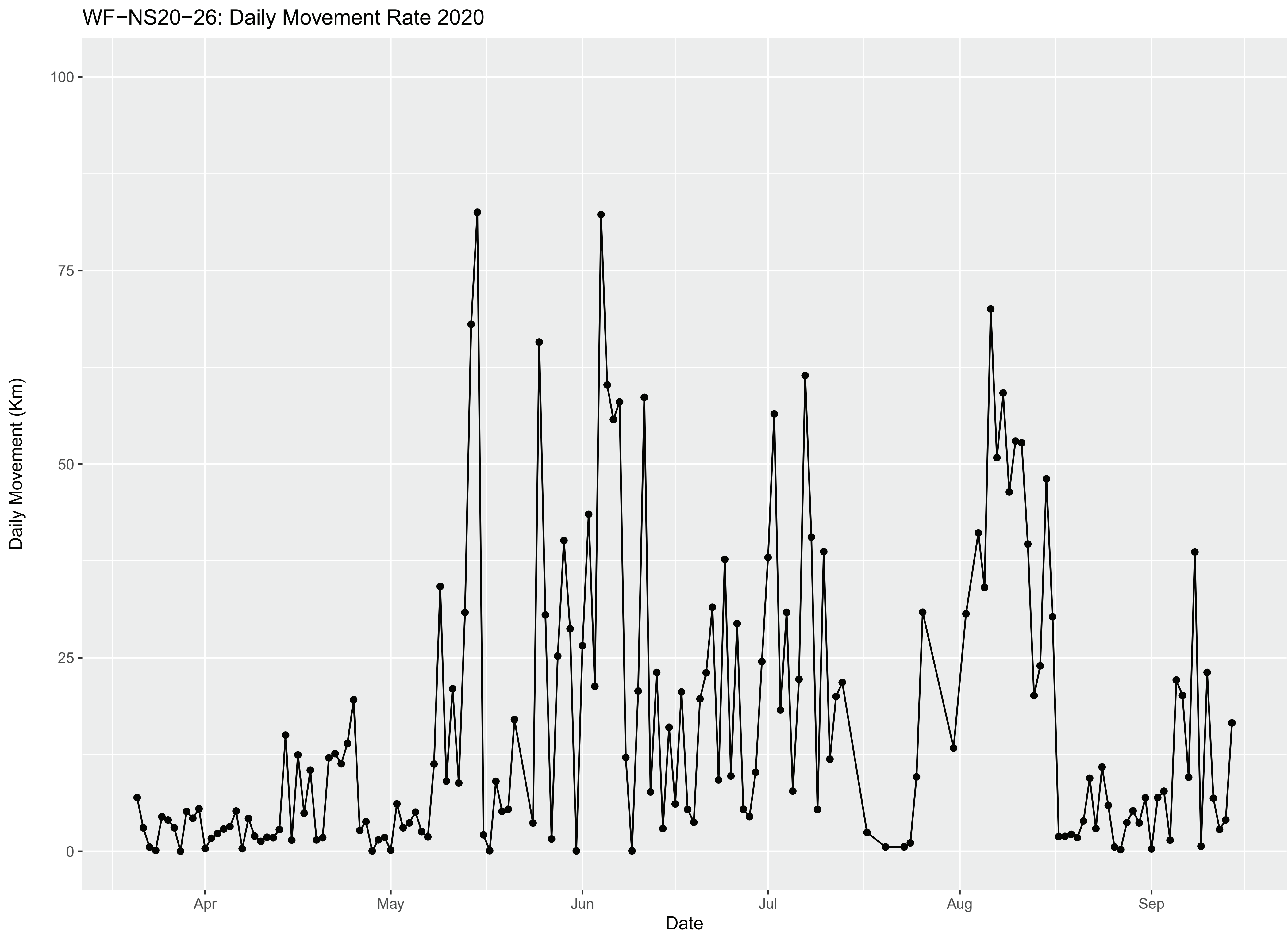
WF−NS20−18: Daily Movement Rate 2020
Daily Movement (Km)
80
60
40
20
0
Apr
May
Jun
Jul
Aug
Date



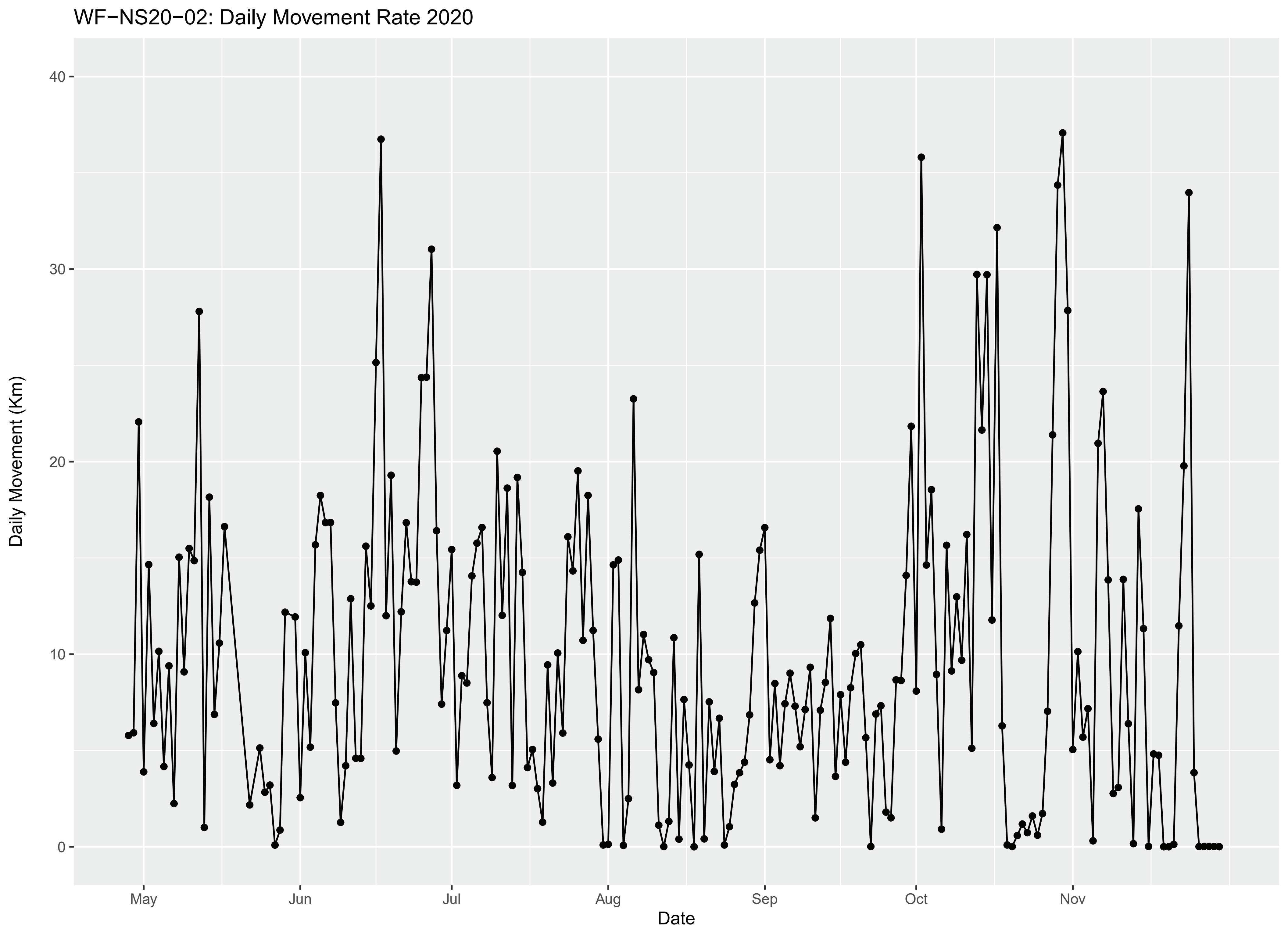
WF−NS20−19: Daily Movement Rate 2020
Daily Movement (Km)
125
100
75
50
25
0
Apr
Date

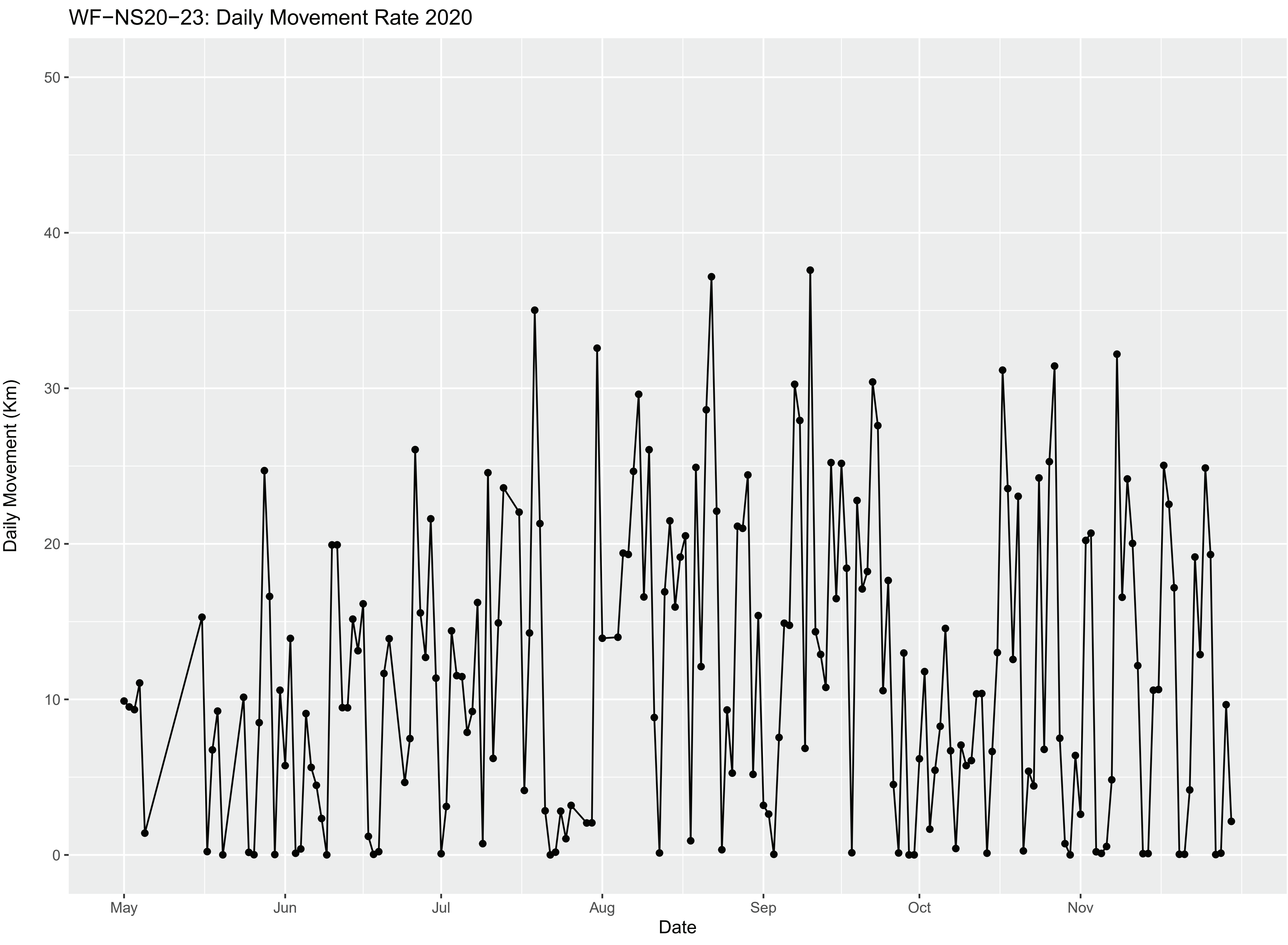


WF−NS20−22: Daily Movement Rate 2020
Daily Movement (Km)
0
10
20
30
40
50
May
Jun
Jul
Aug
Sep
Oct
Date

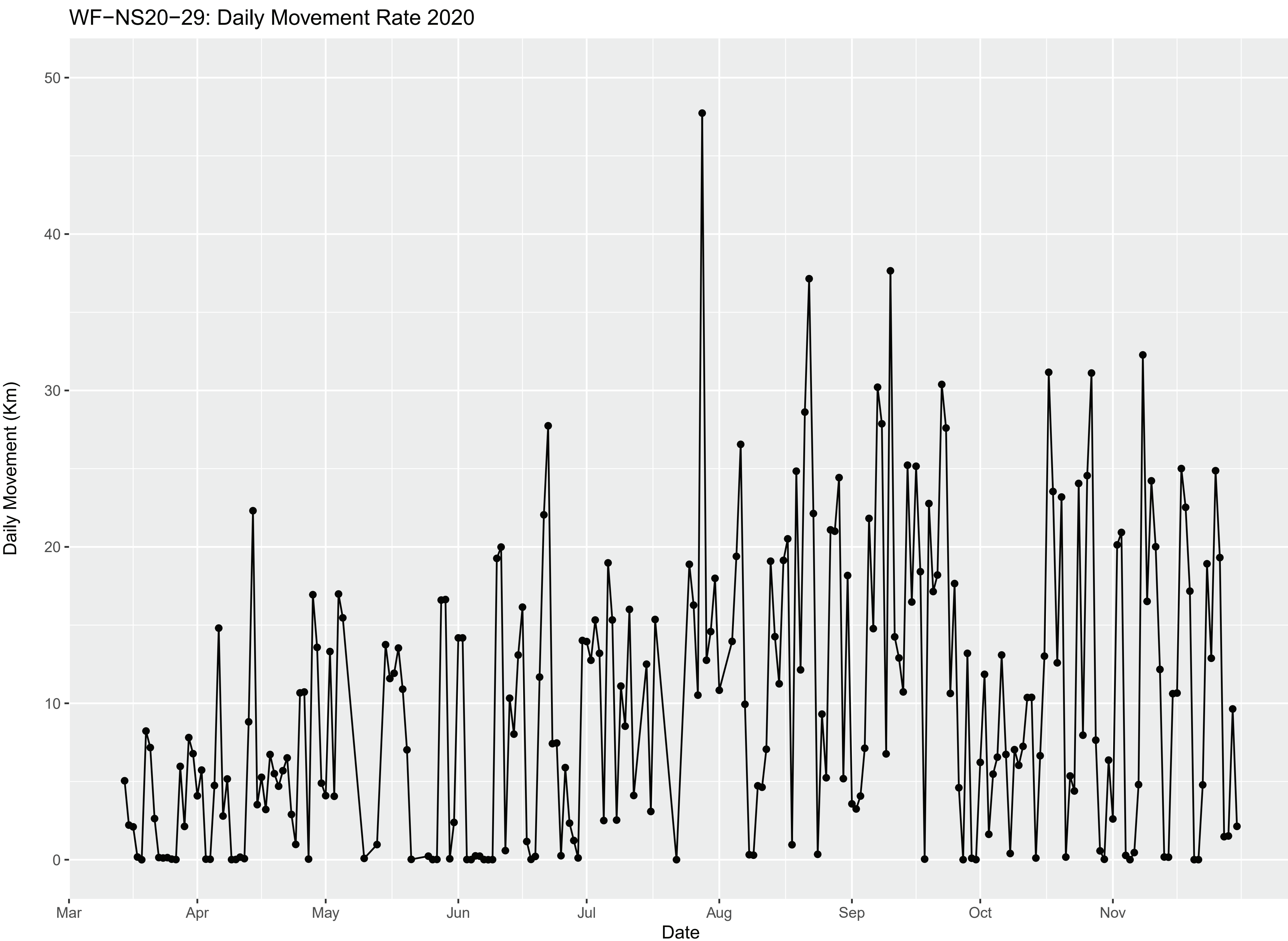


WF−NS20−26: Daily Movement Rate 2020
Daily Movement (Km)
0
25
50
75
100
Apr
May
Jun
Jul
Aug
Sep
Date


