Caribou Range Assessment and Technical Information

APPENDIX E:
Assessment of Seasonal Range Assumptions

1 Overview

Based on discussions arising from a BCRP technical workshop (June 2017), we assessed the implications of input assumptions used to derive the weighted relative range sensitivity map, and the subsequent influence of the sensitivity map on the benchmarking of disturbance thresholds. As shown in Figure 1, the relative sensitivities of seasonal ranges were important assumptions that contributed to the spatial pattern of weighted sensitivities (see Section 4.2.3.2 of main report). In turn, the spatial distribution of weighted sensitivities (Figure 2) was used as an input in to benchmarking disturbance thresholds that were initially defined in reference Range Assessment Areas (RAA), i.e., RAA2 and RAA4 respectively (see Section 4.2.4 of main report).

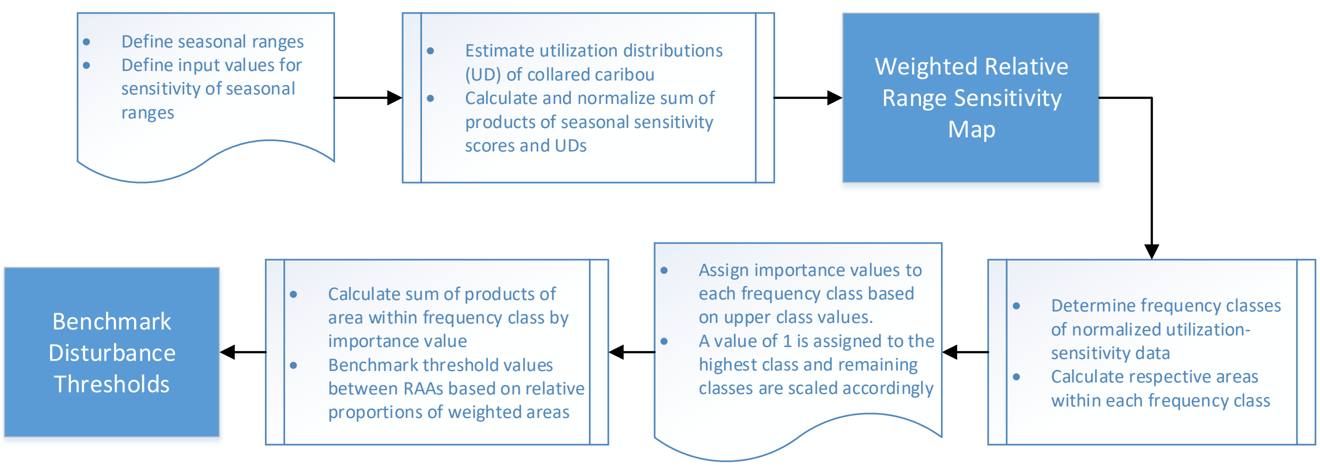


Figure 1. *Methodological approach for incorporating seasonal caribou-range sensitivities in to a weighted relative range sensitivity map, which in turn was used to benchmark disturbance thresholds.*

2 Key Assumptions

2.1 Seasonal Ranges

For the BCRP, we defined an annual life-cycle as comprising five (5) distinct seasonal ranges. Using seasonal ranges to describe the caribou's annual life-cycle is a simplified representation of the true seasonal changes and dynamics in migratory behavior of barren-ground caribou, but it is a useful descriptive convention. We based the description of the seasonal ranges on Nagy's (2011) empirical assessment of 12 activity periods, which he differentiated based on average movement rates of collared Bathurst caribou cows (see Section 3.3.1 of main report).

Although we did not assess the empirical consequences of considering a range in variability in the timing of seasons on weighted range sensitivity maps, we recognize that there are different approaches for defining biological activity periods for caribou, and provide a descriptive summary and comparison of two approaches by Nagy (2011) and Gunn et al. (2013) in Figure 3. Although Nagy (2011) and Gunn et al. (2013) described 12 and 8 activity periods for the Bathurst herd respectively, when we aggregated the activity periods in to 5 seasonal ranges, the timing and extent of the seasonal ranges were similar (Figure 3).

