Assessing Caribou Survival in Relation to the Distribution and Abundance of Moose and Wolves

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Prepared by

Michael Gillingham and Matthew Mumma
University of Northern British Columbia

Natural Resources & Environmental Studies Institute
"Our environment is our future"

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Project Scope

Woodland caribou are listed as threatened or of concern under the Species at Risk Act in Canada. Declining numbers of caribou have been linked to habitat alterations and to complex predator-prey relations. Predators can disproportionately affect one prey species when those predators are numerically linked to another more abundant prey species (e.g., McLellan et al. 2010, DeCesare et al. 2010). This interaction has relevance to caribou on the boreal landscapes of northeast (NE) British Columbia (BC) because wolves are the principal predator of caribou, and because moose, as the primary prey species for wolves, support wolf numbers. Further, current patterns of landscape change in the boreal may result in an increase in moose abundance and subsequent increase in wolf abundance.

Our research is focusing on quantifying the relationships between caribou, moose, and wolves across gradients in anthropogenic disturbances and moose and wolf densities, and we are using the fine-scale data provided by GPS monitoring to test more sophisticated hypotheses related to caribou resource selection and survival. Our first step is to increase our understanding of the drivers of moose distribution and density, which will enable us to evaluate the spatial interaction between caribou and moose, and how this interaction changes under varying levels of disturbance. A similar approach will be used during the development of a wolf risk layer, and ultimately, these layers in conjunction with both anthropogenic and natural disturbances (e.g., fire) will become covariates in our model of caribou survival to identify the attributes that decrease the probability of caribou mortality.

Objectives

Using moose, caribou and wolf telemetry data provided to UNBC, this moose-wolf-caribou study will determine:

1. If moose distribution and abundance is related to human-caused habitat change inside and outside of core caribou habitat?

2. If wolf use of caribou habitat is related to moose distribution and abundance?

3. If predator and prey abundance and behaviour interact to put caribou at risk?

4. What biotic, landscape, and anthropogenic attributes affect the survival of boreal caribou (with particular reference to those attributes that can be managed)?

Project Activities and Status for the Reporting Period

Three activities were begun during the reporting period: A1) receive and analyze moose telemetry data; A2) develop initial moose use/selection layers (existing data); and A3) develop initial caribou risk layers using existing data. Because of the closely related natures of Activities A2 and A3, we will report on them in the same section.

Activity 1: Receive and Analyze Moose Telemetry Data

We began receiving and processing moose telemetry data in mid-April. Initially those data were provided directly to us by Caslys Consulting Ltd., but we are now set up to directly receive all collar data from the Vectronic Aerospace server. Downloads of data from the server include all records sent via Globalstar link to Vectronic Aerospace. Because we need to be able to quickly screen data and update our models as new data become available, we have invested considerable effort during the past several months in developing programs to quickly screen and view data (for now in Google Earth) shortly after each download. For most telemetry collars, there is often additional data stored on the collars that are not successfully uploaded via satellite link. As the project moves forward it will be important to directly download any recovered collars (whether from moose, caribou or wolves) before those collars are either redeployed or sent in for refurbishment.

Study Area and Collar Distribution and Status

Studies of habitat use and selection often just collar females. One of the main objectives of this project, however, is to understand how the presence of moose (through apparent competition) may influence the risk to boreal caribou. Male moose may be selecting different landscape features than cows (perhaps after the rut when male body condition is low) at some times of the year. Therefore, if we only know what females are doing, and wolves are responding to the location and selection of bulls after the rut, then we may miss an important aspect of the interaction between moose, wolves, and caribou. At the same time, we do not want to lose an emphasis on female moose, because information about calving and calf recruitment (from repeated aerial observations of collared cows) may reveal another season when wolves select locations to target vulnerable individuals. Consequently, our target for deploying collars was 1/3 bulls and 2/3 cows.

Several factors could potentially influence the link between presence and risk to caribou through apparent competition. Such factors could include relative densities of moose, wolves, and caribou, and the extent of natural and anthropogenic disturbance on the landscape. In order to maximize the spread across the different gradients potentially affecting the interactions between moose, wolves, and caribou we chose to collar moose in three areas (see Figure 1): the Fortune Core, the Clarke Core, and the Chinchaga RRA.

Because of delays first with funding and then with collar procurement, moose collars were not available for deployment until March 2015. During a short time window before spring temperatures were too warm for collaring, Diversified Environmental Services was able to deploy 38 of the planned 60 Vectronic Aerospace VERTEX Survey Globalstar collars. Collars had been ordered to take two fixes per day at 0300 and 1500 h local time, but they were instead factory programmed for 0300 and 1500 GMT. The distribution of collars throughout NE BC can be seen in Figure 1.

