February 10, 2023

Nunavut Planning Commission
Sharon Ehaloak
PO Box 1797
Iqaluit, NU XOA OHO

Re: Agnico Eagle's Final Written Comments to the 2021 Draft Nunavut Land Use Plan

Dear Ms. Ehaloak,

Thank you for the opportunity to provide Agnico Eagle's final written comments on the 2021 Draft Nunavut Land Use Plan (**DNLUP**).

Agnico Eagle recognizes and respects the hard work and achievement of the Nunavut Planning Commission (**NPC**) in bringing the DNLUP to this point and completing the public hearings in Cambridge Bay, Rankin Inlet, Thompson, Pond Inlet, and Iqaluit. We continue to support the development of a Nunavut Land Use Plan (**NLUP**), as required by the Nunavut Agreement (**NA**), and our following comments are intended to be constructive and to support the NPC in its goal of developing a fair and balanced draft for presentation to the signatories.

Agnico Eagle appreciates the large volume of submissions that NPC is likely to receive and has focused this submission accordingly. However, in making the following comments we also wish to emphasize that there is much in the current DNLUP that Agnico Eagle supports. We appreciate the care that NPC has taken in presenting information they received in their consultations with Inuit, communities, and stakeholders, such as participants in the mining industry. As an example, in Section 5.1 the DNLUP specifically acknowledges the importance of the mining industry as a key contributor to Nunavut's economy. We understand that NPC recognizes the challenge of existing rights and the need for proponents to have certainty with respect to their ability to continue to advance properties and build on the investments made to date. We also recognize the importance of addressing community views and feedback. In making the following suggestions, Agnico Eagle has relied on the creativity that has been shown by NPC in presenting various options for land use designations in the DNLUP that respect community values and IQ, while providing a path forward for responsible and sustainable development. We understand that compromise and collaboration is essential. We believe that a final NLUP can be achieved that will support the goals of the Nunavut Agreement, including those relating to environmental protection and opportunities for lasting economic prosperity, for years to come.

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1. Introduction

Agnico Eagle participated and presented in the DNLUP public hearings in Cambridge Bay, Rankin Inlet, Thompson MB, and participated in the final proceedings in Iqaluit. We have also provided a number of written submissions to NPC which are included in the NPC public registry, which this submission is intended to supplement.

As we presented to the NPC, Agnico Eagle has been implementing advice from the community that mining must proceed in a manner that protects caribou. In respect of our mines (Meadowbank Complex and Meliadine in the Kivalliq region, and Doris North/Hope Bay in the Kitikmeot region), Agnico Eagle provided evidence to NPC of its Terrestrial Environment Monitoring and Mitigation Plans (**TEMMP**) and related Terrestrial Advisory Groups (**TAG**) that apply to protect caribou at the mines in accordance with project certificates issued by the Nunavut Impact Review Board (**NIRB**). Agnico Eagle and the Kivalliq Inuit Association (**KivIA**) also discussed Mobile Caribou Protection Measures, which are a set of measures developed by KivIA that are tailored specifically to exploration activities.

As set out in this submission, we encourage the NPC to give formal recognition to these important tools that help protect caribou wherever they may be located. We also provided data on Agnico Eagle's monitoring activities, which confirm that effects on caribou are consistent with the environmental predictions made during the NIRB process. All of this information supports the conclusion that caribou and mining development can successfully co-exist. Agnico Eagle respectfully suggests that this information should be reflected as evidence in the final NLUP.

Evidence was also presented by Agnico Eagle that caribou are not static, and that Agnico Eagle has fundamental concerns with the methodology currently reflected in the DNLUP that was used to delineate map-based protection. We have serious concerns with a map-based protection approach in any event, but at minimum it is essential to ensure the data any such maps are based on is accurate. As explained in Section 4.3 we recommend that the NPC develop a focused polygon working group including scientists and knowledge holders to address the methodological errors reflected in the polygons that are currently included in the DNLUP, so they may provide a more accurate snapshot that could be included in the NLUP at a later date.

It is clear to all that caribou populations must be supported in Nunavut. However, we are very concerned that the prohibition/map-based options presented in the DNLUP will not be effective and will unfairly restrict current and future opportunities for the mining industry and Inuit to work together to develop mining projects that protect caribou and allow Inuit to achieve economic goals, particularly on Inuit Owned Lands. Agnico Eagle and the Kitikmeot Inuit Association (**KitIA**) align on this point. Agnico Eagle heard the message that protection of the environment and Inuit culture is a community priority, and we also heard that the availability of employment opportunities is an important value. Agnico Eagle shares many of the procedural concerns reflected in the various submissions from participants to date, including concerns about the level of understanding reflected by community members about the consequences for the map-based approach proposed by NPC during community consultations.

