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Adam Scott
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Re: Review of the barren-ground caribou movement and habitat selection analyses from telemetry data report

Dear Adam Scott,

The Independent Environmental Monitoring Agency (Agency) has reviewed the Burgundy Diamond Mine (Burgundy) barren-ground caribou movement and habitat selection analyses from telemetry data report (telemetry report) for the Ekati Diamond Mine, prepared by Rettie et al. and released on 26 February, 2024. Burgundy held a virtual wildlife telemetry workshop on 11 April, 2024 to present the rationale, methods and results of the analysis. The Agency thanks Burgundy for the opportunity to comment on the report.

The telemetry report covers Stage 1 of a study to address concerns raised for many years by a number of stakeholders about the effect of the Ekati Diamond Mine on caribou behaviour when they approach the mine. The study in part was a reaction to an analysis conducted by the Agency that suggested that current mitigation is not effective at facilitating caribou movement through the mine site (Poole et al. 2021). Burgundy's telemetry study is a detailed analysis of radio-collar location data to examine the responses of caribou to mine infrastructure and mine roads after accounting for land cover distribution and insect abundance.

The telemetry report was reviewed by Kim Poole, Agency Director. The Agency also contracted Dr. Craig DeMars, Biodiversity Pathways | Wildlife Science Centre, to assist in the review.

We appreciate that the authors have invested a significant amount of effort into this analysis, and the presentation on 11 April helped clarify the process that was undertaken. However, the Agency finds the analysis to be unnecessarily dense and complex, and we have a number of concerns, comments and recommendations regarding the report. We have broken these into overall comments, followed by more specific comments. We appreciate that our comments are often highly technical in nature, but this level of comment is required to address our concerns.

Overall comments

1. Analyses objectives and approach

Model selection obscures focal objectives

Model selection is appropriate for finding the most parsimonious (best and simplest) model for generally explaining the spatial behaviour of caribou, but it is sometimes less satisfactory if there is a specific objective or hypothesis of interest that is encapsulated by a covariate or suite of covariates. In this case, there is specific interest in caribou responses to mine infrastructure. Although covariates representing these caribou-mine relationships may not be in the top model as determined by model selection, it is still useful and relevant to know their specific outcomes, particularly if the animal is maintained as the sampling unit (see below). As a hypothetical example, distance-from-mine-infrastructure may not be in the top model as selected by Akaike information criterion or Bayesian information criterion (criterion for selecting the best model), but knowing that 75% of caribou selected for distances further from mines than random expectation (while accounting for the selection of other covariates) may be useful information to convey. In general, summaries of the percent of animals showing a specific focal behaviour are more useful and intuitive than model selection results, beta coefficients and p-values.

Analyses incorporating caribou movement

The Burgundy study largely focussed on broad-scale movements of caribou potentially interacting with the mine. For example, the executive summary stated "*The results did not generally support concerns of exposure to diamond mining infrastructure and roads yielding deflected,* ***longer movements*** *by caribou, nor* ***delays in range-scale movements***" (emphasis added; p. x). From the Agency's perspective, the main goal of the study should have been to determine if and how mine development impacts caribou movement, habitat selection, and distribution as they approach the mine. With that in mind, the study design should have evaluated how movement parameters (e.g., step length and turning angle) interacted with other covariates of interest. We fully acknowledge that habitat selection per se drives many decisions regarding caribou movements. But to address the question at hand, interacting distance-from-mine with step length and turning angle would yield inferences on whether movement speed and directionality changed as a function of proximity to mine, while accounting for the selection of other covariates. Simply regressing step length and turning angle against distance-from-mine-infrastructure (simple to "*satisfy requests of GNWT-ENR [ECC] and IEMA*", p. 29) outside of the Integrated Step Selection Function (iSSF) model misses one of the key advantages to iSSF modelling; that is, accounting for how movement influences habitat selection and vice versa (Avgar et al. 2016). This integrated approach would provide stronger inferences on how the mine potentially influences caribou movement and habitat selection. Such an approach would also render the separate regression analyses unnecessary.

Also, the authors appear to have misinterpreted the coefficients for the movement parameters (turning angle and step length) in their iSSFs (see Section 3.7 Step length and turning angle, p.44). For example, a negative coefficient for step length is incorrectly interpreted as shorter steps lengths being correlated with higher habitat selection values. The step length coefficient actually represents how the observed distribution of step lengths (the "used" steps) differs from the modelled distribution (the random steps).

