Taimyr Wild Reindeer Spatial Fidelity and Calving Grounds Dynamics in a Changing Climate

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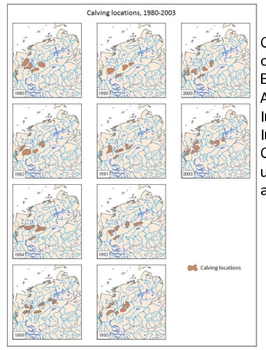
Abstract

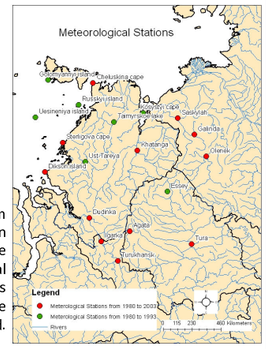
Historical evidence appears to show that *Rangifer tarandus* demonstrate spatial fidelity to specific locations, particularly during calving. However, calving locations exhibit periodic and abrupt changes that create a dramatic impact on ecosystems, population densities, and can cause conflict with other ungulates. The purpose of this study was to investigate the spatial fidelity of the Taimyr wild reindeer herd (TRH) to calving locations and identify possible climatic factors that influence the geographic shift of calving grounds. In order to quantitatively establish the presence of spatial fidelity, four indicators were developed. Spatial fidelity was confirmed through concentration of calving range, overlap between calving ranges, deviation from the geographic mean, and temporal variation of calving ranges. These measures showed three calving areas that TRH use more than 50% of the time. Although the TRH show spatial fidelity, they have experienced subtle, but significant shifts in calving locations. Our models found that the distance traveled from the winter concentration, cloud cover, humidity, and concentration of calving range plays a significant role in determining calving locations. In the future a multi-criteria model should be developed to better understand the causes and consequences of the spatial shifts as well as to assess the role of climate change in reindeer herd dynamics.

Data



Calving locations obtained from the Extreme North Agriculture Research Institute in Noril'sk. 67 Individual Calving Concentrations were used for regression analysis.

Climate data came from the Russian Meteorological Service (ENARI) from local meteorological stations shown above for whole study period.



Climatic and geographic variables considered for correlation

Variables	Units	Calculation of Variable
Lower Cloud Cover	Grades	Average monthly
Precipitation	Millimeters	Average monthly
Humidity	Percent	Average monthly
Snow Cover Depth	Centimeters	Average monthly
Total Cloud Cover	Grades	Average monthly
Surface Temperature	Degrees Celsius	Average monthly
Wind Speed	Meters per second	Average monthly
Distance Traveled from Winter Range to Calving Range	Meters	Distance between geog. mean of winter range and the geog. mean of the yearly calving range.
Longitude of Calving Range	Meters	Longitude value of the geog. mean of yearly calving range
Latitude of Calving Range	Meters	Latitude value of the geog. mean of yearly calving range.
Concentration of Calving Range	Square Meters	Area of individual calving range
Deviation from overall Calving Range	Meters	Distance from the geog. mean of the yearly calving range to the geog. mean of the overall calving range.

Methods

Statistical Analysis of Calving Concentrations → Interpolation of Climatic Variables → Climatic Variables for Calving Concentrations → Regression Analysis

Spatial Fidelity

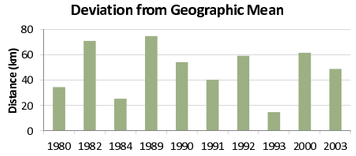
Spatial fidelity is the tendency of an animal to maintain similar space use patterns among a certain period of interest. Knowing that spatial fidelity is present and to what location is useful for habitat management or determining how changes affects a species. Other caribou herds exhibit spatial fidelity during calving.

Measures of spatial fidelity:

- Concentration (or dispersion) of calving range
- Overlap between consecutive calving ranges
- Deviation from the geographic mean of the overall calving range
- Temporal Variation

Deviation from Geographic Mean

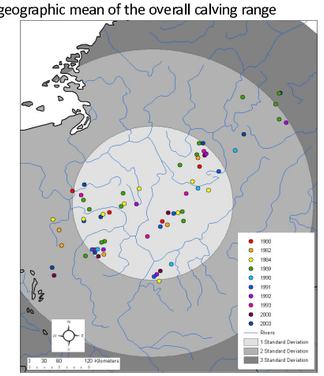
Deviation from the geographic mean of the overall calving range describes similarity on a long term scale. Smaller distances between the overall geographic mean and individual calving year indicates spatial fidelity. Deviation from the geographic mean of the overall calving range averaged 48 km, which in relation to the total TRH range was negligible also confirming spatial fidelity

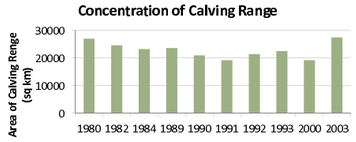


Concentration of Calving Range

The concentration of the calving range verified clustering when 76% of calving ranges were located within one standard deviation and calving range occupied less than 2% of the total TRH range.