Communities and individuals with little to no mining experience, or experience based on techniques and approaches that may have applied before the NIRB was established, may not have an accurate basis for understanding the modern approach to mining. It is also crucial to understand the fundamental role of sustainable exploration in the mining cycle, both to keep existing mines open as long as possible and to find the next viable development opportunity. We are very concerned that prohibitions could be included in the NLUP based on such misunderstandings instead of facts, and generations of opportunity for Nunavummiut could be lost as a result.

Agnico Eagle also presented evidence of its significant and sustained financial commitment to Nunavut. Our vision is to be part of Nunavut for many years to come and to provide a model for sustainable development based on IQ and traditional knowledge. It is essential that existing mineral development rights be acknowledged and respected in the NLUP, along with the robust regulatory system that shapes development in Nunavut under the NA and the *Nunavut Planning and Project Assessment Act* (**NuPPAA**). There are multiple articles of the NA devoted to ensuring any development in Nunavut proceeds in a way that is respectful of community values and with the full involvement of Nunavummiut.

In making its following recommendations, Agnico Eagle also has given careful consideration to the potential approaches that were developed regarding these and other issues by the NPC. We respect the submissions that have been made by many parties regarding existing rights. We also respect the work that NPC has done to identify areas of importance to the community, including both valued ecosystemic components (**VECs**) and valued socioeconomic components (**VSECs**).

Taking all of this into account, Agnico Eagle endorses and strongly recommends that the final NLUP reflect the "Option 4" approach developed by NPC staff in the Options and Recommendations document. This Option 4 land use planning requirement would help proponents ensure their applications to NIRB and other authorities are complete and meaningfully address the issues that Inuit have identified in the NPC process. Relying on Option 4 means that values and priorities reflected in the NLUP would be given proper weight and consideration by the NIRB in the next step of the rigorous Inuit and community-centered regulatory process, and activities would not proceed to approval unless the requirements of the NA for development to proceed are met.

The Option 4 approach is simple and understandable, and also would reduce the need for complex grandparenting language regarding existing rights.

2. Agnico Eagle Contribution to Nunavut

The following section provides the NPC with additional information on Agnico Eagle's contributions to Nunavut to date, and also explains the importance of exploration in the mining cycle.

Agnico Eagle is committed to a long-term presence in Nunavut and to supporting its well-being through its operations. We are grateful for the opportunity to work with Inuit and to help support responsible exploration and mining on both Inuit Owned and Crown lands. It is essential for proponents to have certainty in their ability to explore and develop existing land tenures. This is required to ensure Agnico Eagle (and the mining industry in Nunavut as a whole) has the confidence necessary to support continuing future investments in a stable jurisdiction. Agnico Eagle is the contributor of more than 25% of the GDP of Nunavut, the largest miner and private sector employer in Nunavut. Since 2007, Agnico Eagle has invested more than $9 billion in Nunavut. In 2021 alone, Agnico Eagle contributed about $28 million in annual salaries for Kivalliq communities, about $8.2 million in payroll taxes to the Government of Nunavut, and invested about $9.8 million in exploration spending. Since 2013, Agnico Eagle has invested more than $34M in training our Nunavummiut employees.

The ability for Agnico Eagle to conduct mineral exploration on its tenures is key. During exploration, geologically interesting areas are targeted and following years of work and significant investment, discoveries can be made. Not all of the land within a mineral exploration tenure will be explored, developed or even occupied. Only a small number of interesting areas turn into discoveries, hence the need to be able to explore over large territories before identifying a deposit with economic extraction potential. Exploration activities are temporary with low impact. Following discoveries, drilling, bulk sampling, and many studies are required to assess the profitability of the project. Only a very small fraction of projects have the potential to turn into existing mines with a minimal footprint compared to the area initially explored. Exploration also occurs once a mine has commenced production to sustain the life of the mine, and its associated economic benefits.

If exploration is restricted, the ability to develop new mines or extend the operation of existing mines will be severely impacted.