Since collaring, there have been 2 mortalities (one bull by wolf predation, one cow associated with calving), 3 animals that have moved into the NWT, and 2 additional collars that have stopped communicating with the Vectronic's server (although the VHF signal suggests the animals are still alive — see Table 1). Thus we are currently receiving positional information from 31 collars within BC. It is our hope that the two 'failed' collars can be retrieved during the second collaring session scheduled to begin in December 2015. It is possible that those collars are still recording accurate position information even though that information is now only being stored on the GPS collar.

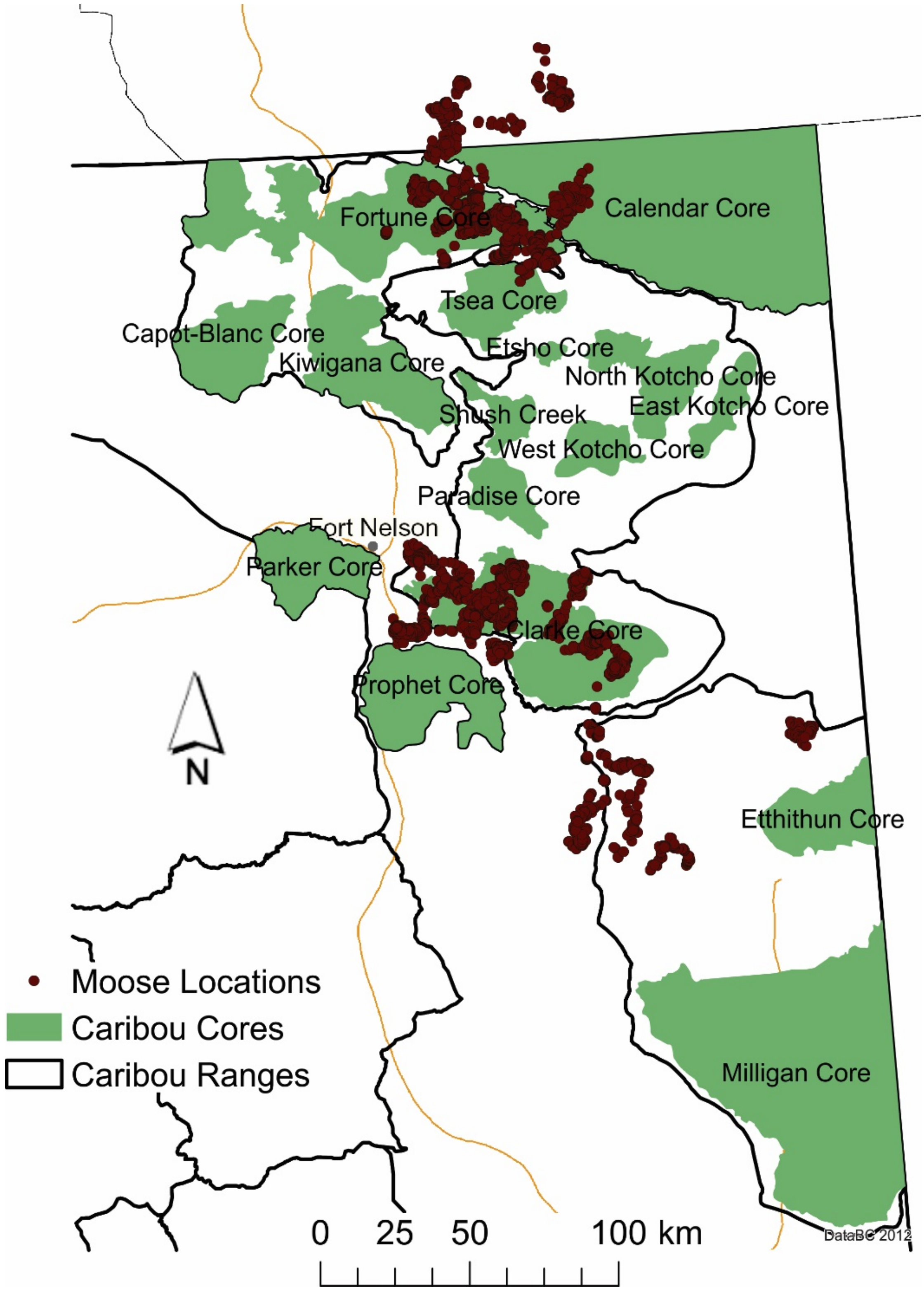

Figure 1: Distribution of moose telemetry fixes from March through August 2015. Bullets represent individual fixes for the 37 moose that were collared.