A negative coefficient does not imply that step lengths get shorter with increasing probabilities of habitat selection (see Avgar et al., 2016 and Fieberg et al., 2021).

Recommendation: Burgundy should revise the analysis to ensure that step length and turning angle are examined concurrent with distance to mine, while accounting for the selection of other covariates. Burgundy should also ensure that the interpretation of negative coefficients is appropriate.

2. Caribou as the sample unit

The habitat selection analyses (HSA) used a method where all collar individuals were combined and contributed to a single overall model for each season and sex, to assess the effect of the proximity of the mine on seasonal habitat selection. Our preference is to explicitly maintain the animal as the sampling unit. Such an approach yields variance estimates that represent variation among individual caribou. Moreover, this approach allows for an explicit evaluation of the percentage of the population exhibiting a given behaviour, which is advantageous for assessing potential population-level impacts from mine developments and activities. For example, if a portion of the population is doing one thing and the other portion is doing the opposite, then the 'average' population level analysis could result in a finding of no significance, while in fact half of the sampled individuals are reacting (selection or avoidance). This also helps to balance out the importance of animals by not over-emphasizing those with the highest number of locations within the mine halo. For the most part the importance of the animal as the sampling unit is not carried through for HSAs. By not maintaining the animal as the sampling unit, variance estimates and p-values are not really interpretable at the population scale (see for example Muff et al., 2020 and also Northrup et al. 2022).

Recommendation: Burgundy should restructure the analysis to consider the animal as the sampling unit.

3. Consideration of mine infrastructure and roads

Distance to mine infrastructure and distance to mine roads were examined separately; in effect there was no single 'distance to mine'. The ratio of nearest distance to either entity differed between the 8-hour and 1-hour analyses. This separation was one of the preliminary group recommendations when the analyses methodology was being developed 1.5 years ago ("*Distance to roads and distance to other mine infrastructure will be determined separately*") (Slide 6, 15 Sep 2022 workshop slide deck). That aside and now that we have seen the analysis, we question whether a single mine footprint would have resulted in a stronger signal of mine effect. Vehicle traffic may be one of the main sensory disturbances for caribou (Severson et al. 2023, Boulanger et al. 2024), and vehicles certainly frequent the main mine footprint. We know that traffic at site and on the roads varied markedly during the study period – the Covid 19-related closure of the mine during 2020-21 ensured little consistency in sensory disturbance over time.

Recommendation: Burgundy should examine how analyses with a single mine footprint compares with separate examination of 'infrastructure' and 'roads'.

4. Application of SSF and iSSF

We are not entirely clear why Step Selection Functions (SSFs) were used in some instances and iSSFs in others (i.e., for 8-hr data, movement parameters were excluded for Phase 1 but included for Phase 2

and the justification for this approach is not clear). We are unclear why the analysis did not just use one approach across all phases so that the comparison is more "apples-to-apples".

Recommendation: Burgundy should clarify the different approaches to different phases of the analyses.

5. Assessment of model performance

We suggest that the metrics of model performance presented here are not appropriate for HSAs. Because the used (GPS collar) locations are a subset of available locations, the two categories are not mutually exclusive. Receiver Operating Characteristic analyses evaluate the performance of binary classifiers where the two categories are mutually exclusive (see Boyce et al., 2002; Northrup et al., 2022). Moreover, in a used/available framework, it is not possible to estimate specificity (the true negative rate) because available locations are not necessarily unused (i.e., true negatives are unknown). These factors may contribute to the generally low performance of the HSA models in this report (e.g. Table 3-12, p.46).

Recommendation: Burgundy should provide a more appropriate metric of model performance, such as k-fold cross-validation or validation using a withheld data set (Northrup et al. 2022). See Fortin et al. (2009) for an example of a cross-validation approach for evaluating the predictive performance of SSFs.

6. Discussion

The Discussion is somewhat repetitive of the Results. There is no discussion of how the current results compare to other studies of caribou behaviour near development. The vast majority of papers that have examined the reaction by caribou to mines, roads and other source of human disturbance indicate significant impact of mines and mine roads on caribou movement and behaviour (references available upon request).

Recommendation: Burgundy should revise the discussion to compare their results with the broader literature.