The following table provides a summary of our claims in relation to the DNLUP:

Claim Type	Total Area (ha)	Percent
Territory of Nunavut Total	209,300,000	Not applicable
Agnico Eagle Total Mineral Claims surface areas	697,889	0.33% of Territory of Nunavut
Agnico Eagle Potential Mine Footprint (should sufficient resources to support development be found after exploring Mineral Claims)[a]	6,978	0.003% of the Territory of Nunavut
Agnico Eagle Claims on Limited Use areas	313,950	45% of Agnico Eagle claimed areas (0.15% of Nunavut)
Agnico Eagle Claims on Conditional Use areas	3,321	0.5% of Agnico Eagle claimed areas (0.002% of Nunavut)
Agnico Eagle Claims in Kivalliq region	447,146	65% of Agnico Eagle claimed areas of which 60% are in Limited Use areas (0.21% of Nunavut)
Agnico Eagle Claims in Kitikmeot region	220,743	35% of Agnico Eagle claimed areas of which 17% are in Limited Use areas (0.11% of Nunavut)

[a] It is important to emphasize this is a very small area relative to the overall size of Nunavut. Exploration of the mineral claims would not result in the full disturbance of these surface areas – most exploration activities are relatively small. For the few claims that actually develop into a mine, the final development footprint would be a fraction of the mineral claim area. Based on Agnico Eagle's approved mine designs that already have been constructed, in our experience the actual footprint of a mine is approximately 1% of the claimed area.

Again, the actual footprint impacted by exploration and mining in Nunavut is very small. To put these statistics in context, the current footprint of Agnico Eagle's Meliadine Mine is 438 ha compared to the 49,000 ha of the Meliadine Claim. Agnico Eagle existing mining activities is able to contribute more than 25% to the GDP of Nunavut with a small footprint of 0.003% of the Territory of Nunavut. Agnico Eagle's mining development activities are an efficient way of developing Nunavut in a way that is respectful of Inuit values and the opportunity created by the NA while supporting lasting economic prosperity in Nunavut for generations.

3. Existing Rights

As the NPC heard from many participants with different perspectives (including all three signatories), the mining industry presents important opportunity for Inuit, as well as those seeking investment in Nunavut. The potential for mining to generate positive change in Nunavut is supported by the NA processes. In order for these benefits to Inuit to be realized, it is essential that mineral tenure holders have the confidence that it is possible to develop their tenures based on investment and successful completion of the regulatory process.

Based on what Agnico Eagle heard through its participation in the public hearings and NPC process to date, presenting existing rights as an “exception” or “exemption” to the usual NLUP requirements risks confusing both proponents and the community. Instead, a revised NLUP that primarily focuses on Option 4 lands, rather than Option 1 and 2 lands, would be a first-generation NLUP that is most reflective of the current evidence and would likely gain broader consensus among Inuit, the signatories and stakeholders.

Agnico Eagle recommends that the revised NLUP should reflect comprehensive and broad grandparenting of the right to explore, develop, produce, and have feasible access to existing mineral claims as of the date the NLUP is approved and certainty that current and future activities to be taken in respect of existing mineral claims are not restricted (as per the conditions defined in Option 1 and Option 2 of the 2021 DNLUP).

Option 4 must apply to the mineral tenures themselves as well as access needed to explore and develop those claims. Maintaining existing rights to explore and develop mineral tenures is meaningless if the same recognition is not given to access. This approach also recognizes how little infrastructure is available to build from in Nunavut. Development of most of our mineral tenures is not at a level that would feasibly permit us to identify specific access corridors at this time. All of Agnico Eagle’s mineral tenures and access to these areas must be recognized as Option 4 and not Option 1 and 2. For example, this includes linear development, marine access, infrastructure, roads and air access. Option 1 or 2 restrictions should not be applied to existing tenures or proposed access to those areas.

Our approach for existing rights does not include triggers for plan variances or amendments. The Option 4 approach would allow for the required certainty in recognition of the significant investment to date and our approach to community engagement. This land use planning approach would support future investment in our tenures and the sustainable and meaningful benefits they can provide to Inuit. As we emphasized above, Agnico Eagle is committed to Nunavut for the long term. We sincerely wish to avoid negative economic impacts to Nunavut based on land use plan uncertainty.

Agnico Eagle emphasizes that our investment has been based on the reasonable certainty that it has had to date that it would be permitted to proceed to the NIRB process as triggered by authorizing activities.

The compensation directly related to the harm to Agnico Eagle’s economic interests that would be required should the NLUP proceed with inclusion of Option 1 and 2 in the areas of our mineral tenures and access routes would be immense. Such an approach would cause very significant economic harm to both Agnico Eagle and Inuit, and would not provide better protection to wildlife than the established systems in place.

The Supreme Court of Canada decision in *Annapolis Group Inc. vs. Halifax Regional Municipality*, 2022 SCC 36 recently clarified the path to establishing a claim for constructive taking (also known as “de facto expropriation”) when government regulation and land use decisions have the effect of depriving property owners of all reasonable uses of their property.

However, we think a much better path forward is to work together with the Option 4 tool developed by NPC staff to achieve a better balance in the final NLUP.