Table 1: Current status and fate of GPS radio collars deployed in NE British Columbia in March 2015.

Area	Collared		Mortality		In NWT		Failed GPS		Active	
	F	M	F	M	F	M	F	M	F	M
Chinchaga RRA	1	3							1	3
Clarke Core	14	4	1				1		12	4
Fortune Core	11	5		1	2	1	1		8	3

Development of Telemetry Screening Tools

There are several reasons to have tools that allow the rapid screening of newly downloaded collar data, both related to data screening and to minimizing the time needed to detect a potential mortality. We have developed programs that quickly remove bad or errant fixes as well as some tools to screen for behaviours potentially related to mortalities — we will focus on the latter.

As described above and in Table 1, there have been two mortalities of collared moose during this study. In both cases, mortality site investigations lagged many weeks behind the mortality. The wolf mortality occurred while other collars were still being deployed and data screening was not fully operational (the conclusion of a wolf kill was made from the intersection of the collared moose with a pack of collared wolves with no further significant movements by the moose collar). The site investigation for the cow mortality was also greatly delayed because of late transmission/detection of a mortality message. The Vertex collars are programmed to send a mortality alert if minimal movement occurs between several consecutive fixes, but there are several types of collar movements that may also be indicative of potential mortalities (or at least animals that should be closely checked for activity after those movements). Several such scenarios are listed in Table 2. For example, an abnormally long movement could be associated with an animal be chased by predators and a subsequent kill might place the collar in a position such that no fix can be received or transmitted for several days.

Table 2: Potential anomalous collar signals and movements that could be associated with potential mortality events.

Move and Fix Scenarios
Abnormally long movement between consecutive fixes
Long collar movement followed by no fixes
Long collar movement followed by little subsequent movement
Many consecutive missed fixes
Many consecutive short movements

Consequently, we developed a program (running as a macro in Microsoft Excel) that identifies the scenarios outlined in Table 2, monitors for rapid fixes that are associated with mortality messages (in case the actual message is not sent or received), tracks fix rate, and produces individual KML (Google Earth Markup language) files for each downloaded moose. The interface for the program (Figure 2) allows customization of the screening criteria, and the resulting KML files are colour-coded for each type of flag, and documents important point attributions (see Figure 3). The result is that data can be quickly screened both by tabular inspection and by examining movement files in Google Earth for anomalous (and potentially mortality related) movements.

Collar Fix Rate Success

Obtaining a high proportion of possible GPS fixes is important in obtaining unbiased estimates of habitat use — if animals in habitats with high canopy coverage have lower successful acquisition of GPS location, then there can be a bias in estimates of habitat use. In our initial routine screening of data for fix rate success, we observed that the rate of successful fixes is declining with time (Figure 4). In addition, we also evaluated if the occurrence of consecutive missed fixes was increasing over time by looking at the average number of consecutively missed fixes. We found that the average number of consecutively missed fixes has increased monthly since March.