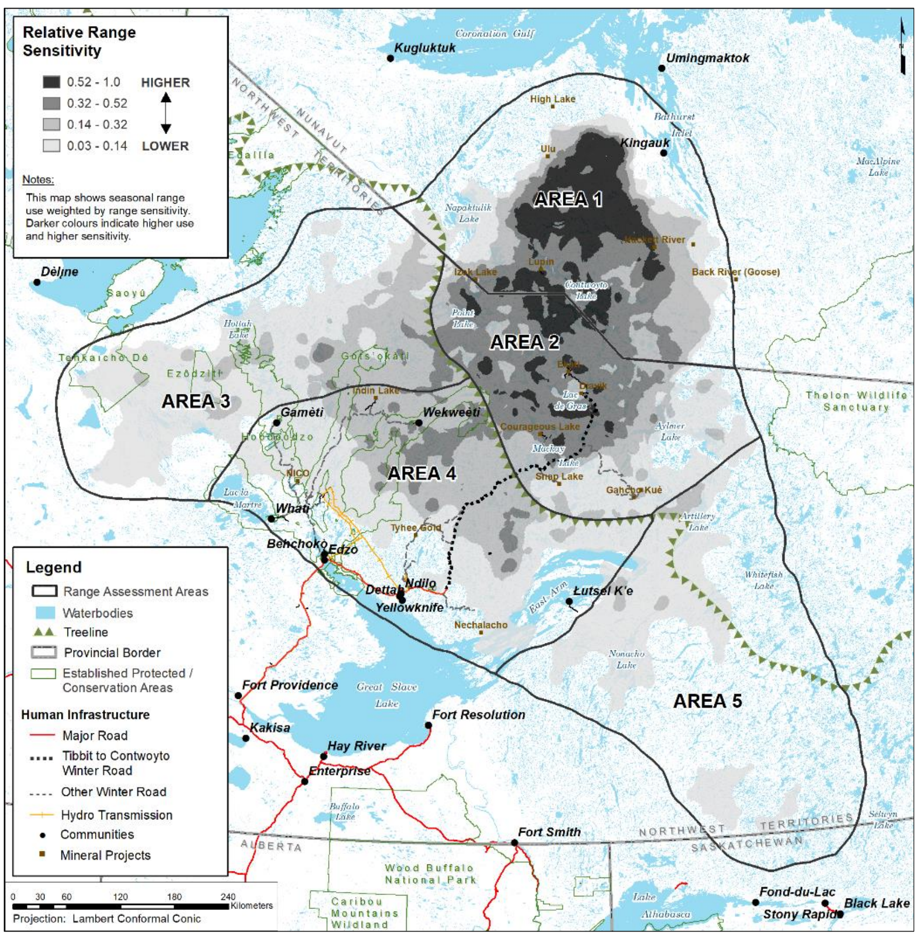


Figure 2. Spatial distribution of weighted relative range sensitivity across the BCRP planning area.

2.2 Input Values for Sensitivity of Seasonal Ranges

As described in Section 4.2.3.1 of the main report, we adapted an approach used by the Beverly and Qamanirjuaq Caribou Management Board (BQCMB 1999) and Porcupine Caribou Technical Committee (PCTC 1993) to rate relative sensitivity of: a) caribou to disturbance during its annual life cycle, and b) the sensitivity of range used by caribou during those life cycle periods, i.e., the seasonal ranges. The primary outcome for incorporating seasonal caribou-range sensitivity values was the generation of a weighted relative range sensitivity map (see Figure 2), which illustrated important areas for Bathurst caribou within its annual range. By calculating weighted relative sensitivity values, important areas for caribou were defined as those portions of the annual range that have been: a) used most frequently by caribou (based on collar data from 1996 – 2014), and b) where caribou and range have higher sensitivities (i.e., lower tolerances) to disturbance.