WF−NS20−02: Daily Movement Rate 2020
Daily Movement (Km)
40
30
20
10
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

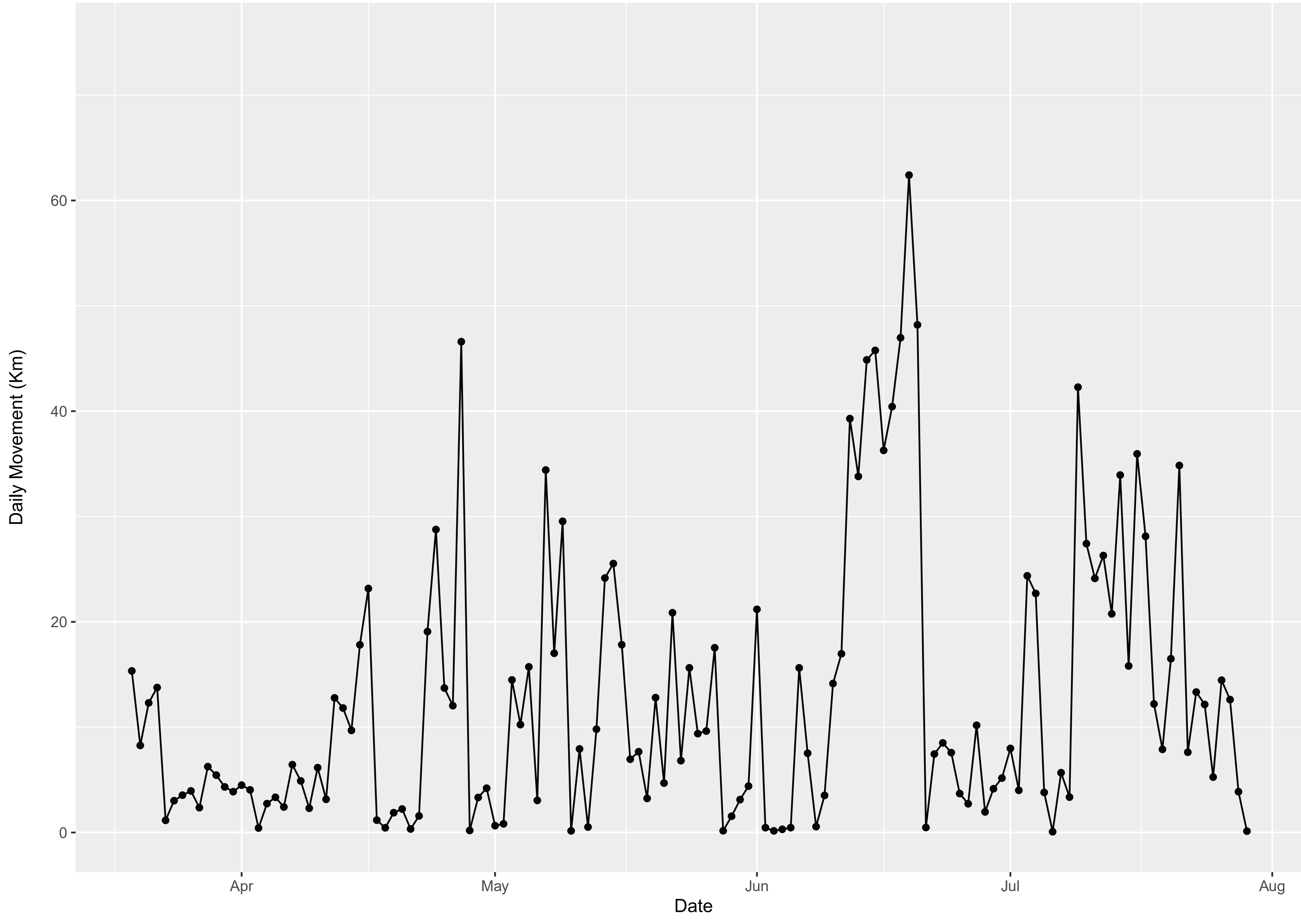


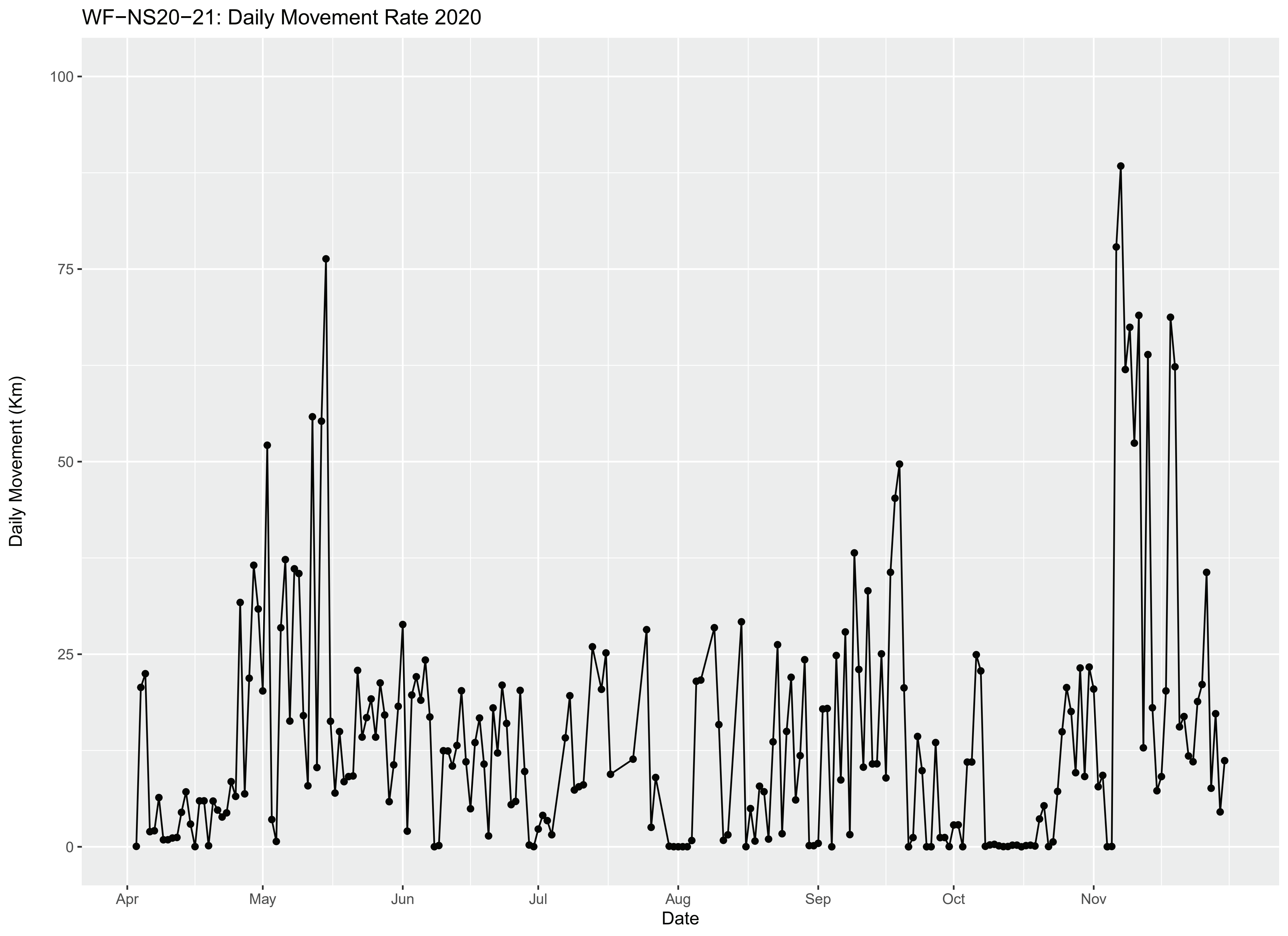
WF−NS20−23: Daily Movement Rate 2020
Daily Movement (Km)
0
10
20
30
40
50
May
Jun
Jul
Aug
Sep
Oct
Nov
Date



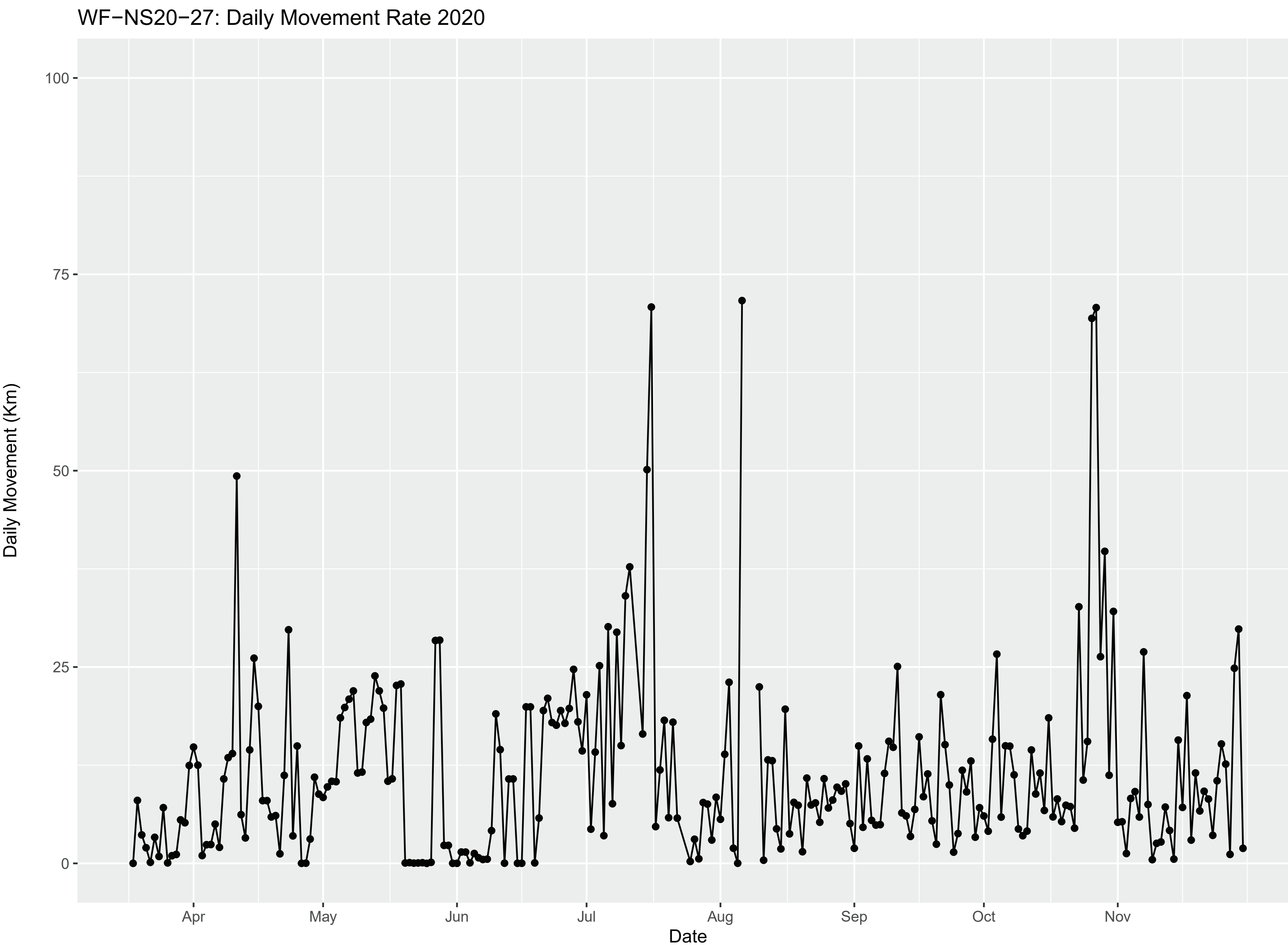
WF−NS20−29: Daily Movement Rate 2020
Daily Movement (Km)
0
10
20
30
40
50
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