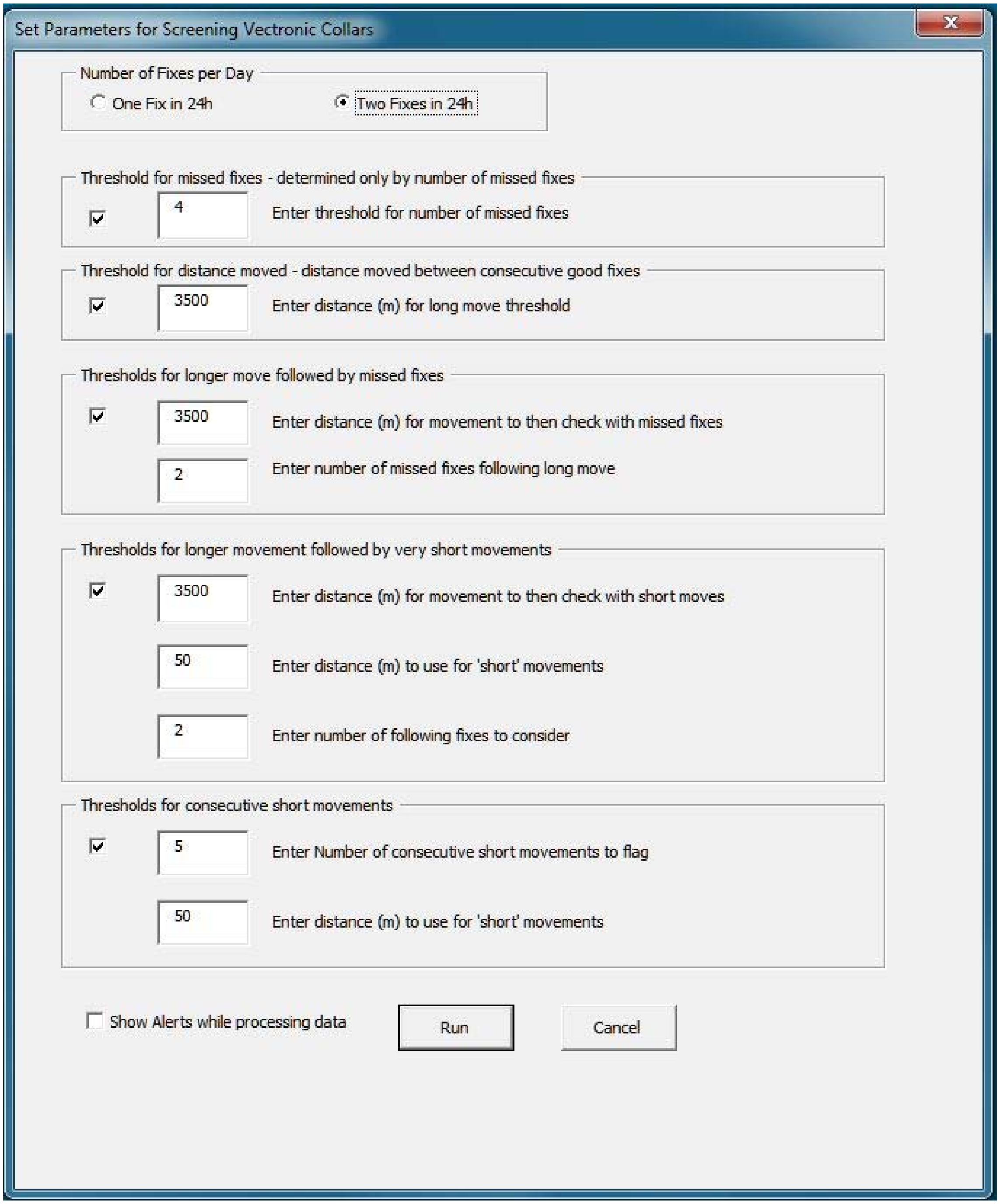

Figure 2: Screen capture of user-interface for screening Vectronic radio-collar downloads.