In response to discussions from the June 2017 BRCP technical workshop, we varied the relative caribou-range sensitivity values to evaluate its influence on the distribution of weighted relative range sensitivity areas. These analyses were conducted to address the following issues:

a) numerical ratings of sensitivity values presented beyond the decimal point imply a level of precision that is not warranted; and
b) sensitivity of the fall seasonal range should be increased to be more consistent with a recent assessment by Poole and Gunn (2015) on susceptibility of barren-ground caribou to disturbance.

Figure 4 summarizes the influence of the caribou-range sensitivity values on the weighted relative range sensitivity outputs. Key results as summarized in Figure 4 are twofold:

- Inputting caribou-range sensitivity values for summer and winter as decimal fractions was not meaningfully different than when the values were inputted as whole numbers. There was a minor difference (i.e., < 4%) in composition of the second highest frequency class in RAA4. Consequently, the whole number values were used as current assumptions in the Draft Bathurst Caribou Range Plan.
- Increasing the fall sensitivity value from low (4) to moderate (6), increased the amount of area in the highest category of weighted relative range sensitivities in RAA1 and RAA2 by 2.8% and 5.6% respectively. Compared to the current assumptions, there was a 3.5% increase in the proportion of RAA4 that occurred in the second highest frequency class. Overall, the differences resulting from increasing fall sensitivity from low to moderate were considered minor.

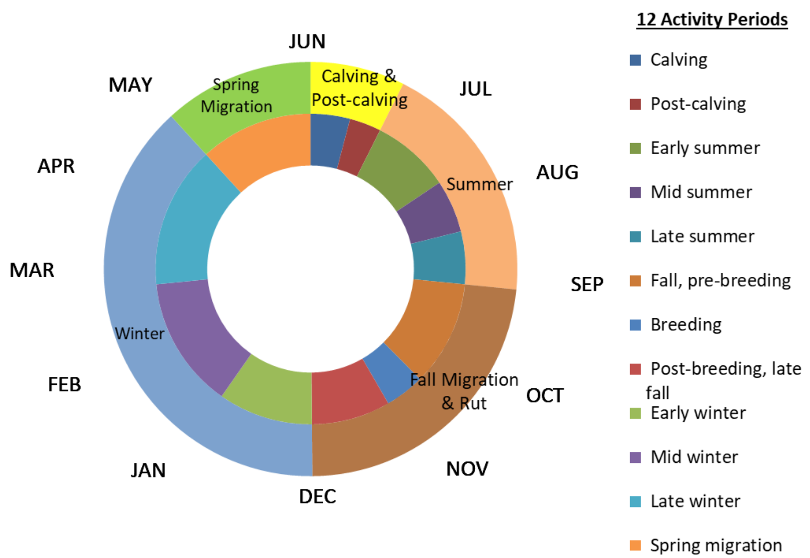
2.3 Benchmarking Disturbance Thresholds

In addition to comparing the influence of different caribou-range sensitivity values on the spatial distribution of weighted relative range sensitivity classes, we also assessed how the sensitivity input assumptions may affect values of benchmarked disturbance thresholds. To assess the influence of sensitivity values, we calculated the corresponding benchmarked disturbance thresholds based on the method described in Section 4.2 of the main report.

The results of these calculations are summarized in Table 1, and show that there was no difference in benchmarked threshold values between original and current assumptions.