WF−NS20−12: Daily Movement Rate 2020

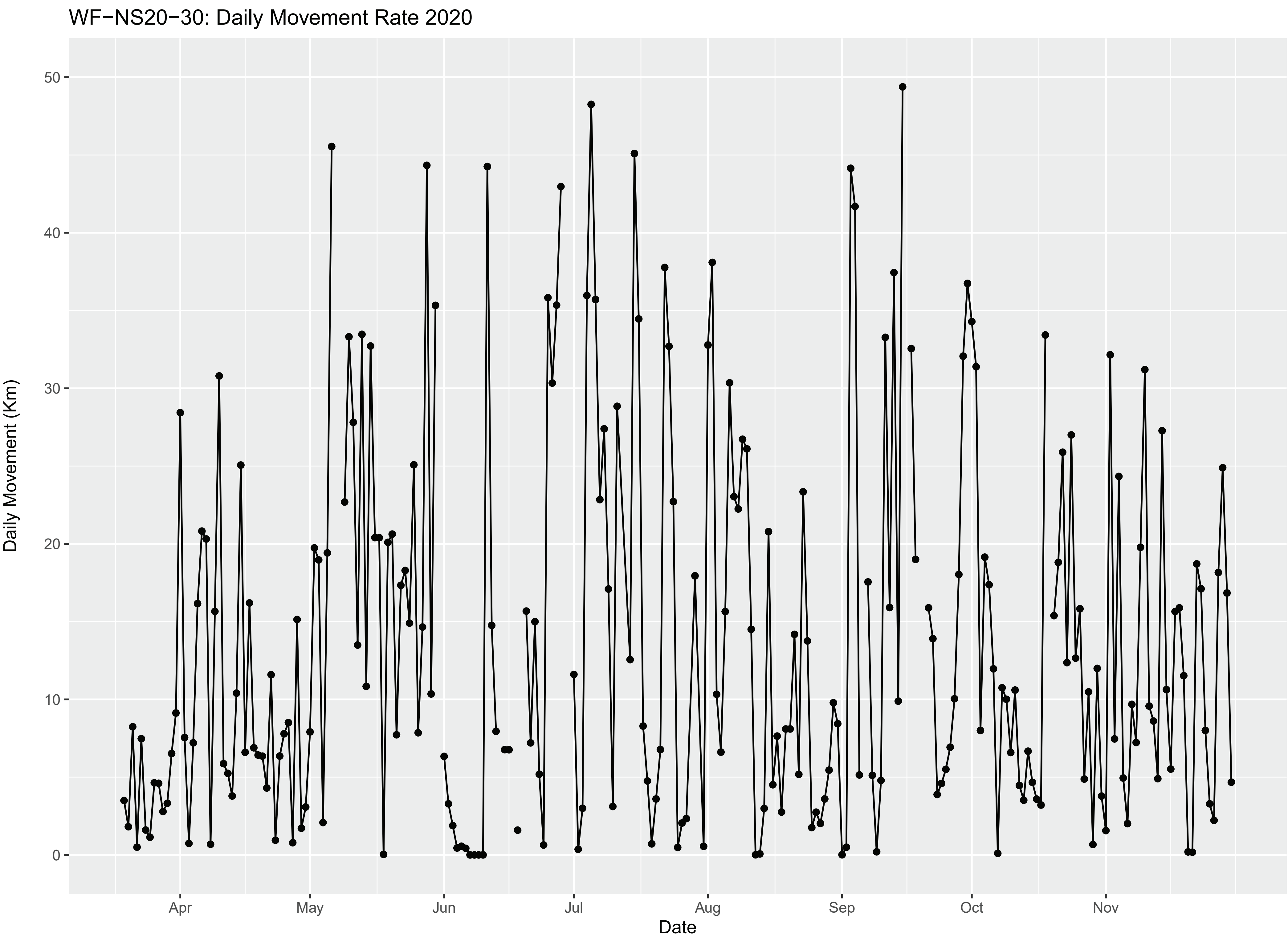




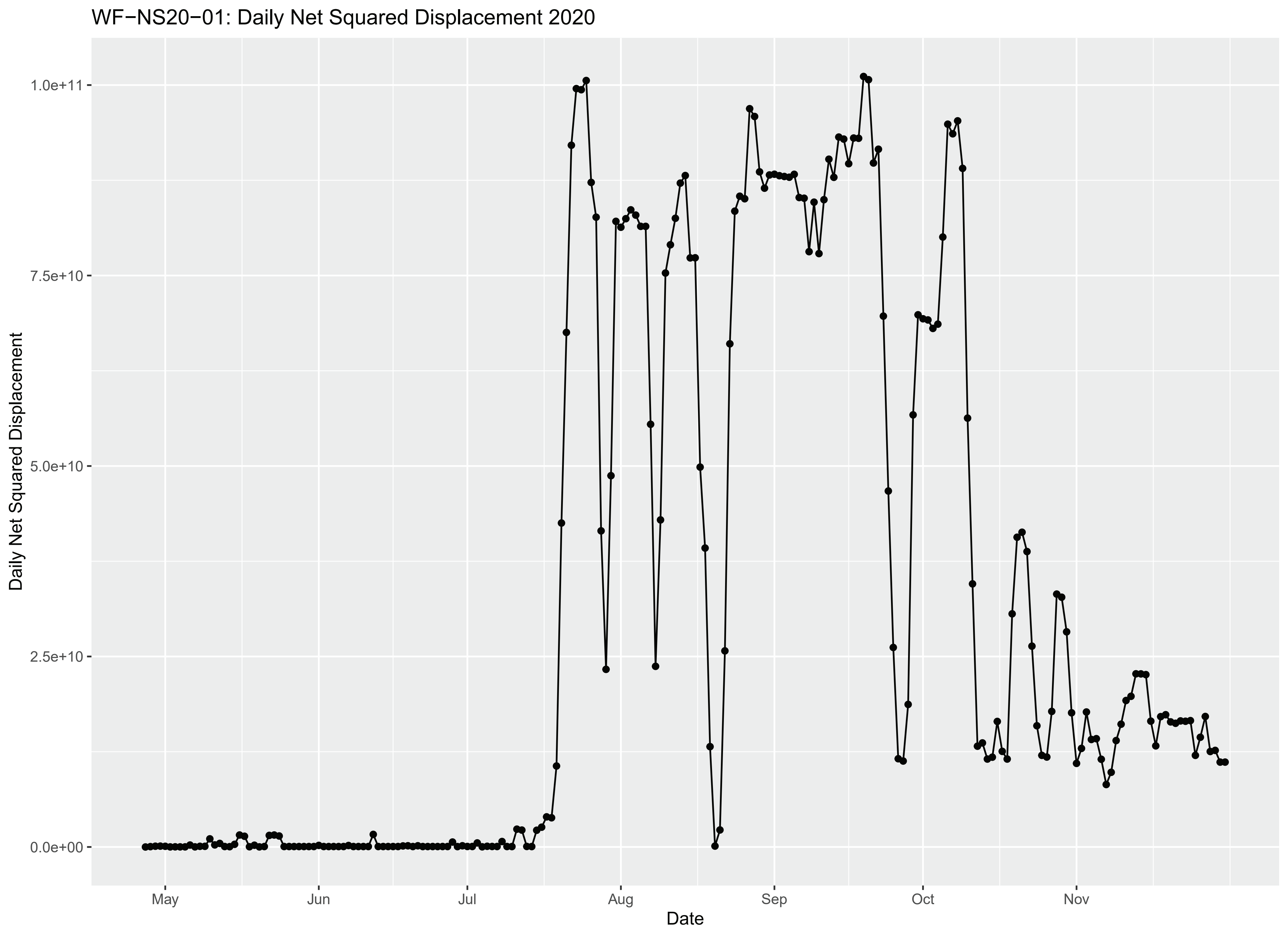
WF−NS20−21: Daily Movement Rate 2020
Daily Movement (Km)
100
75
50
25
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

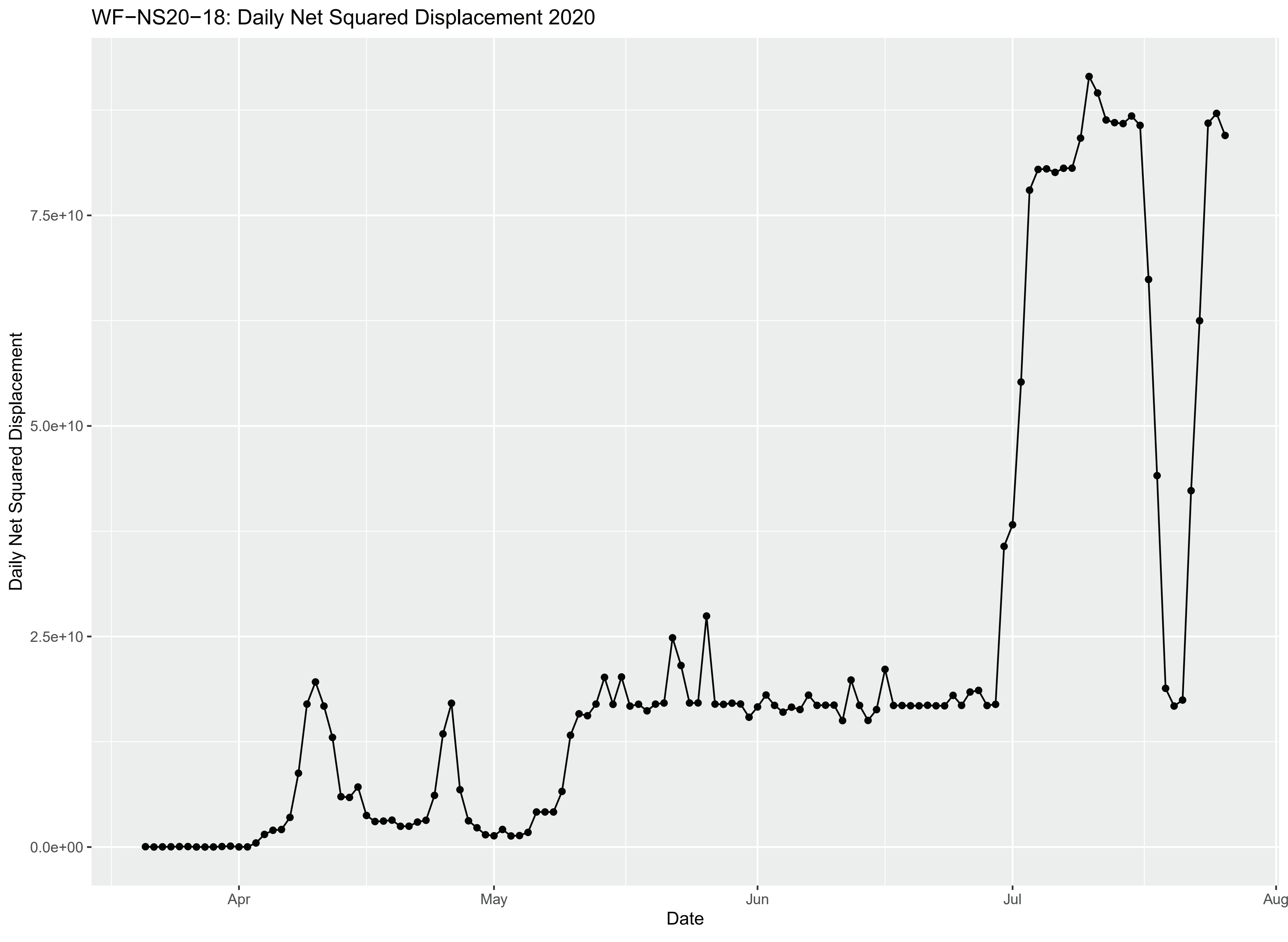


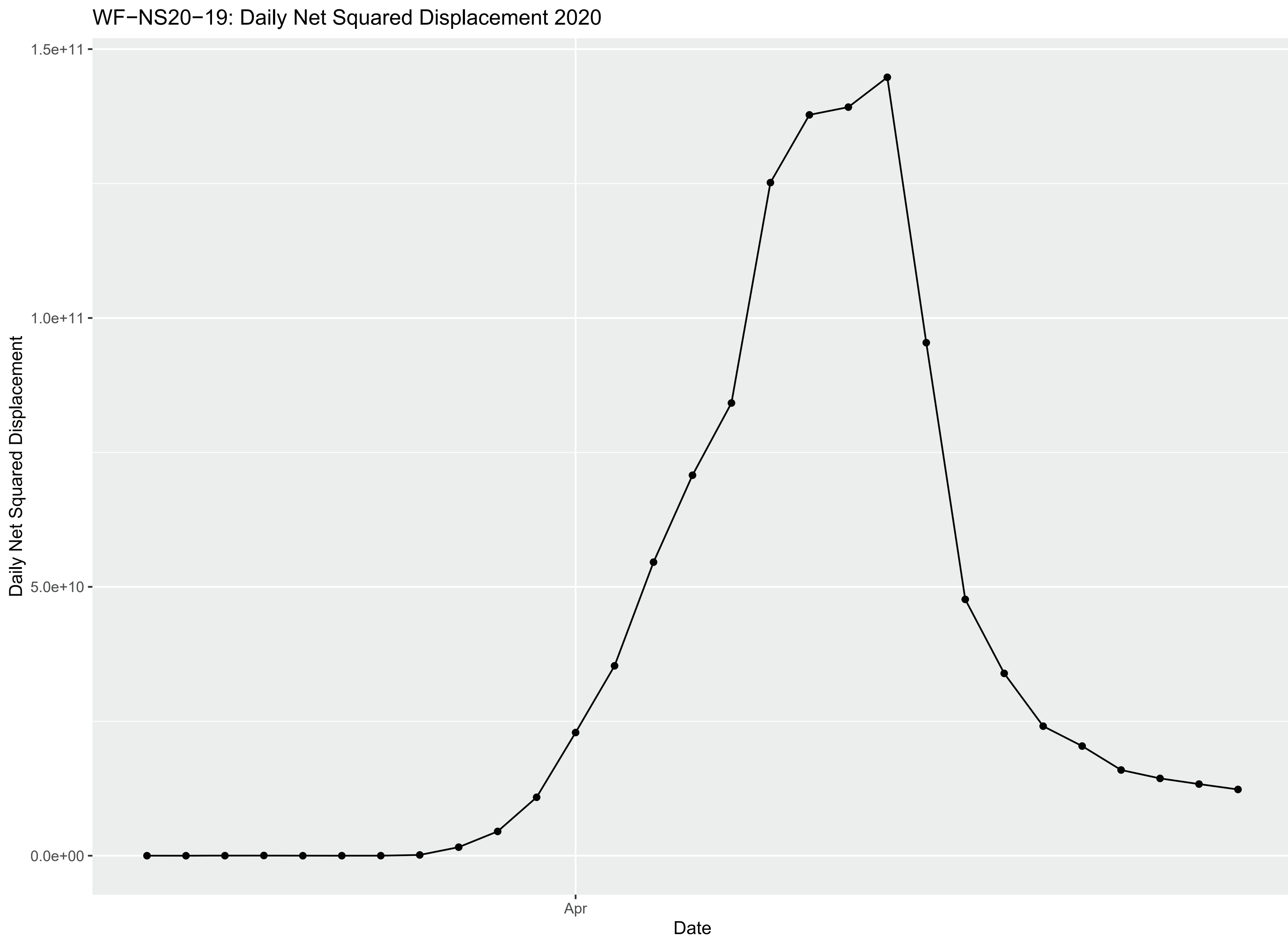
WF−NS20−27: Daily Movement Rate 2020
Daily Movement (Km)
100
75
50
25
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