4. Protecting Wildlife

4.1 Development of Wildlife Protection Plans

As Agnico Eagle presented to the NPC along with other parties, exploration and mining activities that take place in Nunavut cannot proceed without successfully completing a multi-step regulatory process required by the NA, which includes Inuit decision makers. Some community participants appeared to be unfamiliar with this system. We encourage the NPC to enhance understanding of the robust Nunavut regulatory system and include a section of the NLUP that sets out the regulatory permitting steps required to proceed with exploration and mining activity in Nunavut, and the ongoing post-permitting monitoring system. The Nunavut Co-Management system was established under the NA to reinforce the equal role and power of Inuit alongside government. These bodies are unique to Nunavut and specifically designed to ensure that Inuit views are heard and respected. Again, these are existing tools in the NA, unique to the NA, which were carefully developed to guide exploration and mining activities in Nunavut to ensure they proceed in a way that is protective. The NA also provides a detailed process outside of Article 11 that is to be followed before conservation areas are to be created. The NLUP should reflect these existing tools and not duplicate or override them.

For major development projects such as the Hope Bay Mine, Meadowbank Complex, and Meliadine Mine, detailed wildlife protection plans are developed through the NIRB related processes that are focused on preventing the potential impacts of the project on wildlife, as well as the most recent information available from IQ and scientific monitoring. Plans are adapted based on site monitoring as per the project certificate terms and conditions. This project specific approach based on best available current information is developed with participation between Inuit and Inuit groups including hunters and trappers organizations, Inuit organizations, government agencies, and the proponent and represents a robust approach to wildlife protection.

4.2 Summary of Evidence that Caribou Protection Measures are Effective and in Place

Agnico Eagle heard concerns from some participants regarding the effectiveness of the caribou mitigation measures that are currently in place that constrain mineral development.

The results of monitoring carried out under NIRB project certificates, as well as other project monitoring, support the view that negative effects on caribou populations have not occurred due to mining. It is also important to note that mining activities take up less than 1/100th of a percent of the landscape utilized by caribou. The view that this level of direct habitat loss could result in herd-level population changes has not been supported by IQ and western science that has been made available to NPC. Finally, the only mines in Canada that we are aware of that shut down to protect caribou are located in Nunavut. This is a very stringent mitigation measure.

4.3 Agnico Eagle has Fundamental Concerns about the Methodology that was Relied on to Create the Polygons that are in the Current DNLUP

The DNLUP includes various maps that purport to describe areas important to caribou, including calving and post-calving areas, and include significant restrictions that would sterilize development of and access to many mineral tenures.

However, as Agnico Eagle has presented, the methodology used to develop those maps is highly questionable and cannot be relied on at this time (see enclosed third party memorandum prepared by ERM for support of this statement).

Agnico Eagle is presenting a constructive approach to get better resolution on this issue. We propose that the current polygons should be removed from the NLUP for the time being, and that NPC convene a polygon working group with scientific and IQ experts to proceed on a validated approach based on better consensus on methodology. Once there is better consensus on methodology, polygons may be inserted in the NLUP at a later date to provide more information on these areas. In the interim, caribou polygons should not be included in the NLUP as they are presenting potentially highly inaccurate information with negative consequences to mineral tenure holders and those that rely on mining and exploration jobs in Nunavut for their family's livelihood and exercise of Inuit rights.

5. Process Concerns

Based on submissions from the signatories and others, it is clear that significant changes should be made to the DNLUP in order to ensure it strikes the right balance for a first-generation land use plan.

In the current NPC procedural guidance, NPC has indicated they plan to revise the DNLUP prior to submission to the signatories, but has not indicated that there will be a public opportunity to comment on that draft before submission. In our view, a fair process would provide participants with the opportunity to comment on that revision before it is provided to the signatories.

6. A Path Forward: Mining Exploration and Development May Only Proceed as per Option 4

Despite NPC's committed efforts, we heard much confusion among individual participants regarding the actual effects of mining and the restrictions/Project controls in place to protect the environment, including wildlife such as caribou. Agnico Eagle recommends that the NPC help support better understanding by providing more expanded background on these topics in the NLUP.

Agnico Eagle strongly supports Option 4 as a balanced approach. Applying Option 4 would mean that the information on community preferences and the important areas that have been identified by the NPC through their consultation process would be highlighted in the NLUP as VECs and VSECs. Proponents would be obligated to specifically address how they will protect those VECs in preparing applications to the NIRB. This is an improvement to the current process, where only NIRB identifies VECs. The complete application, reflecting the comprehensive community information represented in the NLUP, would be considered through the NIRB process. Every project has the possibility of not proceeding or being approved. But the projects that successfully complete this process are subject to stringent legal requirements and monitoring that ensures wildlife protection.