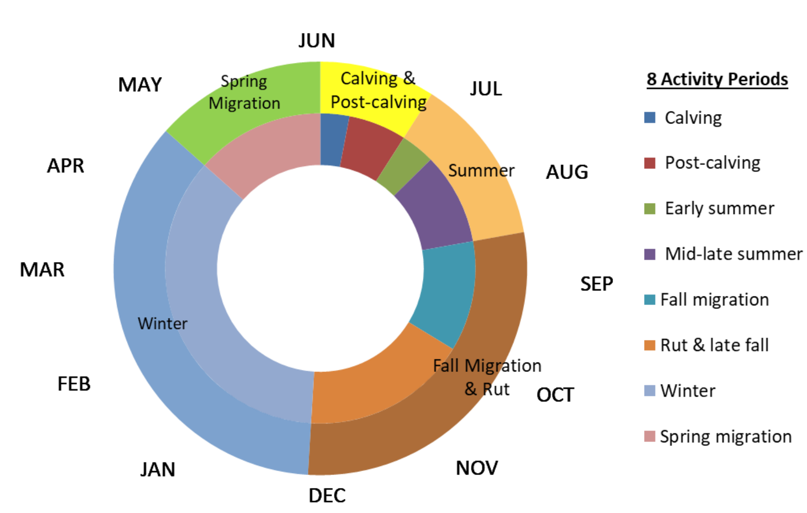
Under the modified assumption, where the fall caribou-range sensitivity value was increased from low (4) to moderate (6), the benchmarked disturbance threshold in RAA1 was estimated at 17% or 13,000 km^2, which was greater than the 16% disturbance threshold assigned in RAA2. This occurred because under the modified assumption, the difference in proportions of weighted areas between RAA2 and RAA1 increased. Based on the benchmarking method, the disturbance threshold in RAA1 was increased by 1% to 17% to account for the difference in proportion of weighted areas (Table 1).

A) 12 activity periods defined by Nagy (2011)



Seasonal Range	Start	End	Days	Year (%)
Calving & Post-calving	02-Jun	28-Jun	27	7.4%
Summer	29-Jun	06-Sep	70	19.2%
Fall Migration & Rut	07-Sep	30-Nov	85	23.3%
Winter	01-Dec	19-Apr	140	38.4%
Spring Migration	20-Apr	01-Jun	43	11.8%
			365	100.0%

B) 8 activity periods defined by Gunn et al. (2013)

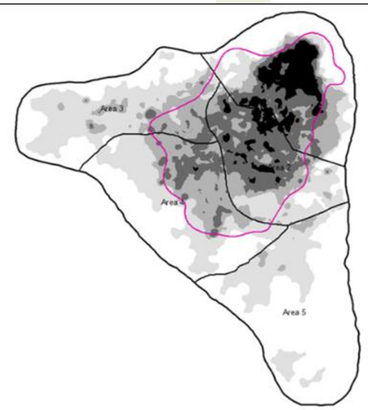


Seasonal Range	Start	End	Days	Year (%)
Calving & Post-calving	03-Jun	05-Jul	33	9.0%
Summer	06-Jul	22-Aug	48	13.2%
Fall Migration & Rut	23-Aug	05-Dec	105	28.8%
Winter	06-Dec	14-Apr	130	35.6%
Spring Migration	15-Apr	02-Jun	49	13.4%
			365	100.0%

Figure 3. *Characteristics of five seasonal ranges for Bathurst caribou based on aggregation of A) 12 or B) 8 activity periods. Activity periods are represented by the inner circle, and align with the timing and extent of 5 seasonal ranges that are represented by the outer circle. Descriptive details of timing and extent are summarized in respective tables.*

A) Original assumptions (decimal fractions)

Season	Start - End Dates	Sensitivity to Disturbance: Habitat	Caribou	Overall	Sensitivity Scores to Disturbance: Habitat	Caribou	Overall
Spring Migration	20 Apr - 01 Jun	Moderate	Moderate	Moderate	3	3	**6**
Calving & Post-calving	02 Jun - 28 Jun	Very High	Very High	Very High	5	5	**10**
Summer	29 Jun - 06 Sep	Moderate-High	High	High	3.6	3.9	**7.5**
Fall	07 Sep - 30 Nov	Low	Low	Low	2	2	**4**
Winter	01 Dec - 19 Apr	Low	Low	Low	1.5	2.0	**3.5**