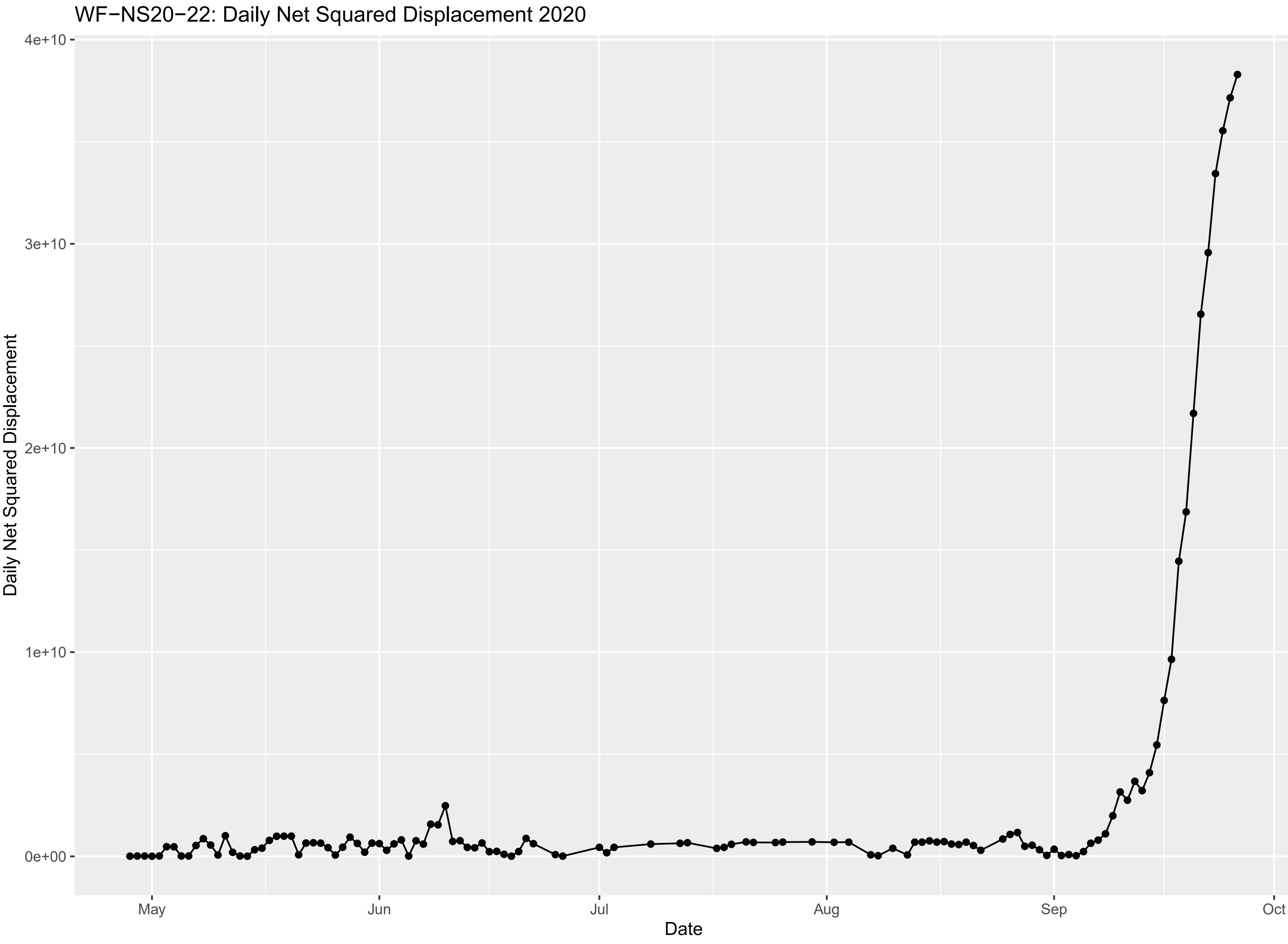


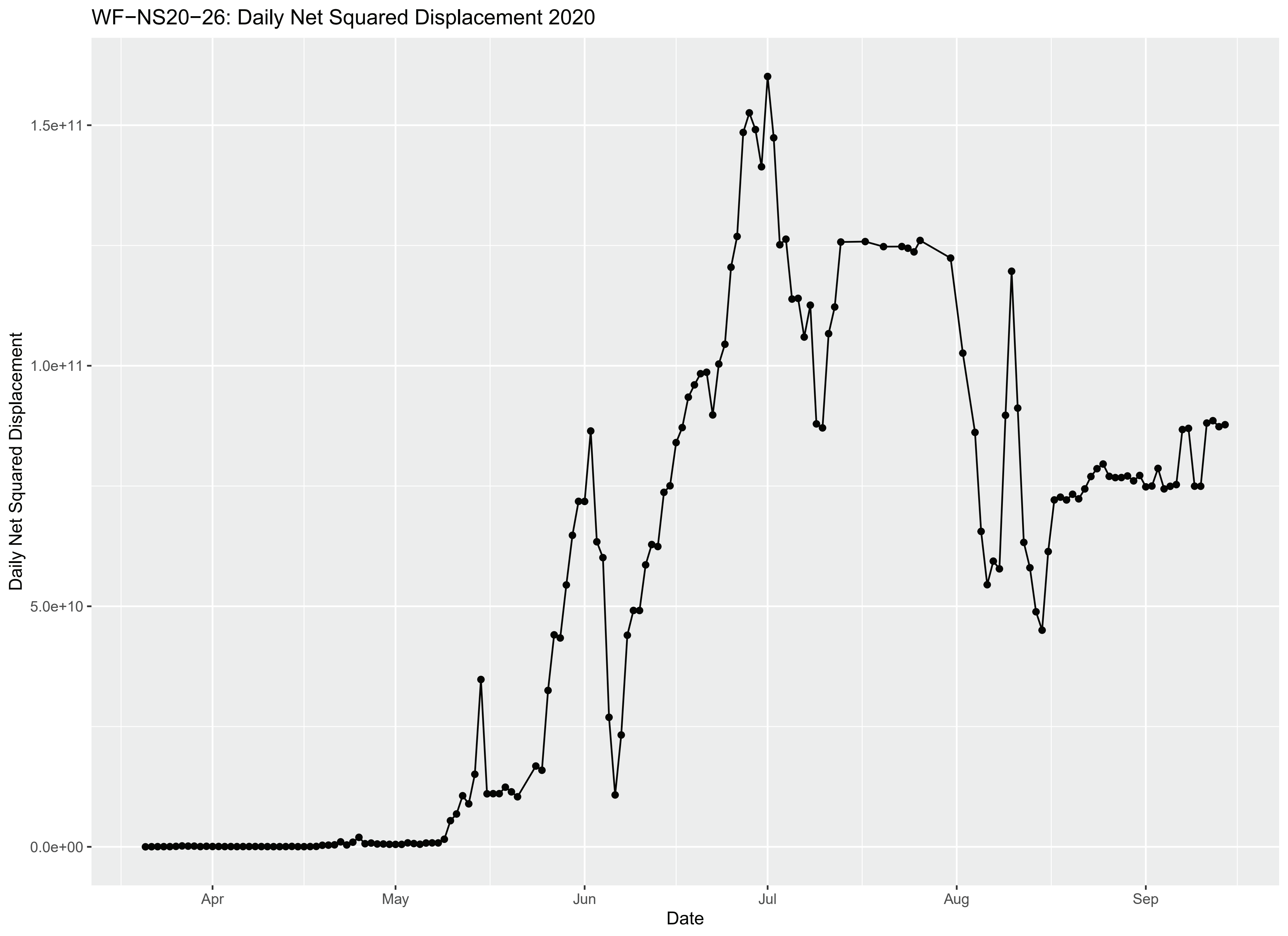
WF−NS20−30: Daily Movement Rate 2020
Daily Movement (Km)
0
10
20
30
40
50
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

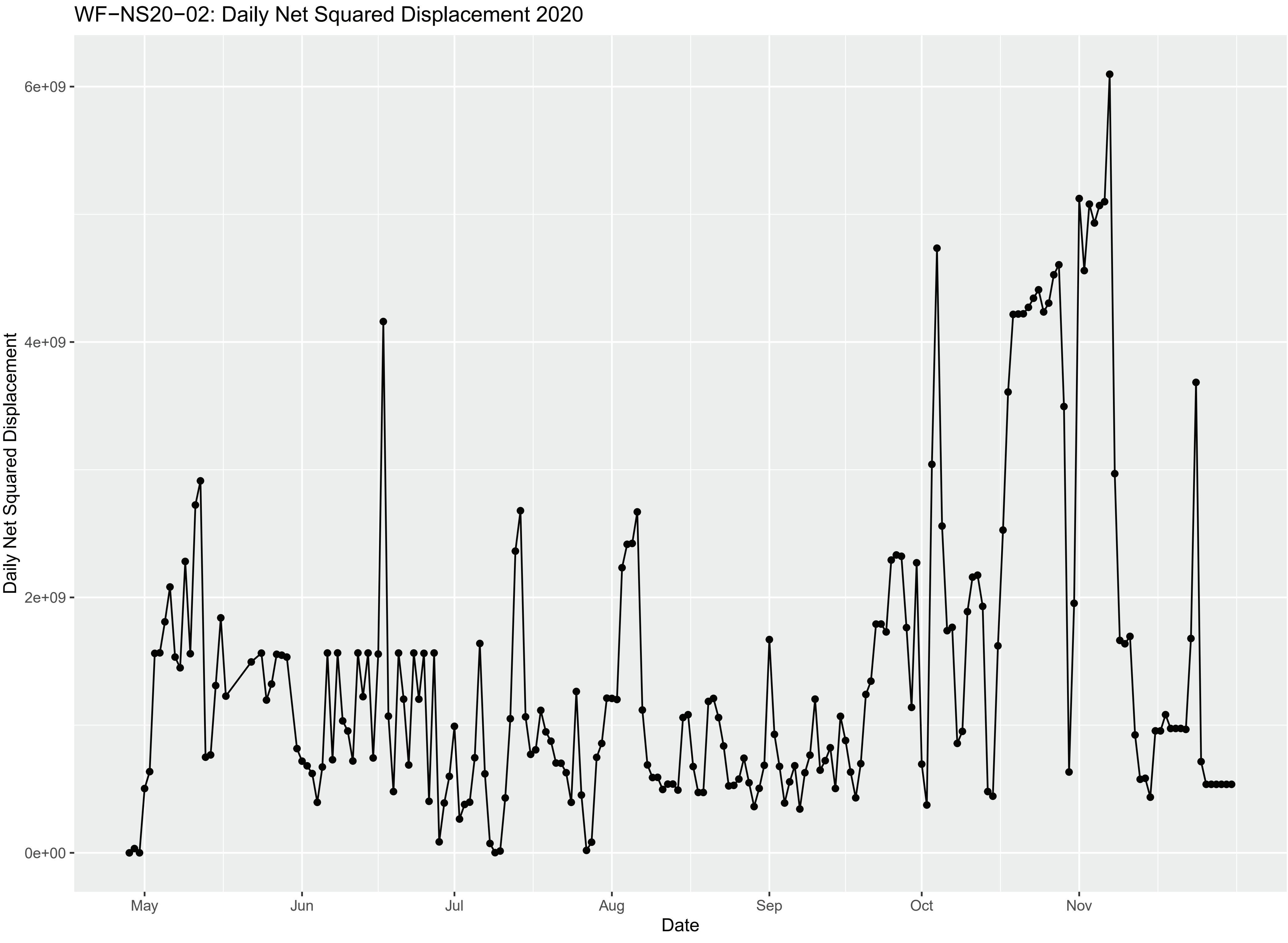

WF−NS20−01: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
1.0e+11
7.5e+10
5.0e+10
2.5e+10
0.0e+00
May
Jun
Jul
Aug
Sep
Oct
Nov
Date


WF−NS20−18: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
7.5e+10
5.0e+10
2.5e+10
0.0e+00
Apr
May
Jun
Jul
Aug
Date

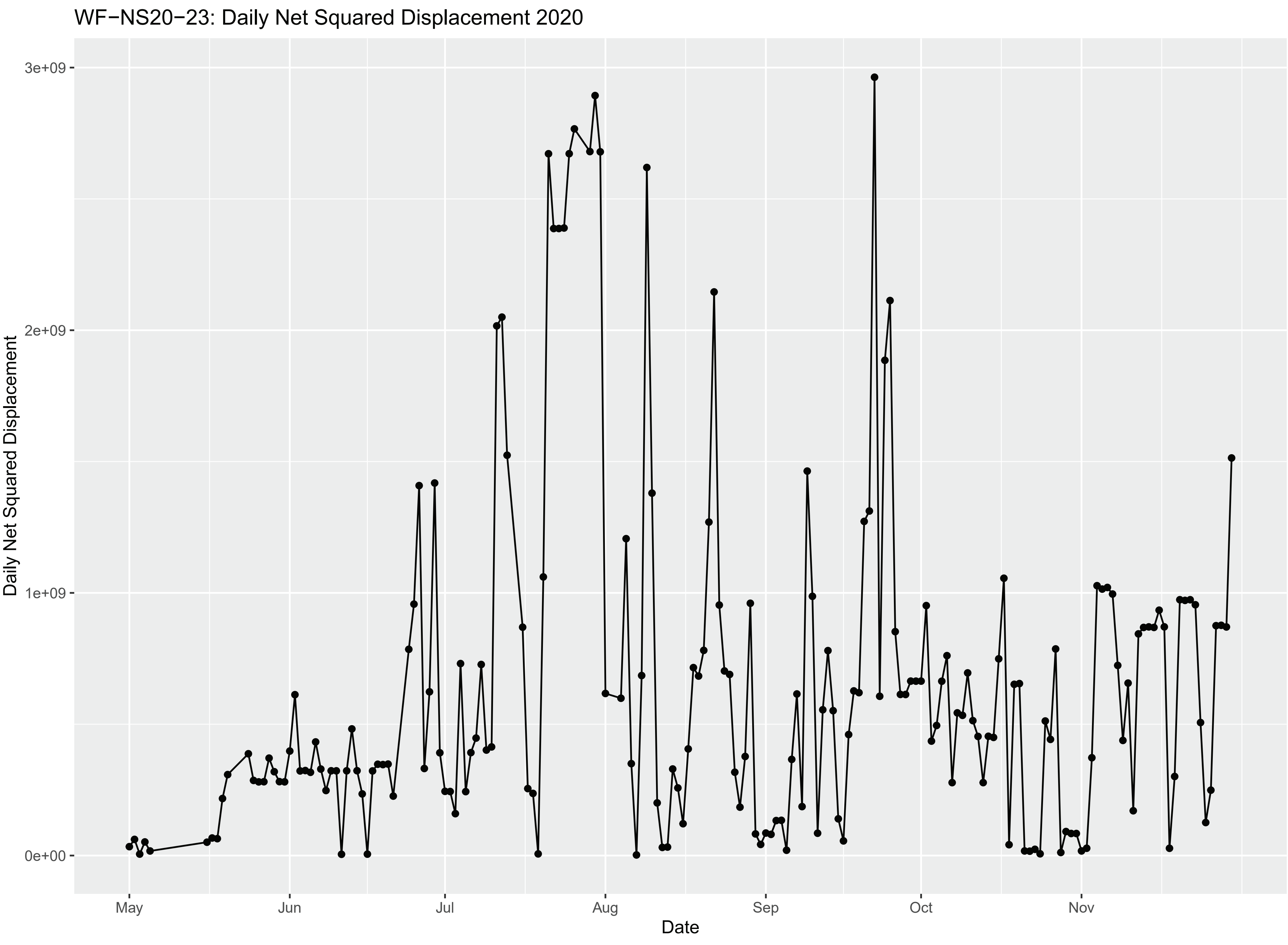

WF−NS20−19: Daily Net Squared Displacement 2020
1.5e+11
1.0e+11
5.0e+10
0.0e+00
Daily Net Squared Displacement
Apr
Date


WF−NS20−22: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
4e+10
3e+10
2e+10
1e+10
0e+00
May
Jun
Jul
Aug
Sep
Oct
Date

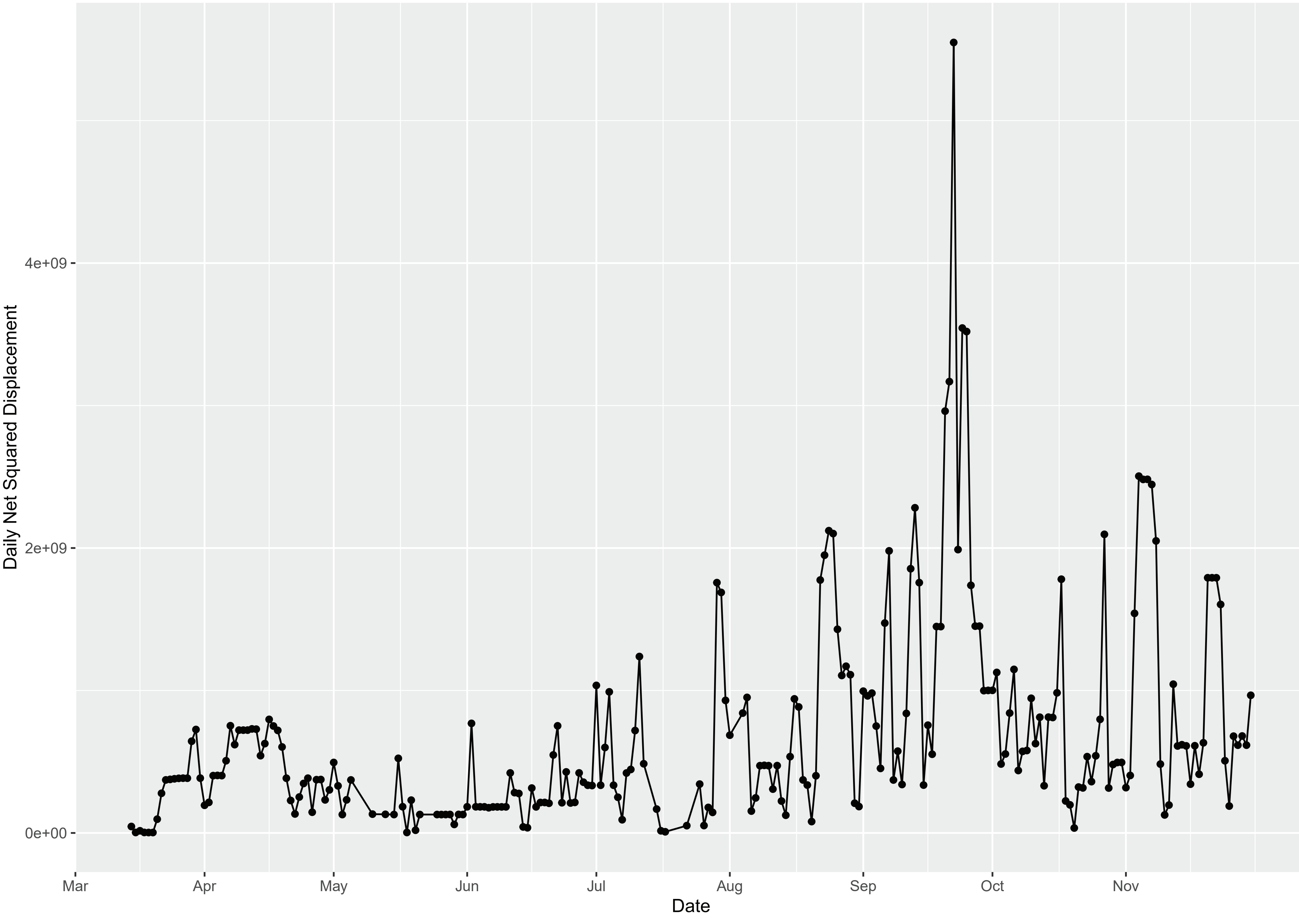

WF−NS20−26: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
1.5e+11
1.0e+11
5.0e+10
0.0e+00
Apr
May
Jun
Jul
Aug
Sep
Date