This approach also builds on and respects the mitigations that have been developed and existing data on actual effects. There is good evidence that has been provided to NPC that the mitigations in place in exploration and mining are working to reduce impacts and ensure that mining and caribou can be compatible.

The drafting change needed would be relatively simple. The NLUP would be revised to clearly reflect that Option 1 and Option 2 land use restrictions do not apply to any project proposals in respect of any activities to access, explore or develop mineral tenures issued by the Crown or NTI, and that Option 4 applies to those areas.

7. Closure

We appreciate NPC's willingness to engage in dialogue as all parties move towards a NLUP that supports communities, responsible resource development and the essential goals of the Nunavut Agreement. Agnico Eagle is committed to doing our part to achieve these goals as well.

If you require any further information, please contact the undersigned.

Sincerely,

Jamie Quesnel
Director, Permitting & Regulatory Affairs
Agnico Eagle Mines Limited

Attachment A: Review of DNLUP Calculation of Kernel Density

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Memo

To	Jamie Quesnel and Manon Turmel, Agnico Eagle
From	Arianne Albert, Statistics Lead, ERM
Date	5 February 2023
Reference	0652009
Subject	Review of DNLUP calculation of Kernel Density

1. EXECUTIVE SUMMARY

In 2021, the Nunavut Planning Commission (NPC) has produced an updated draft version of the Nunavut Land Use Plan (DNLUP), which has resulted in an expansion of the prohibition of land development by 60% since 2016 based on models of land use of barren-ground caribou (*Rangifer tarandus groenlandicus*).

The identified calving and post-calving models for barren-ground caribou (*Rangifer tarandus groenlandicus*) were provided by the Government of Nunavut (GN), based on modelling using utilization distribution (UD) areas calculated by applying Kernel density estimate (KDE) methods. Although the methodology for calculating UD areas was not specified in the 2021 DNLUP, it was assumed that it was consistent with the methodology used in the previous version of the 2016 DNLUP. Supporting documentation for the estimation of UD areas (Caslys 2015) was thus reviewed by ERM. Our review has uncovered flaws in the methodology for calculating KDE - including instances where the UD area of caribou is likely being over- and/or under-estimated by the decisions made in Caslys (2015).

These flaws include:

- The methods for KDE estimation by the GN have not been provided so that they can be reviewed. Methods are assumed to be consistent with those used by the GN in 2016 (Caslys 2015).
- The use of arbitrary bandwidths and the application of fixed distance bandwidths across different herds in different seasons – Bandwidth defines how "smooth" a polygon will be; too high a bandwidth and the polygon can be a circle, too low and the polygon will fragment into tiny areas, the correct bandwidth gives an accurate depiction of the herd habitat usage.
- Double-smoothing of the UD area – The smoothness of KDE polygons is defined by the bandwidth to represent the true herd distribution. Caslys (2015) introduced additional smoothing by adding and then subtracting 11 km without providing justification. This is not a standard KDE method.
- Time-dependent bias in herd selection and data exclusion – Collars pre-2011 were classified to separate herds using a standard scientific method, but were classified by eye post 2011,

leading to two types of classification systems. All data should be classified using one, scientifically defensible method.

- The accepted definition for “core habitat” is a 50% kernel density. Caslys (2015) used 80% kernel density to represent “core habitat”, which is not a standard method.
- Collar data is by-definition autocorrelated (collar points from each animal are not independent of each other). Caslys (2015) used one point per day to address autocorrelation. Instead, there are more sophisticated statistical methods that should be used to address autocorrelation in the movement data to avoid bias in estimation.

Overall, these analysis flaws have led, in our opinion, to uncertainty in whether the DNLUP caribou polygons accurately portray the true land use by caribou.

2. INTRODUCTION

The Nunavut Planning Commission (NPC) released drafts of the Nunavut Land Use Plan (DNLUP) in 2016 and 2021. Both versions of the plan include identified areas for caribou calving and post-calving that were provided by the Government of Nunavut (GN). The DNLUP includes prohibitions on development in “Limited Use” areas including calving and post-calving areas. These prohibitions make up 48% of the Kitikmeot and 28% of the Kivalliq regions and have expanded across Nunavut by 60% from the 2016 version to the 2021 version of the DNLUP.

With such a large proportion of the land area banned from development, it is critical that the methodology in generating these polygons be defined in a clear and transparent manner. Unfortunately, the 2021 DNLUP does not include a description of the methods used to calculate the caribou polygons. Therefore, ERM Consultants Canada Ltd (ERM) performed a review on the supporting documents provided by the GN for the polygons presented in the 2016 DNLUP (Caslys 2015).

