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Mackenzie Valley Environmental Impact Review Board
200 Scotia Centre
P.O. Box 938
Yellowknife, NT
X1A 2N7
Attn: Chuck Hubert, Senior Environmental Assessment Office

Re: EA1314-01 Jay Project, Dominion Diamond Corporation Developer's Assessment Report Adequacy Review

Dear Mr. Hubert:

With reference to my letter of December 15, 2014 to the Chair of the Mackenzie Valley Environmental Impact Review Board (MVEIRB), please find attached the last batch of information responses to the Adequacy Review document provided by the MVEIRB for the Jay Project on November 28, 2014. Note that we have included a tracking number to account for individual Adequacy Review items.

- Adequacy Review Item 6.1 – Effects on traditional wildlife harvesting and cultural intangibles (DAR-MVERIB-6), with the following considerations in regard to the proposed approach to address Aboriginal views on changes to intangible elements of culture:

Dominion Diamond is committed to fully engaging with potentially affected communities and Aboriginal groups on the Jay Project and has undertaken extensive engagement on the Project since early 2013. This engagement has involved public meetings in communities, meetings with leadership, workshops and presentations, site visits involving elders, youth and leaders. In December, Dominion Diamond held a two-day Community Engagement session to present the Jay Project Developer's Assessment Report and take questions and comments from participants. Attendance and participation in the engagement sessions over this period has been high. In general, the focus of most of the discussion has been about caribou, other wildlife, fish, water quality and the socio-economic impact of the mine for people in communities. Concerns about loss of Aboriginal culture, particularly intangible elements (e.g., loss of place names and language, traditional knowledge [TK]) have not been specifically identified as a concern.

However, Dominion Diamond recognizes the importance of this issue and is committed to furthering this discussion with communities. To this end, Dominion Diamond will host a one-day workshop in Yellowknife during the week of February 23, 2015 to consider how intangible elements of Aboriginal culture have been affected by diamond mines.

The meeting will be facilitated by a trained facilitator. The scope of the meeting and a draft annotated agenda will be developed in conjunction with the facilitator and sent to community participants for input. A report will be developed on the results of the discussion, which will be provided to participants and the Review Board in advance of the technical sessions scheduled for April. In addition to the issue of cultural change, this workshop could also be used to inform of future TK and other programs at Ekati and for the Jay Project that are important to communities. Review Board staff will be invited to observe the workshop.

Organization for the workshop will be similar to other workshops that Dominion Diamond has successfully organized on other matters in the past.

- o Invitation letters to communities inviting them to nominate 2-3 participants for the workshop. The participants should be a combination of elders, harvesters, leadership, etc. This will be followed up by direct contact to identify appropriate individuals.
- o All engagement will be recorded for the Jay Project Engagement Record.
- o All logistics for participants will be arranged by Dominion Diamond.
- o A Report will be provided to communities and participants based on the results of the workshop.

- Adequacy Review Item 7.1 – Bioaccumulation of contaminants:

Item 7.1 is addressed as part of the Human and Wildlife Health Assessment Report, which is submitted to the MVEIRB in conjunction with this letter.

- Item 8.3 – Approach to impact classification and significance – effects prediction

As described in the January 30, 2015 letter EA1314-01 Jay Project, Adequacy Review item 8.3, caribou energetics modelling was removed from the requirements of the November 28, 2014 Adequacy Review document .

- Item 8.6 – Cumulative effects (DAR-MVERIB-13)
- Item 8.8 – Caribou mortality and population modelling (DAR-MVERIB-15)

The timelines for proposed responses to the Adequacy Review information requests were provided in Table 1 of my December 15 letter, and the items provided herein correspond to the information that were scheduled for February 2, 2015. Please note this is the last batch of responses. The first and second batches were provided on December 18, 2015 and January 19, 2015, respectively.

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Accompanying this letter, we have also provided follow-up responses to requests resulting from the community and regulator engagement meetings from December 9 through December 12, 2014.

Sincerely,

Richard Bargery
Manager, Permitting Jay Project
Dominion Diamond Corporation

Attach.

Information Request Number:	DAR-MVEIRB-6
Source:	MVEIRB Jay Project Adequacy Review Item 6.1
Subject:	Cultural Aspects - Effects on traditional wildlife harvesting and cultural intangibles
DAR Section(s):	12.2.3, 15.4.1.1.6, 15.4.1.2, 15.4.1.2.1, and 15.4.1.3

Preamble (MVEIRB):

The importance of caribou and caribou hunting to Aboriginal groups is recognized in section 12.2.3. On pages 15-39 to 15-41, Dominion describes the incremental adverse effects from the Project to traditional wildlife harvesting. Dominion concludes that “because no mechanism exists with which to measure the extent of the effect, it has not been evaluated in this analysis”.