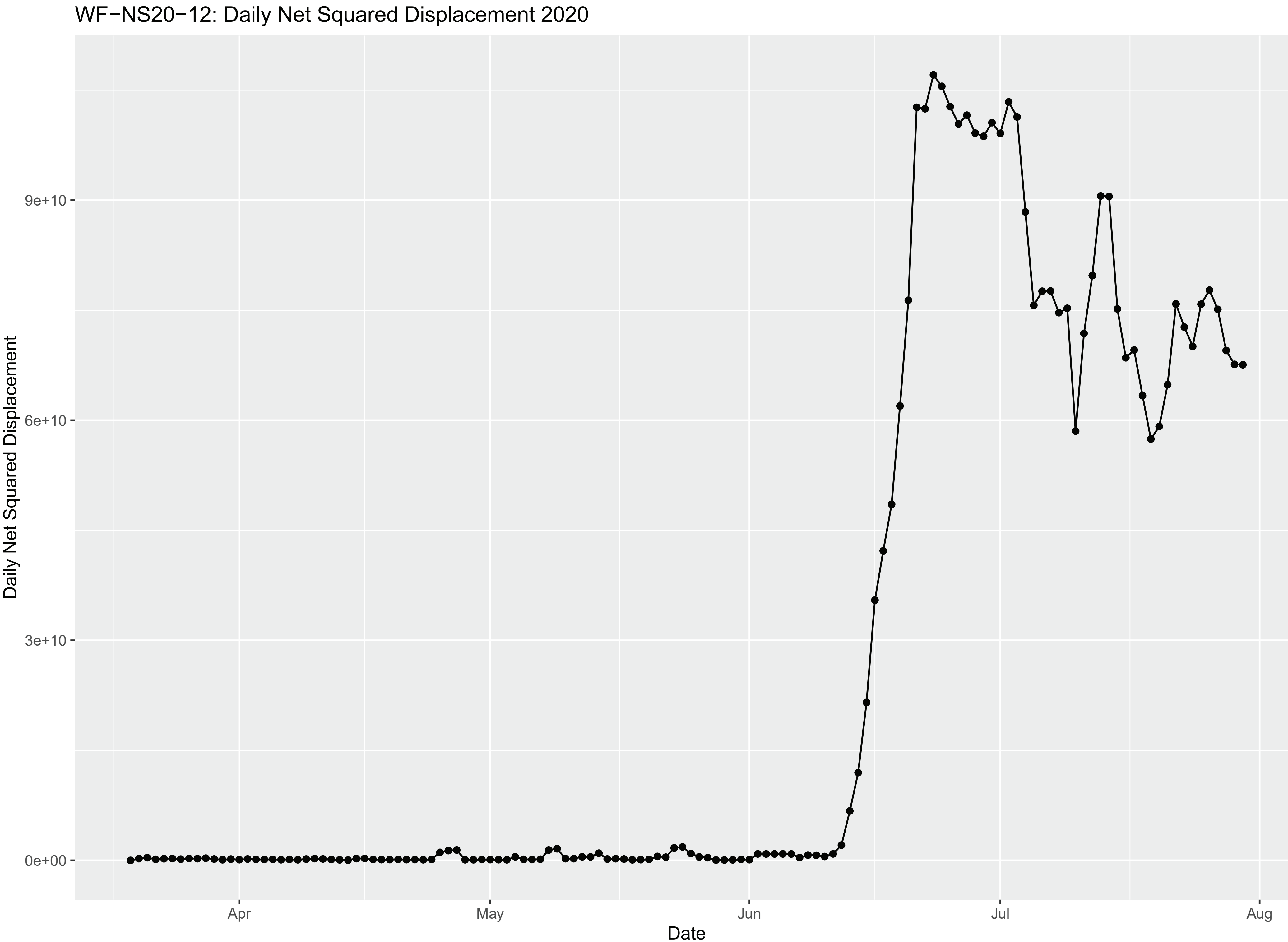


WF−NS20−02: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
6e+09
4e+09
2e+09
0e+00
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

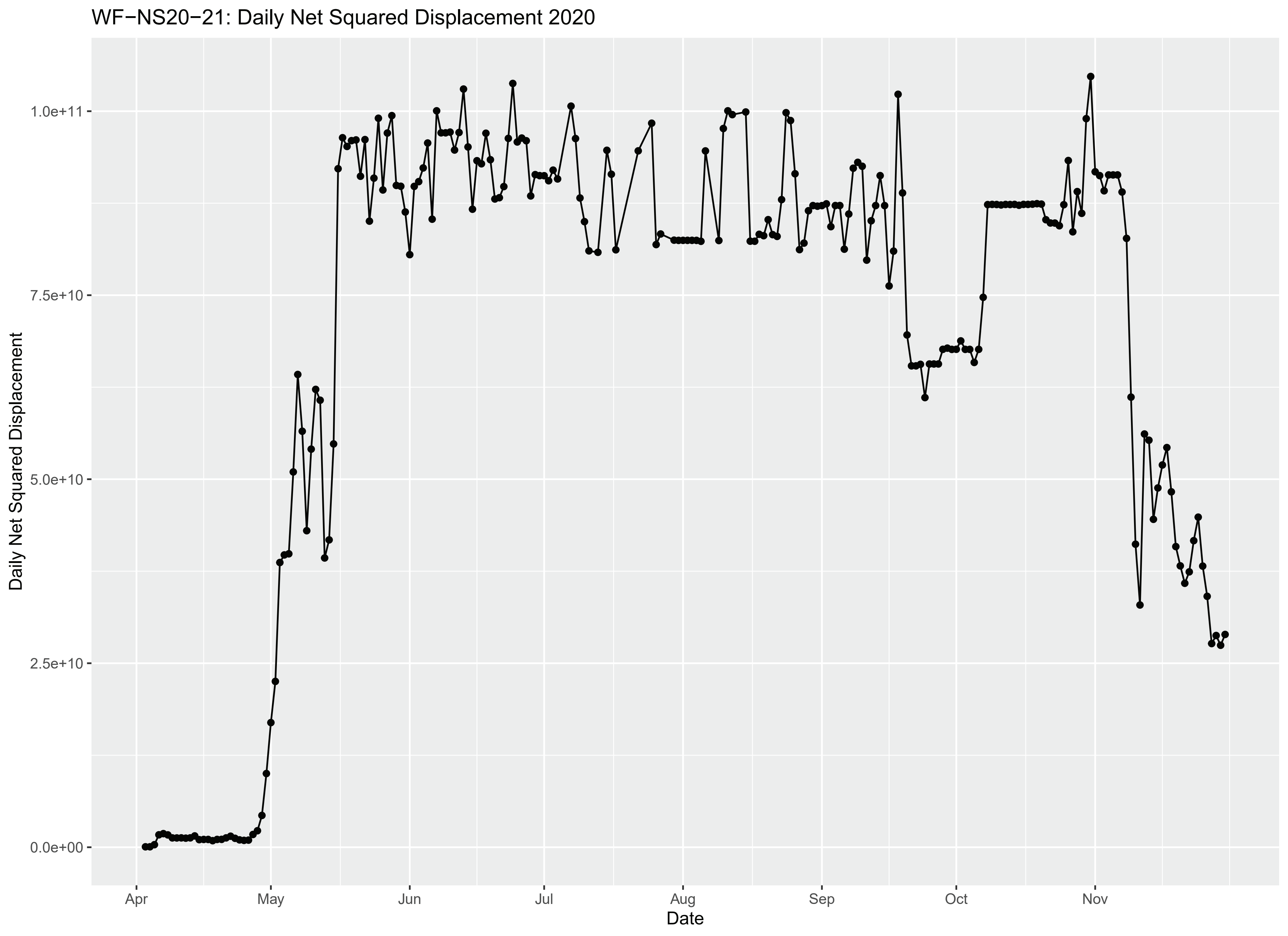

WF−NS20−23: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
3e+09
2e+09
1e+09
0e+00
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

WF−NS20−29: Daily Net Squared Displacement 2020

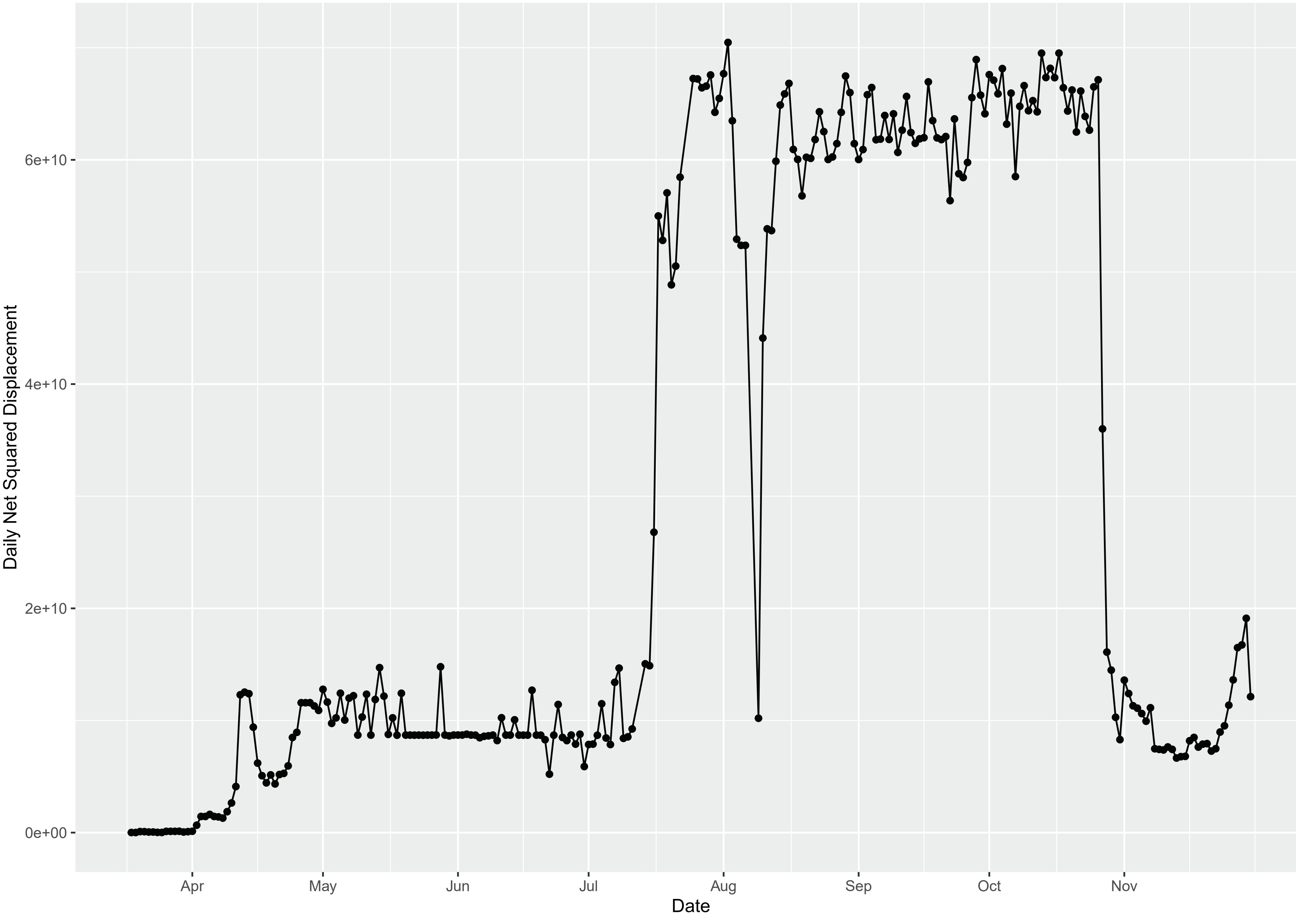




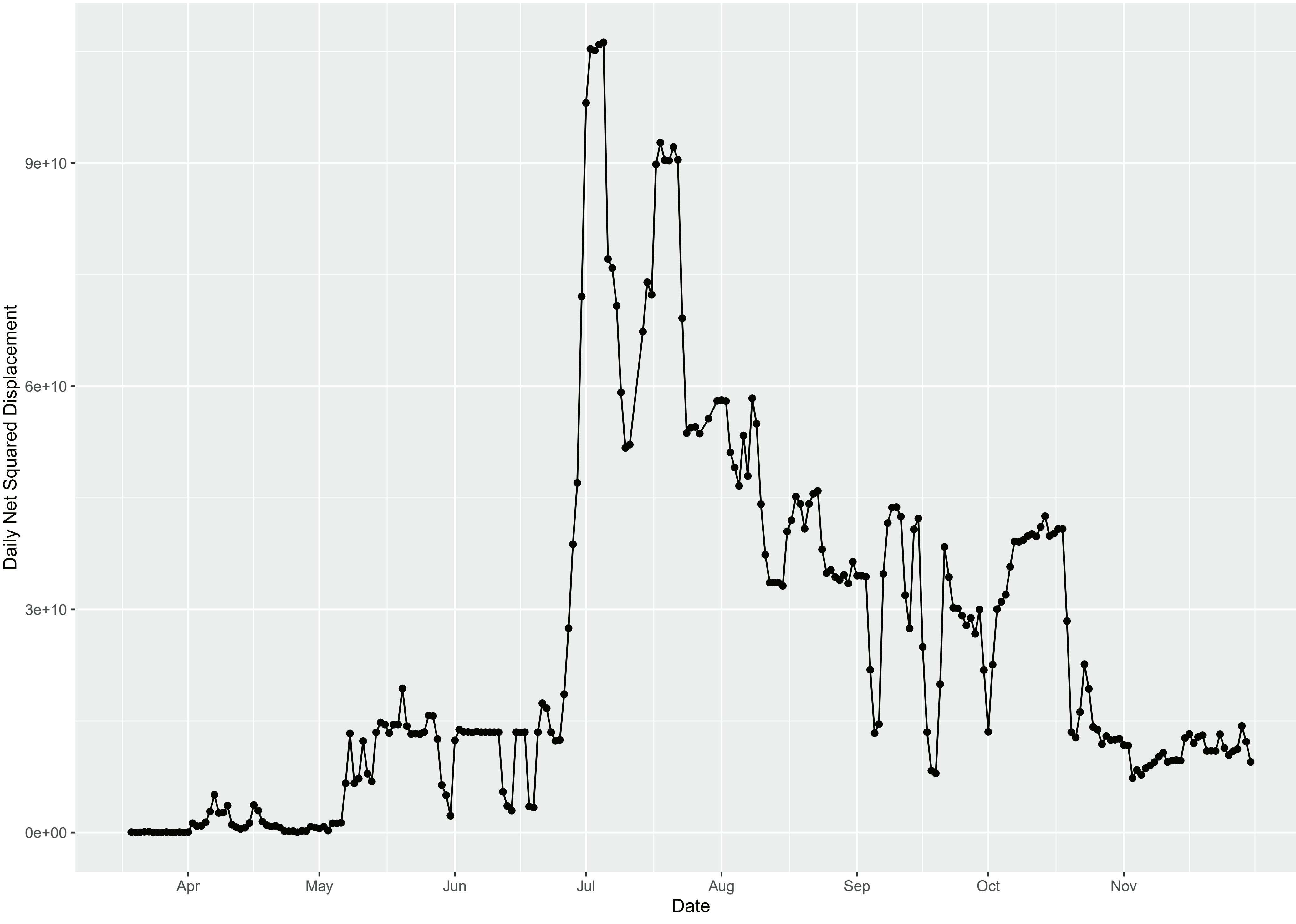
WF−NS20−12: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
9e+10
6e+10
3e+10
0e+00
Apr
May
Jun
Jul
Aug
Date