2.1 Methodology Background

Kernel density estimators (KDEs) are a method commonly used by wildlife biologists of estimating home ranges (utilization distributions) for animals. The availability of easy-to-use software packages to implement these techniques has increased their accessibility to end users. However, as with any statistical technique, it is important to consider the limitations and assumptions that are built into these methods, to ensure accurate, appropriate, transparent, and repeatable results are produced. A brief overview of the methods of KDE will provide some context for the discussion of drawbacks in the methods used in Caslys (2015).

Broadly, KDE is a non-parametric method used to estimate the probability density function of a random variable based on kernels as weights. A kernel is the name given to a non-negative weighting function which estimates a weighted average of the neighbouring observed data in space. Points that are closer together are given higher weights (kernels).

The weighting function contains a smoothing parameter, referred to as the bandwidth. KDE functions similar to the construction of a histogram, except that there is smoothness between the bins as produced by the kernel function. The choice of kernel function does not play an important role in KDE and generally produces very small differences in distribution models (Wasserman 2006). However, the choice of the bandwidth used for smoothing is critical to the development of accurate models.

2.2 Bandwidth selection

The art of performing accurate KDE is in the choice of bandwidth (*h*); the appropriate bandwidth allows the model to take the shape of the underlying distribution in the data. To do this optimally, one would have to have knowledge of the real distribution in the data, which is usually unknown. The sensitivity of KDE to the choice of a bandwidth (*h*) (i.e. bandwidth selection) is an oft-cited drawback of this method (Worton 1995, Seaman and Powell 1996, Kernohan et al. 2001) and is problematic within the analysis conducted by Caslys (2015).

When an appropriate *h* is selected, the underlying density in the data becomes clear. Smoothing of KDE serves to increase precision in the model, but it comes at the cost of increased bias (Simonoff 1996). Caslys (2015) used the term "search radius" to refer to what is more commonly known as bandwidth, which appears to be a terminology artefact of using ArcGIS software to compute kernel densities. Much like the choice of bin width in a histogram, when *h* is too small, the distribution estimate produced is under-smoothed, over-fit, and contains excessive noise and random scatter. In practice, this can take the form of a density estimate where a circle is drawn around nearly every observation in space. When *h* is too large; important, narrower features in the data are smeared out. In practice this can take the form of overly large and indistinct circles drawn around all possible points which over-represents and artificially inflates the size of density estimates in space but can miss areas of higher utilization. The goal of bandwidth selection is to balance the bias-variance tradeoff with the choice of an optimal bandwidth.

A bandwidth for KDE can be either fixed across the entire distribution or adaptive to suit local conditions and timing. Bandwidth for the KDE is generally chosen by either least-squares cross-validation (LSCV), plug-in (PI), solve the equation (STE) or likelihood cross-validation (LCV) methods (Gitzen et al. 2006, Horne & Garton 2006). Biologists desire objective methods of bandwidth selection that automatically applies to numerous sets of locations and provides accurate estimates of utilization distributions.

A further selection issue can arise when choosing whether to use the same *h* for all points (fixed distance), or to allow *h* to vary as a function of the local point densities (adaptive distance). A local bandwidth smoother allows for greater smoothing at the edges of the distribution and assigns more uncertainty where point densities are lower (Worton 1989).

The Caslys (2015) report appeared to use two methods for fixed bandwidth selection, LSCV, and the reference approach (h_{ref}; Worton 1989). The kernel method appears to have been applied using the default Home Range Extension Spatial Analyst tool available for ArcMap. The lower end estimate of 3 km was presumably derived using the LSCV approach which tends to underestimate the optimal bandwidth, and 20 km presumably derived using the h_{ref} approach, which tends to over-estimate the optimal bandwidths (Chirima & Owen-Smith 2017). Ultimately, an 11 km bandwidth was selected for some seasons of the fixed-KDE analysis, on the basis of having some support in the literature regarding a reported Zone of Influence (ZOI) for avoidance behaviours for caribou related to human disturbance (Boulanger et al. 2012). A 20 km bandwidth was chosen for the corridor analysis on the basis of this producing continuous range boundaries.

While we can appreciate the attempted objectivity of the “meet in the middle” choice for the range estimates (mean of 3 and 20 = 11.5 km), this is otherwise an arbitrary choice of bandwidth and makes a number of unstated but important assumptions. Foremost is the assumption that the two default bandwidth selection methods would over- and under-estimate the optimal bandwidth equally, and that taking the average of these values provides the truest optimal value. The degree of over- or under-estimation produced by these methods is a function of the underlying distribution of the data and cannot be directly measured. In addition, a subjective choice of bandwidth selection methods would be preferred (where justification of the selection method is given), as there are dozens of unique approaches are available (Köhler et al. 2011) that could also be used in this model-averaging style approach.