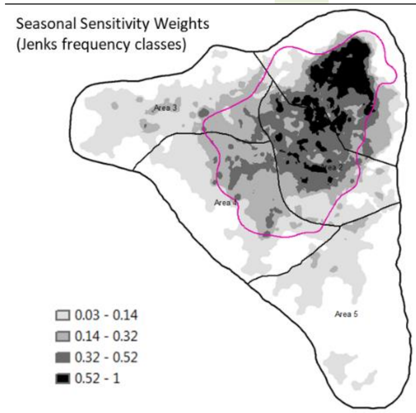


Sensitivity Class	0.03	0.14	0.32	0.52	1.0	(km²)
RAA 1	26365	9173	11253	14394	14709	**75,894**
RAA 2	3944	13418	12203	21628	4940	**56,133**
RAA 3	27267	31686	15046	2998	0	**76,997**
RAA 4	31002	25267	19755	8757	81	**84,862**
RAA 5	69209	24136	1781	0	0	**95,126**

Sensitivity Class	0.03	0.14	0.32	0.52	1.0
Area 1	0.0%	0.0%	-0.2%	-0.1%	0.3%
Area 2	0.0%	-0.8%	0.7%	0.1%	0.0%
Area 3	0.0%	-0.4%	-0.8%	1.2%	0.0%
Area 4	0.0%	-1.8%	-1.9%	3.5%	0.1%
Area 5	0.0%	0.0%	0.0%	0.0%	0.0%

B) Current assumptions (whole numbers)

Season	Start - End Dates	Sensitivity to Disturbance: Habitat	Caribou	Overall	Sensitivity Scores to Disturbance: Habitat	Caribou	Overall
Spring Migration	20 Apr - 01 Jun	Moderate	Moderate	Moderate	3	3	**6**
Calving & Post-calving	02 Jun - 28 Jun	Very High	Very High	Very High	5	5	**10**
Summer	29 Jun - 06 Sep	Moderate-High	High	High	4	4	**8**
Fall	07 Sep - 30 Nov	Low	Low	Low	2	2	**4**
Winter	01 Dec - 19 Apr	Low	Low	Low	1	2	**3**

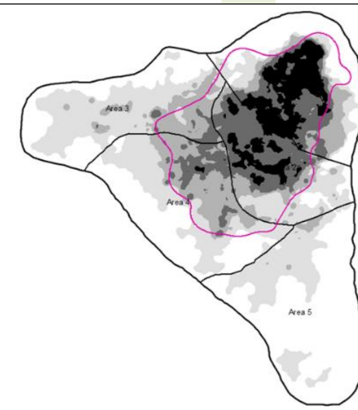


Sensitivity Class	0.03	0.14	0.32	0.52	1.0	(km²)
RAA 1	26365	9173	11417	14439	14500	**75,894**
RAA 2	3944	13875	11830	21545	4939	**56,133**
RAA 3	27267	32031	15644	2055	0	**76,997**
RAA 4	31002	26763	21345	5749	3	**84,862**
RAA 5	69209	24136	1781	0	0	**95,126**

Sensitivity Class	0.03	0.14	0.32	0.52	1.0
Area 1	-	-	-	-	-
Area 2	-	-	-	-	-
Area 3	-	-	-	-	-
Area 4	-	-	-	-	-
Area 5	-	-	-	-	-

C) Modified assumptions (moderate fall sensitivity)

Season	Start - End Dates	Sensitivity to Disturbance: Habitat	Caribou	Overall	Sensitivity Scores to Disturbance: Habitat	Caribou	Overall
Spring Migration	20 Apr - 01 Jun	Moderate	Moderate	Moderate	3	3	**6**
Calving & Post-calving	02 Jun - 28 Jun	Very High	Very High	Very High	5	5	**10**
Summer	29 Jun - 06 Sep	Moderate-High	High	High	4	4	**8**
Fall	07 Sep - 30 Nov	Low	Low	Moderate	3	3	**6**
Winter	01 Dec - 19 Apr	Low	Low	Low	1	2	**3**