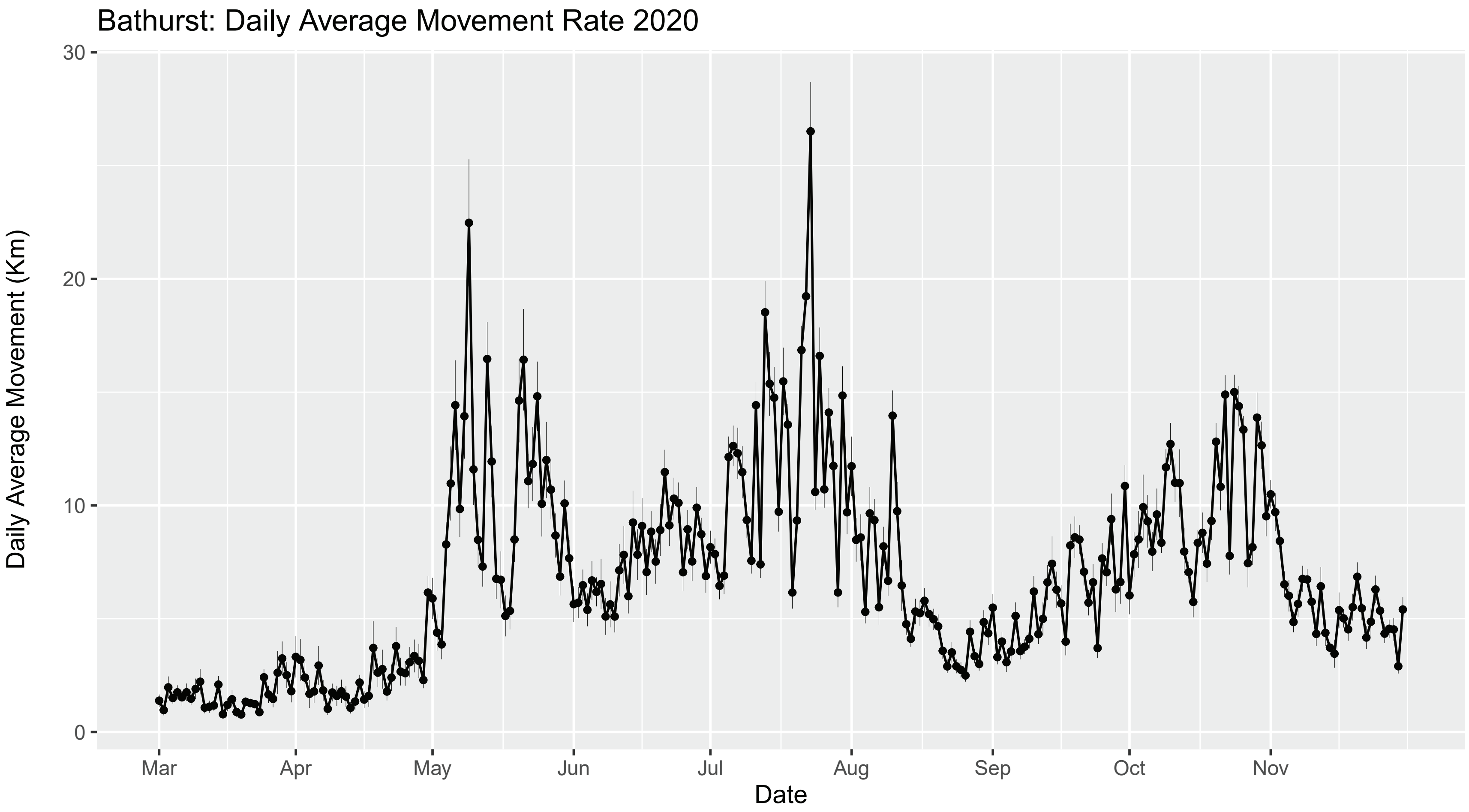

WF−NS20−21: Daily Net Squared Displacement 2020
Daily Net Squared Displacement
1.0e+11
7.5e+10
5.0e+10
2.5e+10
0.0e+00
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

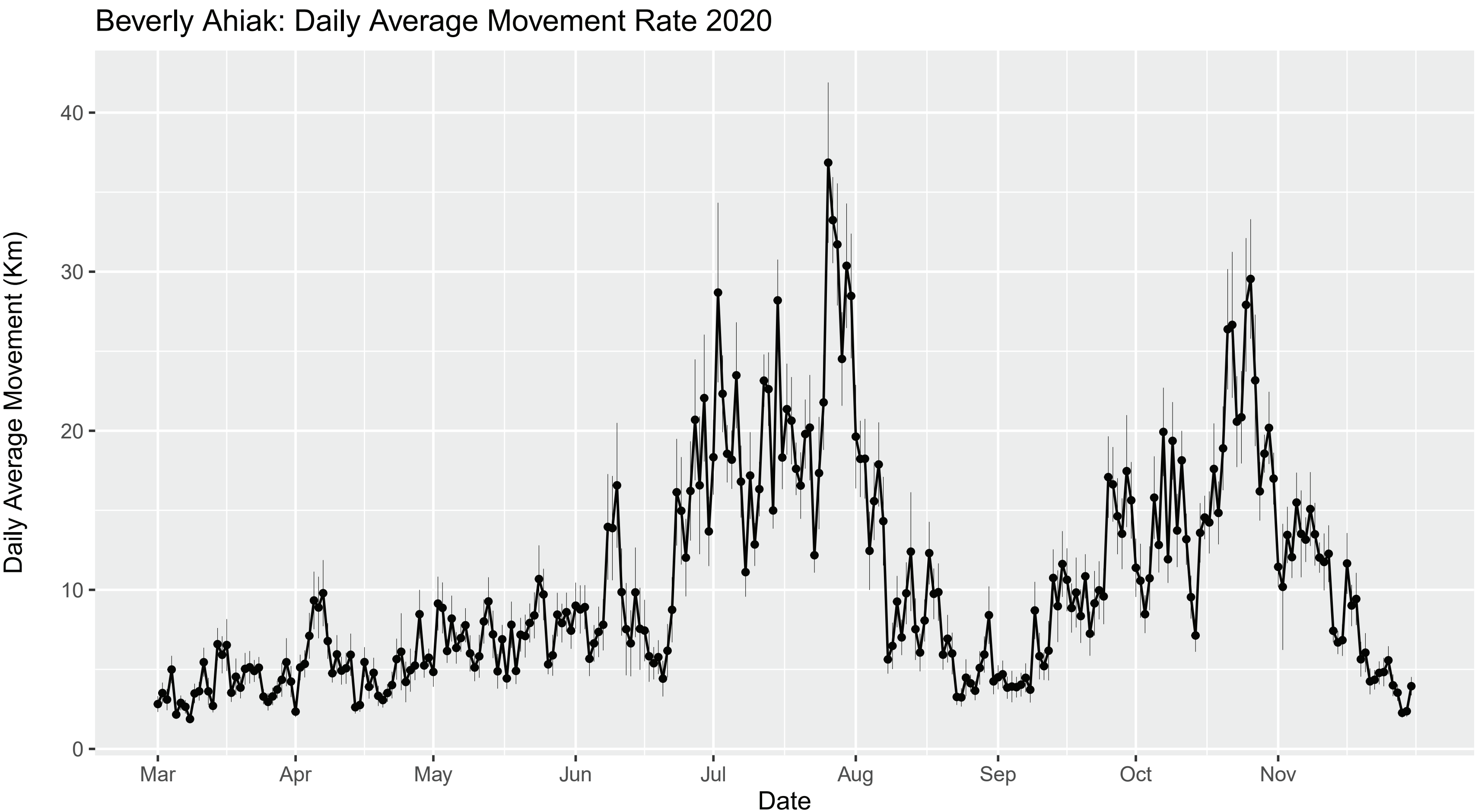
WF−NS20−27: Daily Net Squared Displacement 2020



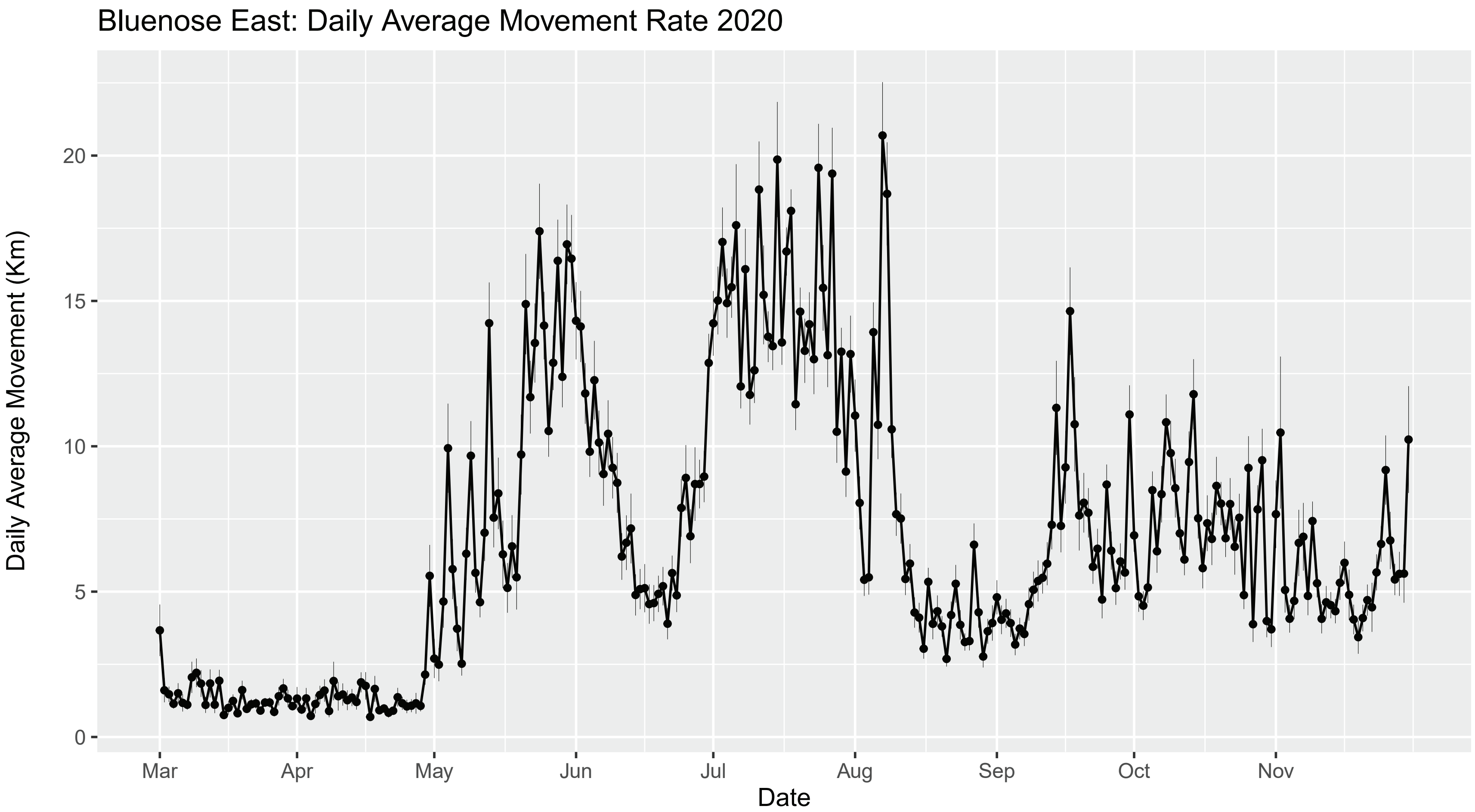
WF−NS20−30: Daily Net Squared Displacement 2020




Bathurst: Daily Average Movement Rate 2020
Daily Average Movement (Km)
0
10
20
30
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

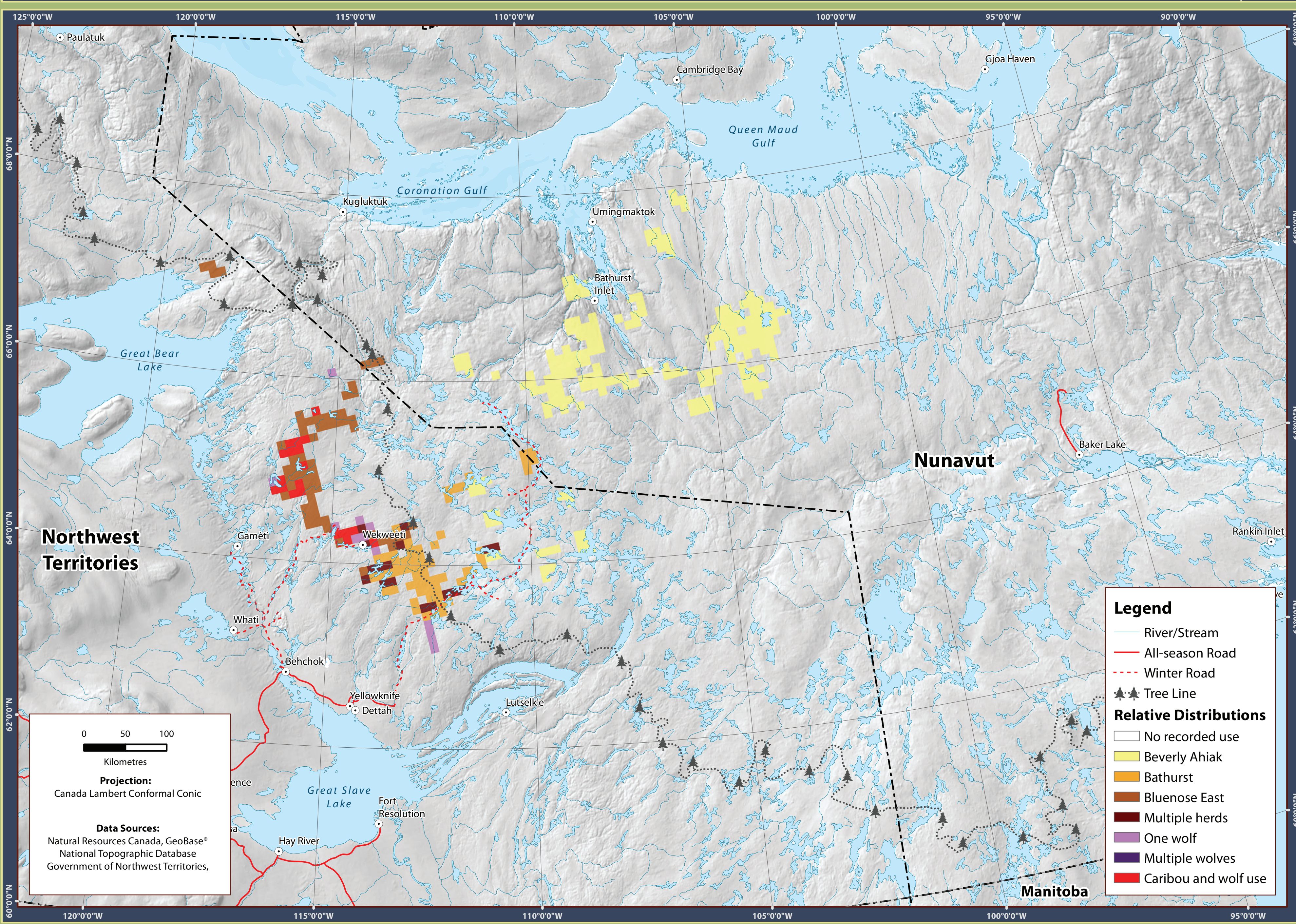


Beverly Ahiak: Daily Average Movement Rate 2020
Daily Average Movement (Km)
0
10
20
30
40
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date


Bluenose East: Daily Average Movement Rate 2020
Daily Average Movement (Km)
0
5
10
15
20
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Date