More importantly, taking the average of these two bandwidth estimates assumes that the relative actual economic costs of over- or under-estimating the zone of influence is equal. There is a balance to be struck between conservation goals and resource use, and optimized decision approaches based on a cost ratio of errors are directly applicable in this context (Mudge et al. 2012). The approach for choosing a smoothing parameter should provide a framework for decision-making that is objective and repeatable and considerate of the tradeoff of costs for all stakeholders. It is also important to note that the choice of potentially too large smoothing parameters, while identifying potential range extent, will inflate the size of the range and remove information about areas of higher UD.

The support of the use of the 11 km bandwidth was provided as a reference to a single study about the ZOI of industrial development on barren-ground caribou (Boulanger et al 2012). ZOI refers to how animals may respond to industrial development by changing their use of habitat and reducing occupancy of areas in proximity to infrastructure (Groffman 2006). A number of papers and reports have been written on this topic, with a range of ZOI values reported. Boulanger et al. (2021) have updated their determination of a zone of influence to a mean of 7.2 km when standardized for drought conditions, although we appreciate that this information was not available at the time that the Caslys (2015) report was produced. Boulanger et al. (2021) went so far as to criticize their own approach of 2012 of using a single ZOI in models across both space and time, as was also done with Caslys (2015). “The lack of support of models with a single constant ZOI illustrates the need for estimation of ZOI across yearly scales rather than pooling all the data into a single period” (Boulanger 2021).

Caribou clearly demonstrated annual and spatial variation in ZOI towards mine sites and the selection of a single fixed value to be applied as a smoothing factor to a pooled set of data ranging from 1987 to 2015 is an unsupported approach. Additionally, each caribou herd in Nunavut individually can be expected to use the landscape differently (concentrated calving by the Beverly herd vs. more distributed calving by the Qamanirjuaq herd) and the fixed value for a herd with smaller annual and seasonal ranges may have a different optimum fixed bandwidth value than a herd that is more wide-ranging.

3. BIAS IN HERD SELECTION

Additional consideration should be given to the methods used by Caslys (2015) to assign animals to subpopulations. The dataset used for this analysis included animal movement data previously collected and analysed by Nagy (2011), and additional animal movement data collected after Nagy (2011) was added to the model. The animals with data collected after Nagy (2011) were categorized by visual inspection of the data, and indistinct animals that could not be assigned to a group visually were removed from analysis.

There are a large number of more sophisticated and objective statistical classification and/or clustering methods available for assigning animals to subpopulations including; randomization, naïve Bayes classification, decision trees, hierarchical and/or fuzzy classification methods, etc. Moreover, the animal data used in Caslys (2015) in the study that overlapped with that used in Nagy (2011) had already been categorized into sub-populations through sum-of-squares agglomerative hierarchical linkage and fuzzy c-means clustering. The initial assignment of animals to subpopulations as completed by Nagy (2011) went to great lengths to objectively classify animals into subpopulations, and as such there should be no further data exclusion occurring in that scenario. This amounts to there being two different categorization methods applied to the movement data (one pre-Nagy (2001) and one post), which creates a time-related sampling bias in the data. More of the recent data collection has thus been trimmed artificially from the analysis as a result of the exclusion criteria used by Caslys (2015), and therefore weights the analysis towards older data and migration patterns.

The number of cases removed as a result of this grouping criteria is unclear, as it is not reported by Caslys (2015). Peripheral populations of animals are those that exist at the geographic margins of their range. As populations collapse, they are often driven to the periphery of their ranges (Lomolino & Channell 1995, Channell & Lomolino 2000). These peripheral animals are often key to conservation efforts where potential for mixing between sub-populations of a species increases genetic diversity and gene flow between sub-populations. Despite experiencing low numbers, occasional gene flow between some subpopulations of migratory barren-ground caribou in Canada has prevented genetic bottlenecks and population isolation (McFarlane et al. 2016). The exclusion of the migratory patterns of peripheral animals in the kernel density estimates potentially excludes important peripheral habitat which links the subpopulations of caribou, thus increasing the chances of isolation and fragmentation. We suggest that may not be necessary to remove valuable data from the analysis, where more objective categorization methods are available.

The grouping of data by Caslys (2015) could bias the results of kernel analysis in two ways. First, there are more animals collared in the post-Nagy data, and the modern GPS collars used now record more points since the deployment of GPS collars after 2010. Satellite collars produce a position fix once every 3-4 days, as compared to a GPS collar that can record position 6-12 times per day means that the recent data swamps the signal from the older data.