Sensitivity Class	0.03	0.14	0.32	0.52	1.0	(km²)
RAA 1	26365	9042	10374	13459	16654	**75,894**
RAA 2	3944	12400	9390	22307	8092	**56,133**
RAA 3	27267	29674	17601	2455	0	**76,997**
RAA 4	31002	24364	20698	8712	86	**84,862**
RAA 5	69209	23618	2296	3	0	**95,126**

Sensitivity Class	0.03	0.14	0.32	0.52	1.0
Area 1	0.0%	-0.2%	-1.4%	-1.3%	2.8%
Area 2	0.0%	-2.6%	-4.3%	1.4%	5.6%
Area 3	0.0%	-3.1%	2.5%	0.5%	0.0%
Area 4	0.0%	-2.8%	-0.8%	3.5%	0.1%
Area 5	0.0%	-0.5%	0.5%	0.0%	0.0%

Figure 4. *Generalized sensitivity ratings for Bathurst Caribou and their seasonal ranges to land use. The figure is organized in to columns, which represent three different assumptions for caribou-range sensitivity values. The top tables summarize overall caribou-range sensitivity values and are followed below by the corresponding maps that illustrate the spatial distribution of the weighted relative range sensitivities in comparison to the center of habitation (highlighted in red). The tables directly below the maps summarize the amount of area within an RAA that occurs within each of the weighted sensitivity classes. The bottom tables summarize the differences in proportions of areas within each weighted sensitivity class, relative to current assumptions where caribou-range sensitivities are expressed in whole numbers.*

Table 1. *Benchmarked thresholds based on different input assumptions for caribou-range sensitivity values*

A) Original assumptions (decimal fractions)

Weighted Sensitivity Value	Area (km^2) Weighted Sensitivity Class 0.03	0.14	0.32	0.52	1.0	Total RAA Area	Total Disturbance Threshold[1]	% Total Disturbance	Sum of Products (Weighted Sensitivity Value x Area)	Remaining Area	Total RAA Area	% Sum of Products (Weighted Area)
RAA 2	3,944	13,418	12,203	21,628	4,940	56,133	**9,000**	16%	**22,088**	34,045	56,133	39%
RAA 1	26,365	9,173	11,253	14,394	14,709	75,894	12,000	16%	**27,870**	48,024	75,894	37%
RAA 4	31,002	25,267	19,755	8,757	81	84,862	**20,000**	24%	**15,424**	69,438	84,862	18%
RAA 3	27,267	31,686	15,046	2,998	-	76,997	19,000	24%	**11,628**	65,369	76,997	15%
RAA 5	69,209	24,136	1,781	-	-	95,126	25,000	26%	**6,025**	89,101	95,126	6%
Total	157,787	103,680	60,038	47,777	19,730	389,012	85,000	22%	83,035	305,977	389,012	21%

Inputted values; Derived values

[1] Benchmarked (i.e., derived) threshold values were rounded to the nearest 1,000 km^2

B) Current assumptions (whole numbers)

Weighted Sensitivity Value	Area (km^2) Weighted Sensitivity Class 0.03	0.14	0.32	0.52	1.0	Total RAA Area	Total Disturbance Threshold[1]	% Total Disturbance	Sum of Products (Weighted Sensitivity Value x Area)	Remaining Area	Total RAA Area	% Sum of Products (Weighted Area)
RAA 2	3944	13875	11830	21,545	4,939	56,133	**9,000**	16%	**21,989**	34,144	56,133	39%
RAA 1	26365	9173	11417	14,439	14,500	75,894	12,000	16%	**27,737**	48,157	75,894	37%
RAA 4	31002	26763	21345	5,749	3	84,862	**20,000**	24%	**14,500**	70,362	84,862	17%
RAA 3	27267	32031	15644	2,055	0	76,997	19,000	24%	**11,377**	65,620	76,997	15%
RAA 5	69209	24136	1781	0	0	95,126	25,000	26%	**6,025**	89,101	95,126	6%
Total	157,787	105,978	62,017	43,788	19,442	389,012	85,000	22%	81,628	307,384	389,012	21%