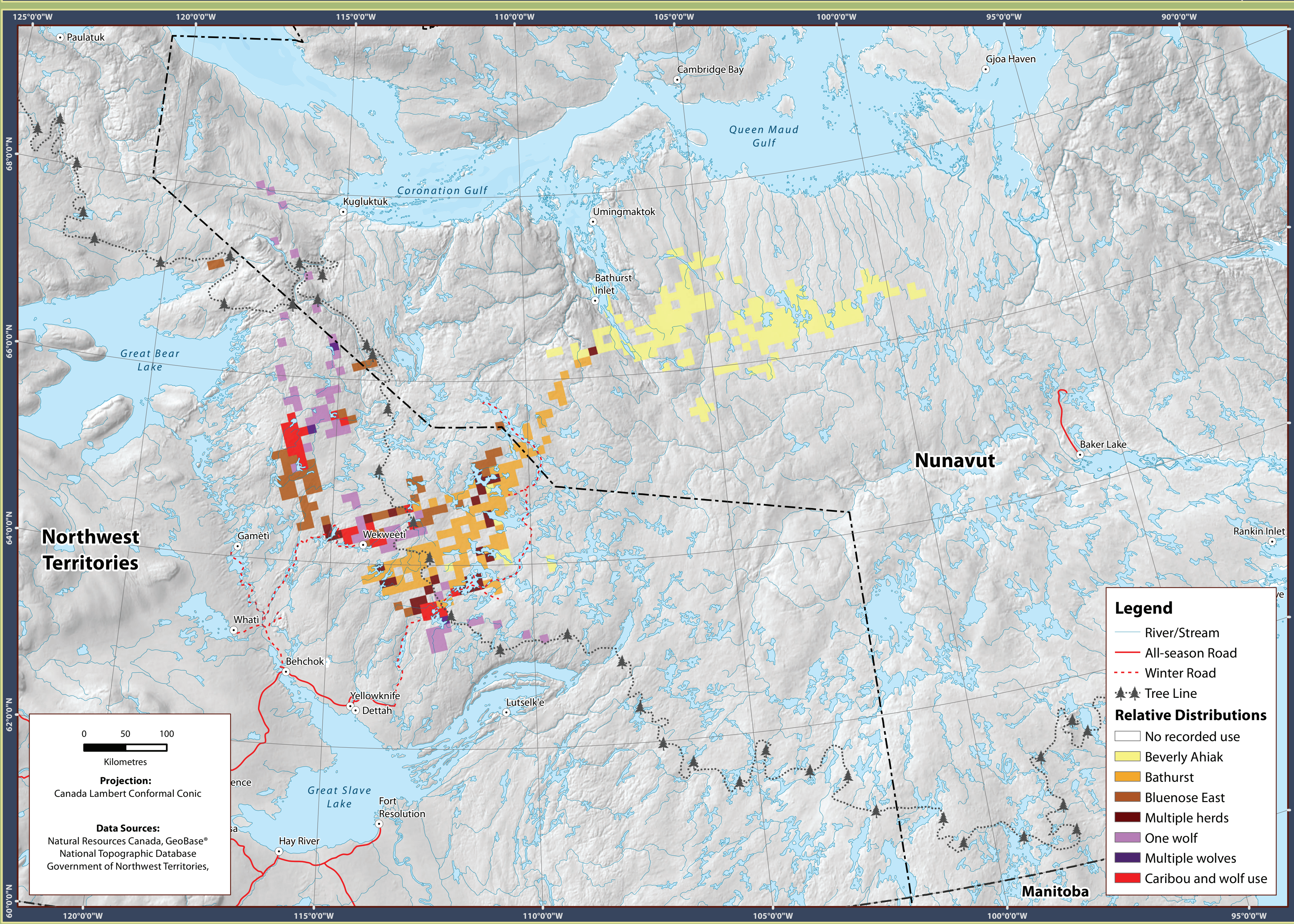
Relative Distriutions Barren-ground Caribou and Wolves - March 2020

DRAFT



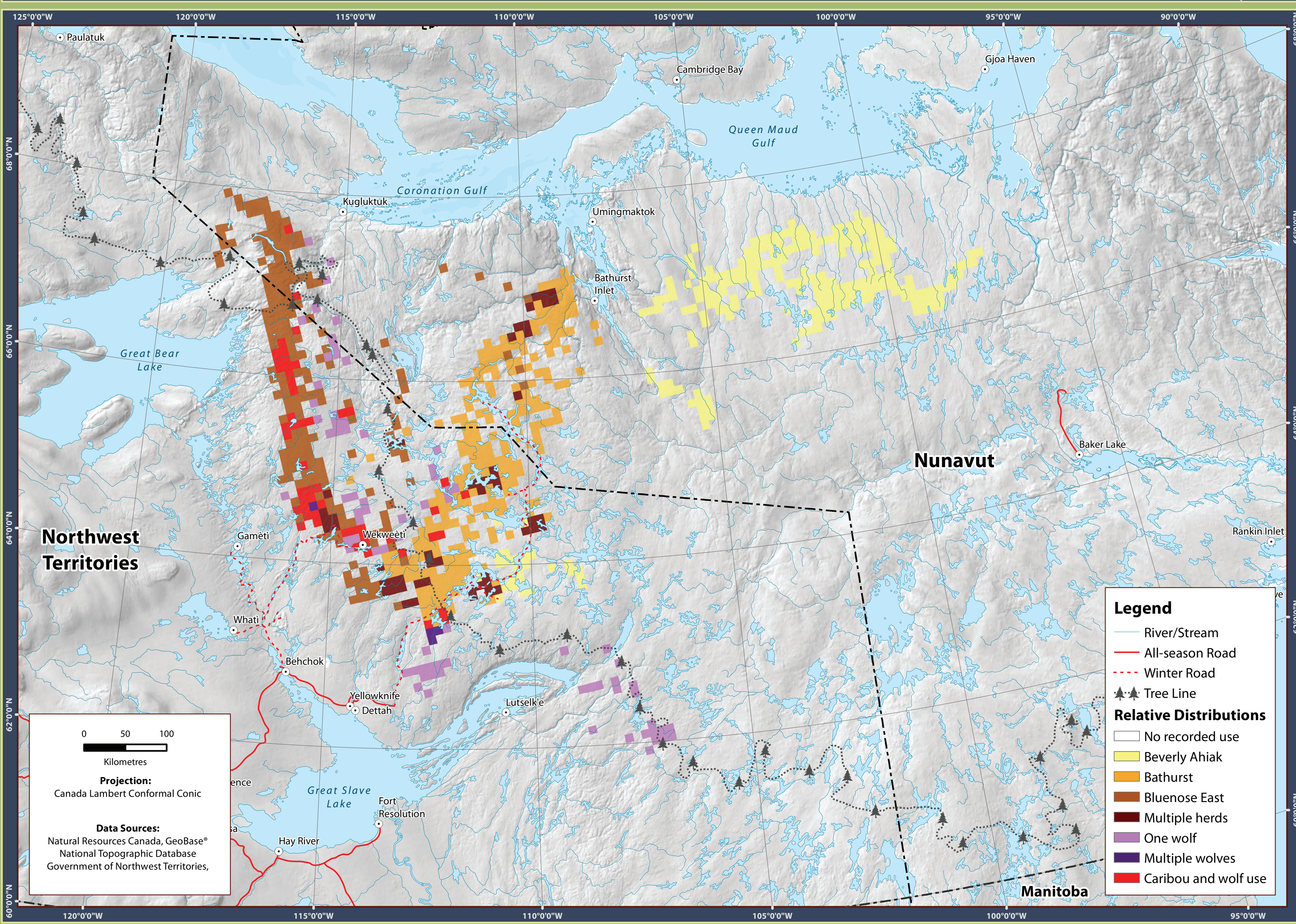
Relative Distriutions Barren-ground Caribou and Wolves - April 2020

DRAFT



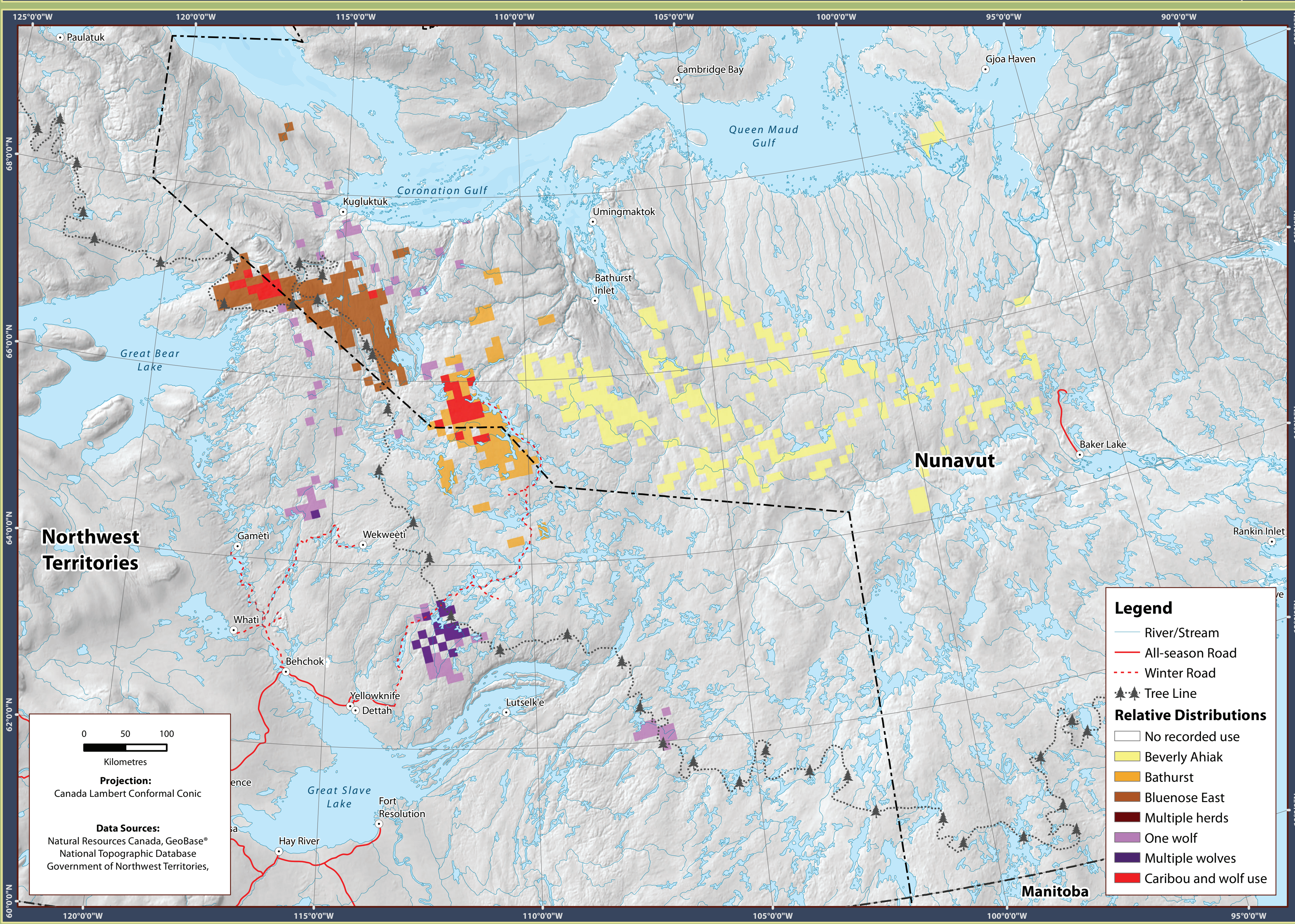
Relative Distriutions Barren-ground Caribou and Wolves - May 2020

DRAFT



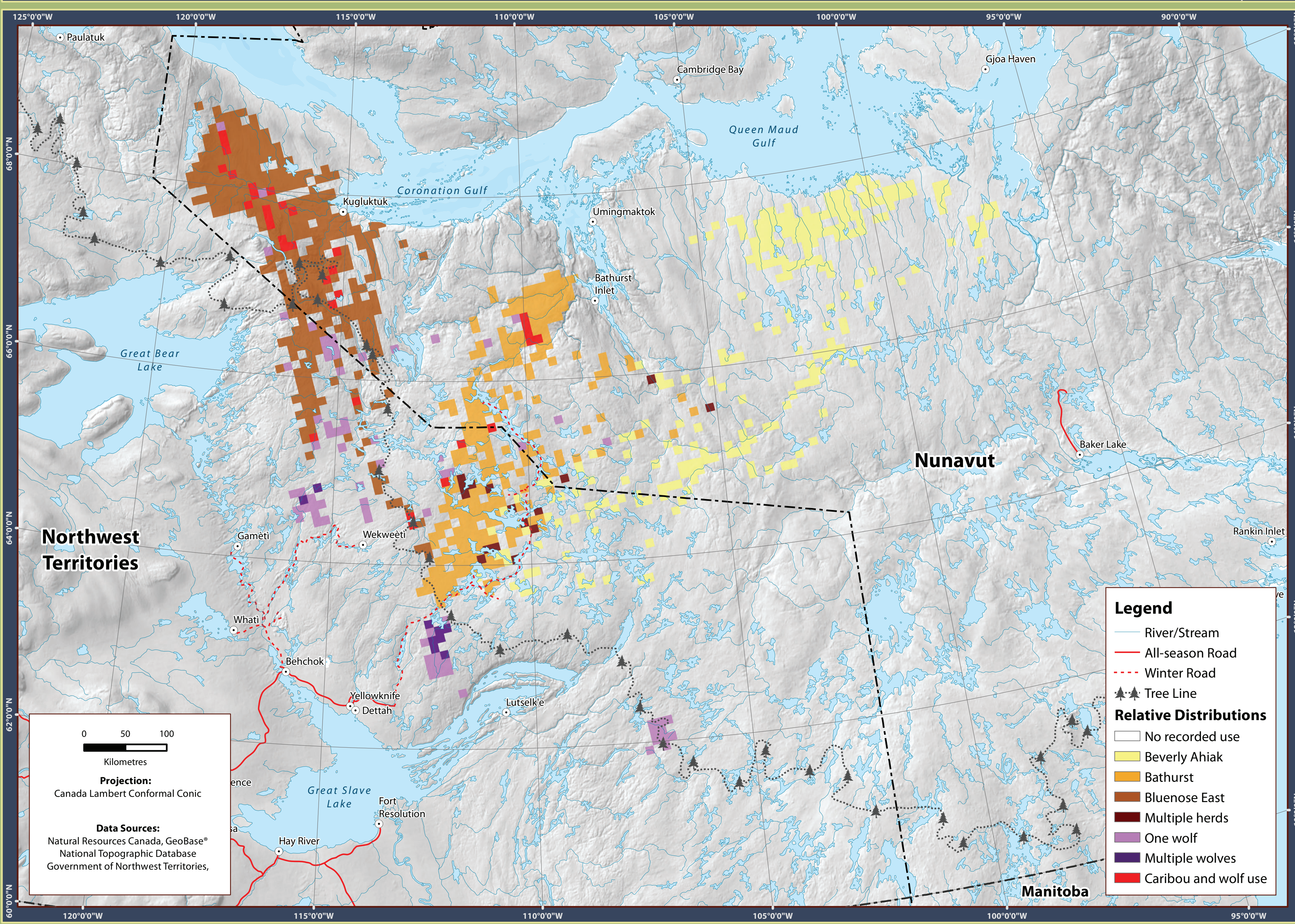
Relative Distriutions Barren-ground Caribou and Wolves - August 2020