The grouping of data for analysis also runs the risk of identifying areas where caribou formerly used to calve, but have not visited in decades. This presents a significant issue in terms of the natural 40- to 70-year population cycles of barren-ground caribou (Gunn et al. 2011). A land-use strategy based on data as old as 1987, is likely inappropriately weighted to larger habitat utilization area than is currently necessary for the current size of the caribou population, which have been in a state of natural decline since the 1990s (Vors & Boyce 2009). The Bathurst herd has declined from an estimated herd size of about 350,000 to 8,200 caribou in between 1996 and 2018 (Boulanger et al. 2011, Adamczewski et al. 2019). Range reductions have occurred over this period in some caribou populations as a result of population declines as related to population decline (Boulanger et al. 2021). Given that the life of mines in the Nunavut is typically 5 to 20 years, and end-of life strategies for these mines include extensive reclamation and re-naturalizing of mineral claims. Land use exclusion from an area that may not be expected to be used again by caribou for several decades, for a mine with a life of 10 years requires more discussion. We suggest that the pooling of data over a period of 28 years in Caslys (2015), where there is a high likelihood of that analysis being weighted towards a larger population of caribou than can be expected to currently exist is unnecessarily restrictive and detrimental to the economic opportunities that these mines could provide to people living in the North.

4. CORE HOME RANGE CALCULATION

The classical definition of home range given by Burt (1943) lacks an objective mathematical description that allows for a clear choice of the use of % kernel density to be assigned as the home/herd range in KDE. However, Fleming et al. (2015) attempted to provide an operational definition of a home range in movement data that includes a longer, continuous trajectory with movement-path realizations that result in larger heavy use core path areas, with excursions that stray off into little-used regions being assigned lower probabilities. As such, a definition of home range area is given and a percent coverage region of 95% of all possible paths.

The range distribution addresses the lifetime space requirements of an animal and provides a metric that can be compared across individuals (Fleming et al. 2015). Further, Fleming (2017) defines the “core” home range as the median area used by an animal population (i.e. the 50% percentile of the KDE). This 50% kernel density represents the areas of highest probability of use, and is the traditional choice of kernel density for assessing the “core” UD areas (Worton 1989, Borger et al. 2006, 2008). Casyls (2015) defined the “core seasonal ranges” as the 80% kernel density for migratory seasons, and a modified 95% UD for the other seasonal ranges, in contrast to more accepted definitions.

A further issue is created in the modification of the boundaries of the non-migratory seasons by Caslys (2015), where an additional geoprocessing smoothing parameter is added to the model that already contains a kernel smoothing parameter in the form of the bandwidth. In this method an 11 km buffer is added to the boundary, the area is merged, and then an 11 km buffer is subtracted. This has the effect of further smoothing the polygons and reducing some finer details of the probability distribution produced by the original model on the premise of 11 km being representative of the ZOI for barren-ground caribou. Applying two different smoothing functions twice to the same model is disconnected from the biological relevance of the changes in UD areas it might produce and should be considered more carefully in the magnitude of the conservation decisions it affected.

5. AUTOCORRELATION IN MOVEMENT DATA

An assumption of KDE analysis is that the data used to model the distribution must be independent and identically distributed. Animal movement is by its nature a continuous process;

autocorrelation is the rule, not the exception in animal movement data. A collared animal will produce data in the form of tracks, where the location of an animal in space is highly dependent on the previous location of that animal. It also implies that the correlation will carry on into the future. The home range area of animals based on autocorrelated movement tracks data can underestimate the home range area, sometimes dramatically, in conventional KDE calculations (Fleming et al. 2014) because of the violation of the independence assumption. Common suggestions for dealing with autocorrelation in location data are to use a coarser sampling rate (Swihart & Slade 1985), to stratify sampling across individuals (Otis and White 1999), and to use longer observation periods (Fleming 2015).

Caslys (2015) has attempted to mitigate the issues of uneven sample sizes between years in the caribou movement data by collapsing movement data into a single observation per day. While this method can also inadvertently provide some relief from autocorrelation in the movement data, even this has been shown to fail for a conventional KDE. More modern and rigorous autocorrelated KDE models have been developed (Fleming 2015) and would be a more appropriate choice given the nature of this data.

6. CONCLUSION

In conclusion, numerous issues with the statistical analysis used to generate polygons for barren-ground caribou have been identified in this review. This review is based on the 2015 Caslys methods summary report. Updates to the modelling methods may have been incorporated into the more recent 2021 DNLUP, however the methods have not been made available for public review. The issues identified in this review can promote significant distortions in the models which could in places over- and under-estimate UD areas. We suggest that given the important and significant consequences of the decisions made regarding protection of habitat for caribou herds in Nunavut, that the modelling approach be more carefully scrutinized and adjusted using the best practice methods currently available in the literature.

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