7. Study conclusions

One of the conclusions at the end of the Discussion is "*Ecologically, the concerns of exposure to diamond mining infrastructure and roads yielding deflected, longer movements and delays in range-scale movements do not appear to be warranted*" (p. 84). We suggest this conclusion is not fully supported. Interacting step length and turning angle with distance-to-mine-infrastructure would have yielded stronger inferences on how caribou movement behaviour is or is not influenced by the mine. Also, a more transparent approach would have been to summarize the percentage of caribou displaying a given behaviour in response to covariates representing mine infrastructure/roads. This information is lost in the current analytical framework. The fact that [8-hr analysis] "*for female caribou; in every season the turning angle increased closer to mine infrastructure*" (p. 77) suggests that the mine is affecting caribou movement behaviour.

Recommendation: Burgundy should revise the report's conclusions, hopefully after a revision to the analysis.

Other comments

8. Objectives addressed in this analysis

Objective 2 states "*What are the effects and what are their causes?*" (p. 2). We suggest this objective is unanswerable in the current study, as the suspected drivers of disturbance are not examined (a Stage 2 objective).

Recommendation: Burgundy should clarify the objectives of the telemetry report.

9. Interpretation of distance to measure

Distance-to measures can often be difficult to interpret in terms of biological effects, even when they are log-transformed. For example, a feature could have an actual (but unknown) effect that only extends 1 km but a model that uses distance-to measures may yield inferences that an area 10 km away from the feature is less preferable than an area 100 km away (when in fact the two distances should be roughly equal). Exponential decay transformations of distance-to measures are often better for modelling effects that are predicted to decay after a given distance (see Nielsen et al., 2009 for an example)

Recommendation: Burgundy should consider using exponential decay transformations of distance-to measures analyses.

10. Number of random steps used in analyses

As discussed during the 11 April virtual presentation, we suggest that using 5 random steps in the analyses is too few and may result in a high level of sampling variance (Northrup et al., 2013). The authors suggest later in the Discussion that the low Rho^2_{adj} values for many models were due to minimal differentiation between attributes associated with used and available steps. Model performance could perhaps be improved by increased sampling of random steps per stratum (e.g. ≥20 random steps; Northrup et al. 2013).

Recommendation: Burgundy should review whether increasing the number of random steps paired with 'real' steps would improve model performance. Ideally, a sensitivity analysis should be used to determine the number of random steps for beta coefficients to stabilize (which will occur when sampling variance is minimized).

11. Turning angle

The report states that "*Poole et al. (2021) used 60° as a threshold of concern for turn angles*" (p. 83). In fact, Poole et al. (2021) used a turning angle of 60° as a metric for identifying a greater proportion of higher turning angles (>60°) possibly reflective of reactions to disturbance. The value was selected as the "*approximate median of the absolute value of relative turn angles for both herds (Bathurst 59.3°; Beverley/Ahiak 57.5°*)" (Poole et al. 2021: p. 10).

Recommendation: Burgundy should clarify this statement in the report.

12. Table of covariate acronyms

A table showing the covariates considered in the analysis and their acronyms used in the model appears to be missing. For example, 'WBAREA' is used 4 times in the main document and hundreds of times in the appendix document, but is never defined.

Recommendation: Burgundy should provide a table of covariate descriptions and their acronyms.

The Agency again acknowledges the effort placed into the Burgundy telemetry analyses and report. However, we submit that the analysis and report should be revised. We have identified a number of deficiencies in the report and provided suggested solutions to how these issues could be addressed. The Agency believes that these concerns need to be addressed before moving to Stage 2 analysis.

Should you have any questions concerning these comments, the Agency is pleased to discuss these at your convenience.

Sincerely,

Ron Allen
Vice-Chairperson

Cc: Burgundy– William Liu, Lindsay Seier, Harry O'Keefe, Sheila Chernys
Tłı̨chǫ Government – Violet Camsell-Blondin, Brett Wheler
Yellowknives Dene First Nation – Ryan Miller, Johanne Black
Łutsel K'e Dene First Nation – LKDFN Lands Manager
North Slave Metis Alliance – Orna Phelan, Noah Johnson, Alex Alan
Kitikmeot Inuit Association – Katrina Hatogina
Government of the Northwest Territories – Laurie McGregor, James Hodson
Crown-Indigenous Relations and Northern Affairs Canada – Megan Larose, Michael Roesch

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