Geographic means and standard deviation from the geographic mean of the overall calving range

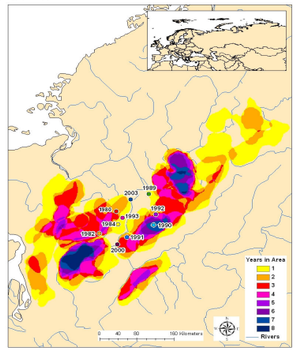




Temporal Variation

Temporal trend in location of the calving ranges examines the trend and location of yearly calving ranges. Mean direction was south at 172°, but circular variance showed that movement spanned the entire compass. with no consistent pattern. From the map, three areas were frequented more than 50% of the years studied.

Spatial distribution and yearly geographic mean of the calving surveys indicating how often reindeer were found in the area.

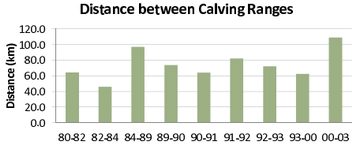


Overlap between Calving Ranges

Overlap between calving ranges is a measure of how similar ranges are from year to year. Overlap was calculated based on Gunn et al. 2008. The percent overlap and distance between calving ranges confirmed spatial fidelity with an average of 28% overlap and only on average 74 km difference between locations.

Matrix of annual overlap (%) of calving grounds.

	1980	1982	1984	1989	1990	1991	1992	1993	2000	2003
1980	100									
1982	30.5	100								
1984	38.0	10.6	100							
1989	30.1	16.1	22.8	100						
1990	12.8	31.2	28.3	22.2	100					
1991	38.4	15.2	37.8	29.9	36.1	100				
1992	15.3	20.4	15.4	30.5	30.3	32.3	100			
1993	46.0	17.6	25.9	41.2	31.7	41.7	30.9	100		
2000	23.6	20.4	15.6	30.5	47.3	47.3	16.9	37.2	100	
2003	15.0	15.6	19.5	36.3	27.0	24.6	23.1	36.6	31.8	100



Factors Affecting Spatial Fidelity

	Humid	Low Cloud	Precip	Snow Depth	Surface Temp	Total Cloud	Wind Speed	Conc. Of Range	Dev. From Mean	Long	Lat	Winter Dist.
Conc. of Range	-.136	.024	.066	**.413(**)**	.213	**-.324(**)**	**-.246(*)**	1	-.052	-.065	-.089	**-.333(*)**
Dev. Mean	.227	.187	-.119	-.181	.136	.145	**.283(*)**	-.052	1	**.391(**)**	**.504(**)**	-.002
Long.	-.232	**-.255(*)**	-.233	-.216	**-.325(**)**	-.022	**-.316(**)**	-.065	**.391(**)**	1	**.745(**)**	**-.443(**)**
Lat.	.103	.057	**-.331(**)**	-.070	**-.304(*)**	.077	.016	-.089	**.504(**)**	**.745(**)**	1	.004

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level

Spatial Fidelity and Geographic Distribution Models

Concentration of calving range and deviation from the geographic mean of calving range were used in the spatial fidelity regression analysis to determine which factors affect the spatial fidelity from year toy year. Longitude and latitude of a specific calving range were used as independent variables to determine which variables affect the geographic distribution of a calving range from year to year.

Model Name	Concentration of Calving Range	Deviation from Geographic Mean	Longitude of Calving Range	Latitude of Calving Range
R^2	0.522	0.453	0.883	0.851
Significant Variables	Total Cloud Cover (-)	Low Cloud Cover(+)	Humidity (-)	Humidity (+)
	Snow Height (+)	Temperature (+)	Concentration of Calving Range (-)	Temperature (-)
	Distance traveled from winter concentration (-)	Distance traveled from winter concentration (+)	Distance traveled from winter concentration (-)	Distance traveled from winter concentration (+)
	Longitude (-)	Longitude (+)	Latitude (+)	Longitude (+)
	Latitude (+)			Precipitation (-)
				Concentration of Calving Range (+)

Conclusion

The four spatial fidelity measures confirm that the **TRH does exhibit spatial fidelity to calving locations.** On average there was a 28.5% overlap between consecutive calving surveys, calving ranges occupy less than 2% of total TRH range, deviation from geographic mean was on average 48 km, and temporal variation found three areas that TRH are found more than 50% of the time all contribution to the confirmation that the TRH exhibits spatial fidelity.

However, the four measures also show that **variation occurs from year to year.** Spatial fidelity models found that the cloud cover, distance traveled from the winter concentration, and longitude of the calving range are important in determining the location of the current calving range. The geographic distribution models found that humidity, concentration of the calving range, and the distance traveled from the winter concentration play an important role in determining the geographic distribution of a calving range. Winter conditions appear to have the most significant impact on calving ranges.

Summary of spatial fidelity factors among *Rangifer tarandus* herds.

Herd	Location and Surveyed Years	Population Size (Min- Max)	Size of Calving Range (km²)	Overlap (%)	Distance between surveys (km)
Taimyr	Taimyr, Russia 1980-2003	110 000 – 1 000 000	19 228 –27 472	11 - 36	46 – 109
Bathurst (Gunn et al., 2008)	Northwest Territory, Canada 1966-2007	31 900 –55 600	7 937 - 23 372	4 - 78	4- 120
Rivière- aux- Feuilles (Taillon et al., 2012)	Quebec, Canada 1995 -2010	56 000 – 1 193 000	19 740 –158 000	Avg 48	NA
Rivière- George (Taillon et al., 2012)	Labrador, Canada 1974- 2009	5 000 –775 000	2 000 –66 000	6- 49	NA

Acknowledgements

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