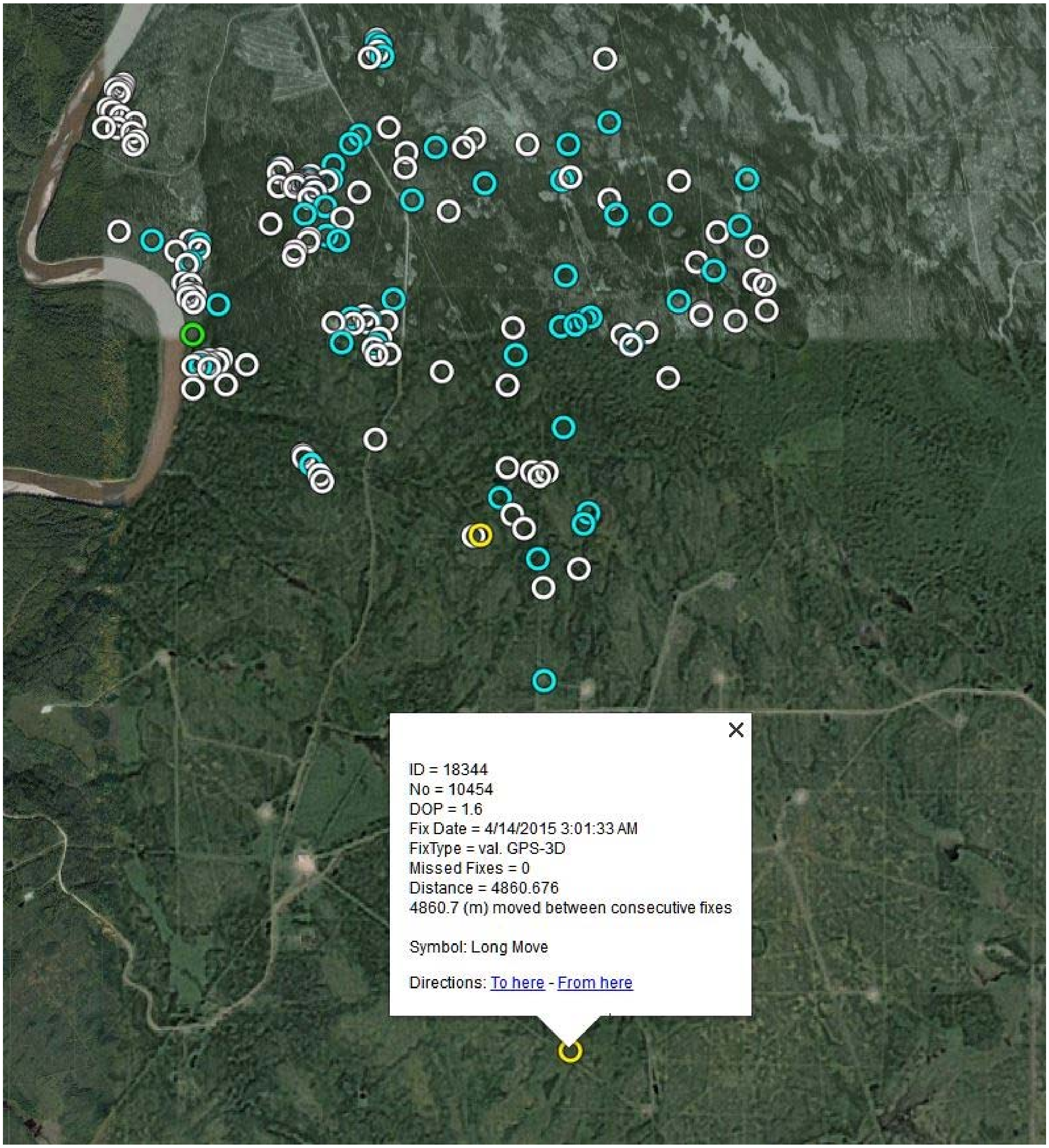

Figure 3: Example of a portion of a KML file (viewed in Google Earth) for an individual collared moose. Different colour symbols are used to indicate long movement, missed fixes, and other scenarios (Table 2). Clicking on any symbol allows the user to view several attributes associated with that location.

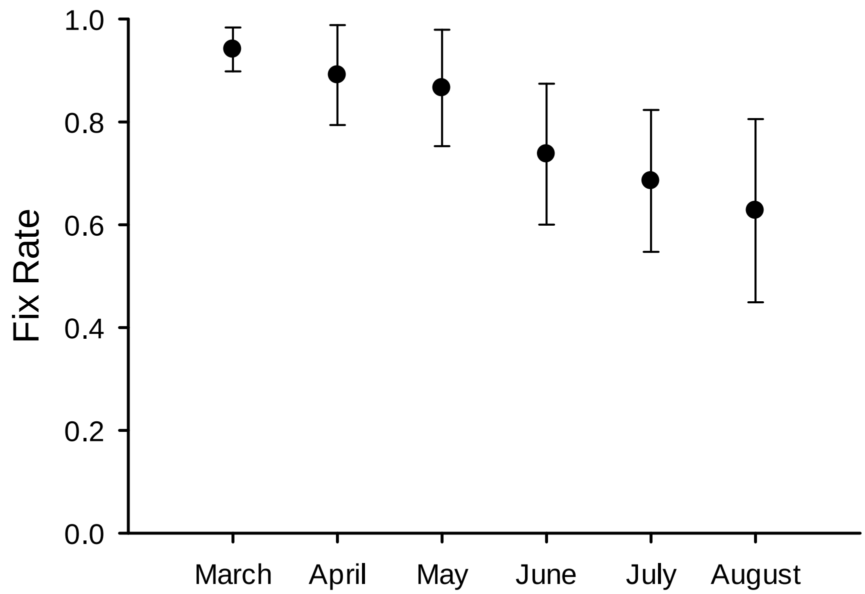

Figure 4: Decline in fix rate success (i.e., the proportion of possible fixes that were successfully recorded) as the study has progressed.

We proposed several hypotheses that might explain these trends including changes in the proportion of open habitats selected, an increase in movement distances between fixes, an on-average northward trend in animal locations affecting satellite dimensionality, and rates being skewed by the failure of a few malfunctioning collars.