On page 15-35, Dominion stated that the Project could affect Aboriginal land users’ relationship with the land, but argues that discussing the extent or the degree of change “is inappropriate within this assessment and, likely, impossible to achieve”.

Section 115 of the MVRMA requires the Review Board to consider the protection of the cultural wellbeing of residents and communities in the Mackenzie Valley. The courts have concluded that “the relationship Aboriginal peoples have with the land cannot be understated” (Platinex v KI, 2007). It was included in the Terms of Reference, which requires (Section 8.2.1) “the analysis of heritage resources inclusive and cultural impacts include both tangible and intangible aspects of culture…” (p42). Dominion has acknowledged that the Project could cause such an effect (p15-35).

The same section requires that Dominion “provide a prediction of the total impact of the project on traditional activities, and on the potential for increased or reduced harvesting success including post-mining perceptions of the area for traditional activities and harvesting”. The Terms of Reference require Dominion to predict the impacts of the Project on traditional harvesting activities and on intangibles, even if it needs to do so qualitatively, in a non-mechanistic manner.

Evaluating cultural impacts on intangible values may be best done by a cultural anthropologist. Evaluating impacts on traditional harvesting and on intangible cultural effects can involve conducting a reasonable qualitative analysis using traditional knowledge and community views as a source of information. Such an approach is possible and has been done in previous environmental assessments for cultural impacts.

Request (MVEIRB):

Please provide

1. a qualitative assessment of how the Jay Project expansion of the Ekati mine will impact or change the ability of traditional harvesters to hunt caribou and other wildlife, considering the results of population modelling required by item 8.8 below.
2. an analysis of the potential effects of the project on traditional land users that includes intangible cultural effects, including any changes to Aboriginal land users’ relationship with the land

These analyses will incorporate traditional knowledge information and the views of traditional harvesters.

Response:

1. Section 15 of the DAR (Cultural Aspects) assessed the effects to traditional wildlife harvesting, and considered the results of the Caribou KLOI (DAR, Section 12) and the Wildlife and Wildlife Habitat SON (DAR, Section 13). The Caribou KLOI assessed the residual cumulative effects on caribou as low to moderate in magnitude. The Wildlife and Wildlife Habitat SON assessed the residual cumulative effects on waterbirds, and wolverine and grizzly bear as low and low to moderate in magnitude, respectively. Noticeable and detrimental effects resulting from cumulative development have already affected preferred wildlife harvesting areas, although other preferred harvesting areas remain available for use.

   As a result of the above factors with consideration of the additional effects of sensory disturbances, social and economic factors, and human or ecological health concerns, effects on traditional wildlife harvesting were assessed as negative in direction, moderate in magnitude, regional in geographic extent, long term, and irreversible. Cumulative effects are not expected to significantly affect the assessment endpoint of maintaining continued opportunities to participate in traditional wildlife harvesting.

   The caribou population modelling undertaken for Adequacy Review item 8.8 (see the response to DAR-MVEIRB-15) did not result in a change to the residual cumulative effects to caribou or the residual cumulative effects to wildlife. Therefore, there is no change to the effects on traditional wildlife harvesting as a result of the caribou population modelling. .

2. As described in the cover letter to this submission, Dominion Diamond will host a one-day workshop in Yellowknife during the week of February 23, 2015 to consider how intangible elements of Aboriginal culture have been affected by diamond mines. A report will be provided to communities and participants following the workshop, with a summary provided to the MVEIRB prior to Jay Project Technical Sessions.

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Information Request Number:	DAR-MVEIRB-13
Source:	MVEIRB Jay Project Adequacy Review Item 8.6
Subject:	Barren-Ground Caribou - Cumulative Effects
DAR Section(s):	17.8

Preamble (MVEIRB):

The TOR required (a) a scenario analysis of relative and potentially important projects in its cumulative effects assessment (b) how Dominion will reduce or avoid any predicted cumulative effects. (c) a description of current efforts towards cumulative effects assessment and management should be described.

The DAR reports limited scenarios for caribou (such as high or low insect harassment or harvesting) but not including scenarios such as continued decline or recovery in caribou abundance or changes in development plans. The DAR predicts that the incremental and cumulative effects will not be significant but uncertainty was high for the reasonable foreseeable project scenario. The DAR does not propose how to reduce the uncertainty. The DAR mentions mitigation but does not detail how mitigation can be intensified to reduce cumulative effects. The description of efforts toward cumulative effects assessment and management does not include approaches applied to other current mines (operational and being assessed).

Request (MVEIRB):

Please address the lack of scenarios and population model especially relative to the recent decline of the Bathurst herd. The DAR should explain how to reduce or address consequences of the uncertainty in the predicted effects for the reasonable foreseeable projects.