DRAFT



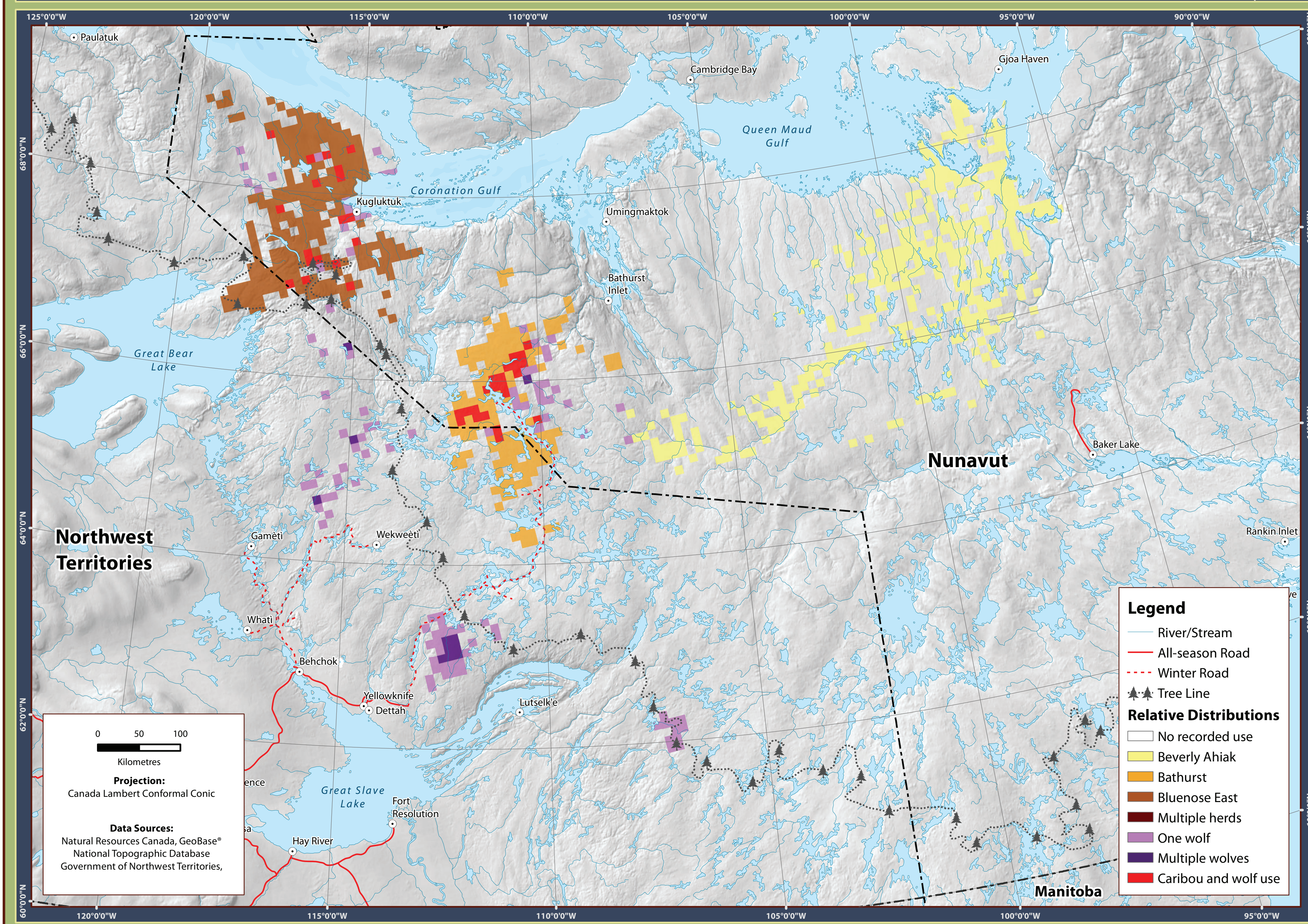
Relative Distriutions Barren-ground Caribou and Wolves - June 2020

DRAFT



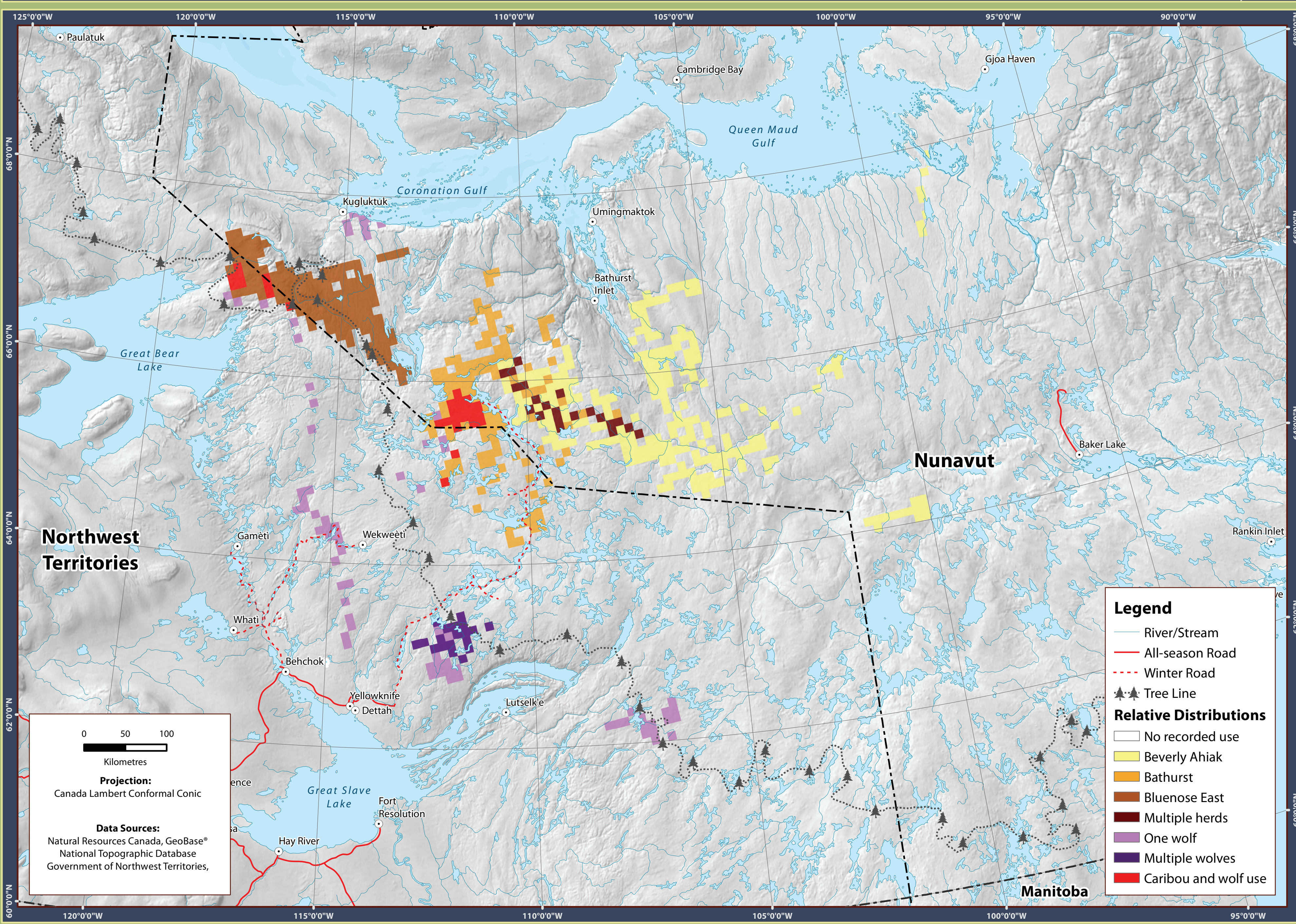
Relative Distriutions Barren-ground Caribou and Wolves - July 2020

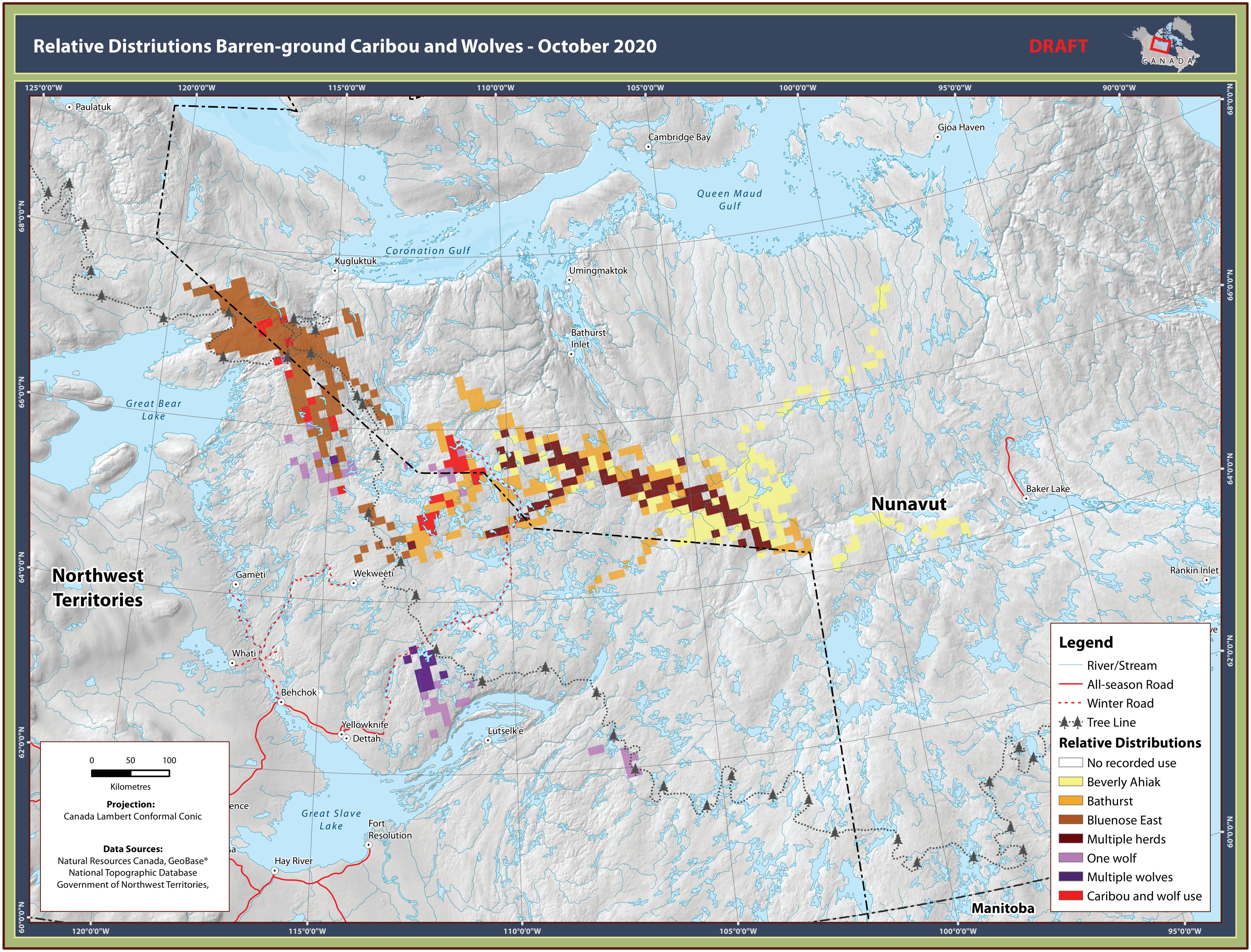
DRAFT



Relative Distriutions Barren-ground Caribou and Wolves - September 2020

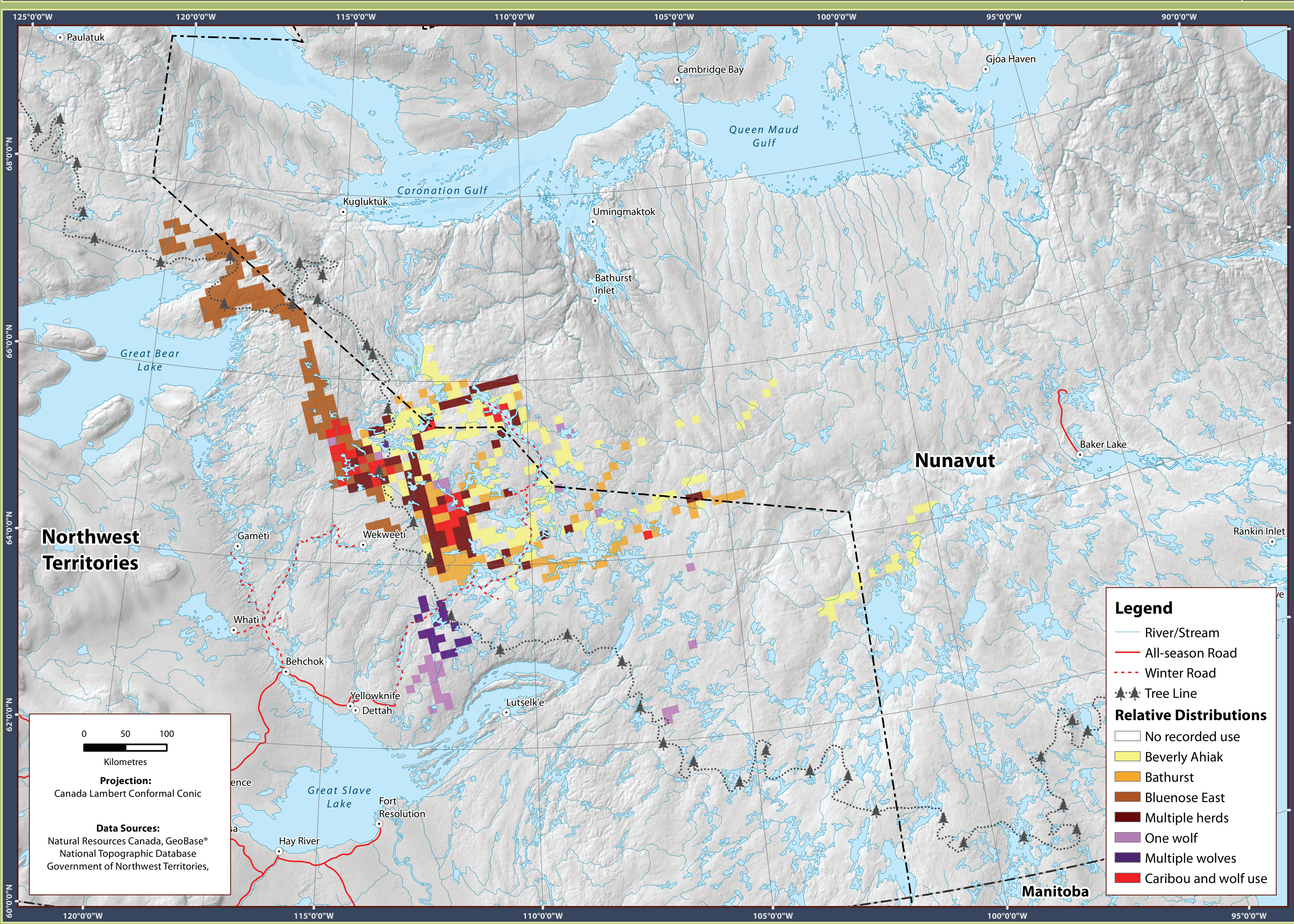
DRAFT




Relative Distriutions Barren-ground Caribou and Wolves - October 2020
DRAFT
CANADA
Paulatuk
Cambridge Bay
Gjoa Haven
Queen Maud Gulf
Coronation Gulf
Kugluktuk
Umingmaktok
Bathurst Inlet
Great Bear Lake
Nunavut
Baker Lake
Northwest Territories
Gamèti
Wekweètì
Rankin Inlet
Whatì
Behchok
Yellowknife
Dettah
Lutselk'e
Great Slave Lake
Fort Resolution
Hay River
Manitoba
0 50 100
Kilometres
Projection:
Canada Lambert Conformal Conic
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Government of Northwest Territories,
Legend
River/Stream
All-season Road
Winter Road
Tree Line
Relative Distributions
No recorded use
Beverly Ahiak
Bathurst
Bluenose East
Multiple herds
One wolf
Multiple wolves
Caribou and wolf use

Relative Distriutions Barren-ground Caribou and Wolves - November 2020

DRAFT



APPENDIX E - WOLF INJURY DOCUMENTATION FORM

Location	H.	B.	Fractures	Puncture wounds (ex; en)	Other
Head					
Neck					
L Shoulder					
R Shoulder					
L Forelimb					
R Forelimb					
L Flank (external)					
R Flank (external)					
Chest/thorax (internal)					
Abdomen (internal)					
L Hindlimb					
R Hindlimb					
Tail					

Wolf Injury Documentation

NSR number _____________

Volume of blood in chest:

Volume of blood in abdomen:

Total number of bullet holes:

Likely killing shot/injury:

Fetuses/Feti	Crown-rump length	Weight