To examine the potential influence of 'open' habitats, we reclassified the 30 vegetative classifications of the Ducks Unlimited Vegetation Layer (Ducks Unlimited Canada 2013) into open and closed habitats in accordance with classification descriptions provided with the data layers. We then calculated for each individual by month the fix rate and proportion of fixes in open habitats. Although a few individuals have maintained high fix rates and a few individuals have experienced large declines, there are no significant correlations between use of open habitats and fix rate. Overall the majority of individuals appear to be undergoing a similar moderate decline in fix rate over time, but we do observe that individuals that spend >70% of their time in open habitats in a given month appear to have fewer low fix rates. We recently conducted a similar analysis of the same model of collar that has been deployed in central BC for approximately 2 years. In those data, we see a similar drop in fix success rate during the summer months of both years (we see only a portion of this cycle in Figure 4) followed by an increase in fix success during the fall and winter months. The most likely explanation appears to be that in warmer months moose are likely spending more time in closed canopy areas, which may be leading to reduced fix success. With both sets of data in hand, we are planning on consulting with the collar manufacturer about their take on these results.

Activities 2 and 3: Development of Initial Moose Use/Selection Layers and Caribou Risk Layers

Several actions during the reporting period have contributed to the development of moose selection layers and ultimately to caribou risk layers.

Procurement of Data Layers

We have signed an agreement with Ducks Unlimited Canada that has allowed us to use their vegetation classification layer for the boreal region of British Columbia (Ducks Unlimited Canada 2013). Their classification of the boreal divides the region in to 30 classes. We re-classified these vegetation classes in to 8 classes in accordance with the methods detailed by Demars (2015). These include coniferous swamp, hardwood swamp, rich fen, poor fen, treed bogs, upland deciduous, upland conifer, and other, which contains several non-habitat or minimally present vegetative classes (e.g. open water, anthropogenic, etc.)

In addition, we downloaded layers from several BC provincial sources. We obtained water, fire, and an elevation raster from the BC Data Distribution Service, which permitted us to generate slope, northness, and eastness layers (sensu Gillingham and Parker 2008). From the Oil and Gas commission, we procured a suite of disturbance layers, including seismic, well site, and road layers.

Evaluation of Moose Movement Distance

We calculated the distance moved between all 12-h consecutive fixes (Figure 5). The average movement distance was 437 m with the lower 5% of movements spanning less than 26 m and the upper 95% of movements exceeding 1625 m. As has been seen with other examinations of seasonal movement in British Columbia (e.g., Gillingham and Parker 2008), we observed that movement distances increased from March to July before declining in August (Figure 5). There was certainly a lot of inter-animal variation with months with larger mean distances also having larger sample standard deviations.

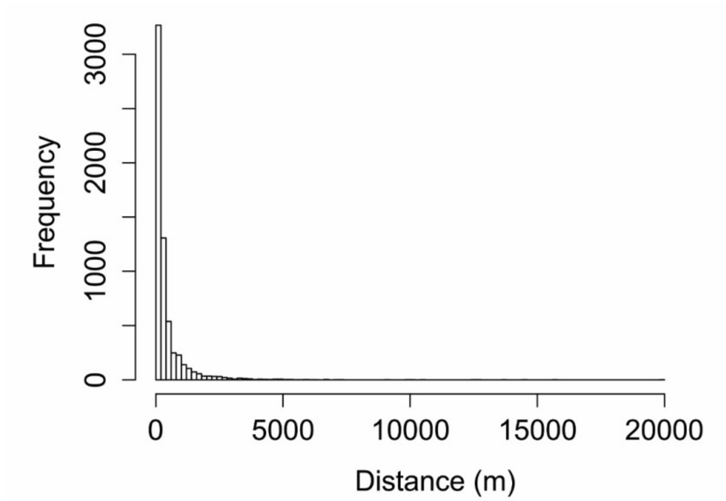

Figure 4: Frequency distribution of distances moved between consecutive 12-h fixes for all collared moose in NE BC.

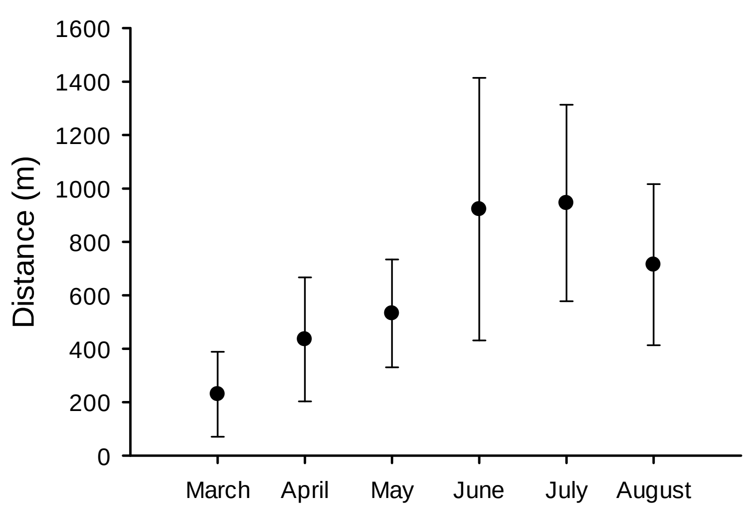

Figure 5: Mean (± SD) monthly distances moved by radio-collared moose in NE BC. .