Inputted values; Derived values

[1] Benchmarked (i.e., derived) threshold values were rounded to the nearest 1,000 km^2

C) Modified assumptions (moderate fall sensitivity)

Weighted Sensitivity Value	Area (km^2) Weighted Sensitivity Class 0.03	0.14	0.32	0.52	1.0	Total RAA Area	Total Disturbance Threshold[1]	% Total Disturbance	Sum of Products (Weighted Sensitivity Value x Area)	Remaining Area	Total RAA Area	% Sum of Products (Weighted Area)
RAA 2	3,944	12,400	9,390	22,307	8,092	56,133	**9,000**	16%	**24,551**	31,582	56,133	44%
RAA 1	26,365	9,042	10,374	13,459	16,654	75,894	13,000	17%	**29,029**	46,865	75,894	38%
RAA 4	31,002	24,364	20,698	8,712	86	84,862	**20,000**	24%	**15,581**	69,281	84,862	18%
RAA 3	27,267	29,674	17,601	2,455	-	76,997	19,000	24%	**11,881**	65,116	76,997	15%
RAA 5	69,209	23,618	2,296	3	-	95,126	25,000	26%	**6,119**	89,007	95,126	6%
Total	157,787	99,098	60,359	46,936	24,832	389,012	86,000	22%	87,161	301,851	389,012	22%

Inputted values; Derived values

[1] Benchmarked (i.e., derived) threshold values were rounded to the nearest 1,000 km^2

3 Summary

The concept of seasonal ranges and the changes in relative sensitivities of caribou and range during the annual-life cycle reflect traditional and scientific knowledge. For the BCRP, we differentiated the annual-life cycle in to five (5) seasonal ranges and ranked their respective sensitivities based on previous expert-based characterizations of caribou-range sensitivity by the BQCMB (1999) and PCTC (1993).

The assumptions we used for caribou-range sensitivities were integrated in to a methodology to benchmark disturbance thresholds that were established in RAA2 and RAA4 respectively. We used the caribou-range sensitivities to estimate weighted relative sensitivity that was integrated with caribou utilization to provide a way to benchmark disturbance thresholds in RAAs. We did not apply the caribou-range sensitivity values to derive spatially or temporally explicit management recommendations for land disturbance or mitigation, which would have required higher confidence in fine-grained spatial and temporal accuracy. In this context, we suggest the differentiation of five seasonal ranges and application of caribou-range sensitivities was appropriate because the assumptions were applied in a manner consistent with the strategic-level assessment of disturbance thresholds. The range of assumptions we explored for the caribou-range sensitivities did not substantially affect the benchmarked estimates of disturbance thresholds in RAAs.

We applied the concept of caribou-range sensitivity based on previous work by the BQCMB (1999) and the PCTC (1993), which was based largely on expert opinion and accumulated experience with migratory caribou. Application of caribou-range sensitivities in the BCRP was used to help broadly define important areas for Bathurst caribou. This applied concept of sensitivity is consistent with a definition used for sensitivity assessments of marine ecosystems, which is the tolerance (or intolerance) of a species or habitat to damage or disturbance from an external factor, with consideration to the time required for subsequent recovery (*sensu* Laffoley et al. 2000, Tyler-Walters & Hiscock 2005). However, additional work is needed to establish an empirical basis for caribou-range sensitivity with appropriate spatial and temporal specificity if it is to be used to develop and implement tactical caribou range management recommendations. This work may also help define ‘critical habitat’ for barren-ground caribou.

4 References

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