Examination of Moose Habitat Use

We estimated the proportion of moose locations found in each of our 8 pooled vegetation classifications (see above) for each month. We also estimated the availability of vegetation classes by taking 10 random locations from within a buffered area around each moose location with a radius set at the 95th percentile of movement distances (1625 m) — this distance is meant to represent a possible radius for use while eliminating those long distances between fixes that might not be associated with normal movement behaviour. Preliminary analyses suggest that moose may be increasing their utilization of conifer swamp and upland conifer in summer, while decreasing their use of treed bogs (Figure 6) — more data are of course needed to see if this pattern holds up across seasons and year.

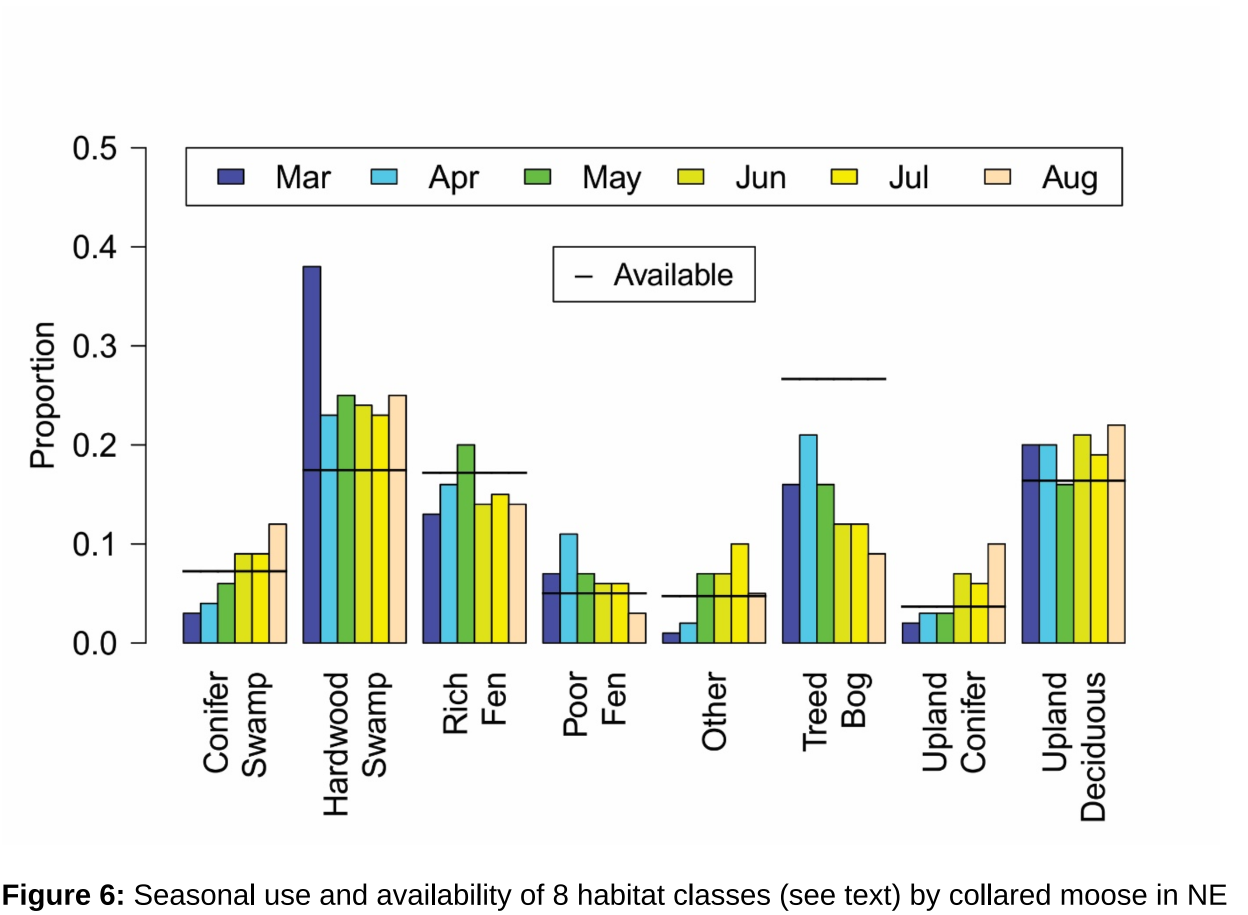

Figure 6: Seasonal use and availability of 8 habitat classes (see text) by collared moose in NE BC. For each habitat class, months are represented chronologically from left to right. Each bar represents the use of that habitat class in a specific month. The horizontal lines represent the availability of each habitat class based on buffers constructed around each radio location (see text for details).

Assessment of Caribou Core Attributes and Moose Density

It was important for us to understand the vegetation composition of the different Caribou Core areas. This information is helping us understand the gradients of habitat type across the cores, and could assist in guiding future moose collaring efforts within the study area. We were also interested in performing a preliminary vegetation-class analysis to assess if vegetation attributes alone were good predictors of current moose density estimates. In this analysis, we estimated the proportion of area burned using the BC fire layer and a surrogate for disturbance via buffering a combined roads layer by 500 m (Environment Canada 2012; Table 3). We also used our reclassified DU layer to determine the proportion of each vegetation classification for each core (Table 3). We are currently exploring the relationship between estimated moose density and the abundance of selected (hardwood swamp) or avoided (treed bog) habitats (see Figure 6).

Table 3: Proportion of each Caribou Core area that is comprised of the 8 vegetation/habitat types (based on Ducks Unlimited Canada classification).

Caribou Core	Fire	Disturbance	Treed Bog	Rich Fen	Poor Fen	Upland Conifer	Upland Deciduous	Hardwood Swamp	Conifer Swamp	Moose per km^2 ‡‡
Calendar	0.1	0.6	0.4	0.0	0.3	0.0	0.0	0.065	0.1	0.018
Capot-Blanc	0.0	0.4	0.3	0.0	0.2	0.0	0.2	0.138	0.1	0.076
Chinchaga-RRA	0.0	0.3	0.3	0.1	0.2	0.0	0.1	0.186	0.1	0.151
Clarke	0.2	0.5	0.4	0.1	0.1	0.0	0.1	0.197	0.1	0.145
Etthithun	0.0	0.6	0.2	0.1	0.2	0.2	0.1	0.093	0.1	0.044
Fortune	0.0	0.3	0.4	0.1	0.2	0.0	0.1	0.149	0.0	0.046
Kiwigana	0.0	0.3	0.4	0.1	0.2	0.0	0.1	0.158	0.0	0.159
Kotcho	0.4	0.6	0.4	0.0	0.3	0.0	0.0	0.080	0.1	0.127
Milligan	0.2	0.8	0.1	0.2	0.3	0.2	0.1	0.031	0.1	0.113
Paradise	0.1	0.4	0.2	0.1	0.3	0.0	0.1	0.161	0.2	0.124
Parker	0.1	0.4	0.2	0.0	0.3	0.1	0.1	0.058	0.1	0.246
Prophet	0.1	0.4	0.1	0.0	0.4	0.1	0.1	0.101	0.1	0.121
Tsea	0.0	0.6	0.3	0.0	0.4	0.0	0.0	0.145	0.1	0.172

‡‡ Density estimates were obtained from McNay et al. 2013 and Thiesen 2010.

Recommendations

Based on our work to date, we offer the following recommendations targeted primarily at the upcoming collaring effort:

- The deployment of the remaining collars in December 2015 should endeavor to balance the sample size within the Chinchaga RRA.
- Capture crews should attempt to recover the two collars (and recollar the individuals with new collars) that are not uploading data — it is possible that considerable locational information is stored on the collar, and it is just the Globalstar uplink that has failed.
- Throughout the balance of the project, all recovered collars (dropped off, mortalities, recollaring, etc.) should be directly download (whether from moose, caribou or wolves) before those collars are either redeployed or sent in for any refurbishment.
- Although moose can move long distances, additional animals collared in the Fortune Core should be targeted well south of the NWT border so that they 'remain' in the study area. We are attempting to get the DU vegetation layers for NWT so that the existing animals can be more fully used in the study (although other anthropogenic layers will not be readily available).
- Collaring efforts should continue to have a target of 66% females and 33% males in the collar sample, but we need to ensure that those targets are distributed throughout the study area.

Acknowledgments

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