Please provide details on monitoring and adaptive mitigation of cumulative effects such as reducing the size of the Zone of Influence, offsetting effects and developing a collaborative adaptive management framework are required together with scenarios for caribou abundance. The framework should specify how the GNWT's Monitoring and Habitat Protection Plan are linked and to Land Use permit conditions and co-management caribou planning. Describe how other mine projects on the Bathurst herd's range will assess and manage cumulative effects and describe how those efforts relate to Dominion's approach. Describe if and how Dominion proposes to work with other mines in the area to cooperatively manage cumulative effects on caribou.

Response:

The scenario analysis used to determine reasonably foreseeable developments is described in Section 6.5.2 of the Developer's Assessment Report (DAR). The scenario analysis used the maximum number of potential future projects that could occur within the effects study (assessment) area of valued components (VCs). The assessment did not evaluate different combinations of numbers, types, and locations of projects, but used a conservative approach that provides the maximum predicted cumulative effects on a VC. Evaluation of different possible combinations of number, types, and locations of projects would add uncertainty to the predicted effects for the Reasonably Foreseeable Development (RFD) Case analyzed in the DAR. In other words, the conservative approach taken was a means of reducing uncertainty. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. Different cumulative effect scenarios specific to trends in the caribou abundance are part of the population model results described in Adequacy response MVEIRB-IR-15.

As is the nature of forecasting into the future, there is inherent uncertainty about which reasonably foreseeable (future) projects will be developed, and the temporal extent of overlap among projects. This is because project development usually requires substantial financial investment. The use of conservative assumptions were applied throughout the assessment to maximize predicted effects, manage uncertainty, and increase confidence that impacts to caribou would not be underestimated through all assessment cases (all development scenarios including the RFD Case). For example, the BIPR and IZOK projects road right-of-ways were assumed to be 250 metres in the RFD case, which is considerably wider than the Misery Haul Road. With respect to mitigation of cumulative effects for the RFD Case, mitigation proposed for the BIPR (ERM Rescan 2013) and IZOK (MMG 2012) projects include similar temporary modifications to traffic patterns and road closures as the Jay Project, which are anticipated to limit effects to migration and maintain connectivity within and among caribou populations. The use of standardized mitigation and monitoring will also help identify cumulative effects across similar developments. Examples of mitigation common among active mines and proposed for the Jay Project (and likely other future projects) include:

- environmental training for personnel;
- interaction of wildlife and caribou with site will be monitored and communicated to operations;
- wildlife (including caribou) always have the right-of-way;
- road speed limits;
- signage to identify areas of high wildlife and caribou use;
- vehicles encountering wildlife on roads are required to stop and communicate the presence of wildlife on the roads to others workers; and,
- a Wildlife Effects Monitoring Program (WEMP) that provides feedback for adaptive management of mitigation and monitoring programs.

Additional caribou-related mitigation for the Jay Project is provided in the DAR (Section 12.3; Table 12.3-1). How conservative assumptions were applied to provide reasonably confident effects predictions in the assessment is provided in Section 12.5. Monitoring and the Environmental Management Framework (including adaptive management) related to the Jay Project are described in detail in response to DAR-MVEIRB-12. This response also provides an example of how Misery and Jay road traffic will be adaptively managed to mitigate impacts to caribou.

The existing Ekati Mine WEMP will be amended to include the Jay Project. The existing WEMP includes regional monitoring of wolverine and grizzly bear through standardized techniques intended to support cumulative effects assessment and management by the Government of the Northwest Territories

(GNWT). Standardized methods for caribou zone of influence (ZOI) monitoring have not been determined but are under consideration through collaboration between the GNWT and industry (GNWT-ENR 2014). Several studies have detected changes to caribou behaviour near mines (see Section 12.2.1.1.2 of the DAR), but it is unknown whether these behavioural changes associated with a ZOI are in response to noise, smells, movement, dust, vibration, or other sensory disturbance. Thus, there is uncertainty about how to mitigate this effect. The approach used at other mines and applied to the Project is to mitigate all potential mechanisms. For example, noisy equipment will be housed inside buildings or mufflers used, roads will be watered regularly to supress dust production, and food waste will be segregated and incinerated to limit smells.

The use of similar mitigation and standardized monitoring as described will provide the GNWT with development information for this purpose. Each development is responsible to adaptively manage its own site through monitoring and communicate results through annual reports as conditions of land use permits, and for the NWT diamond mines, Environmental Agreements. Dominion has and will continue to seek feedback from and collaborate with the GNWT, other mine operators, regulators, and communities on mitigation and design and results of monitoring programs through cumulative effects (GNWT-ENR 2013a) and wildlife monitoring workshops (Marshall 2009; Handley 2010; GNWT-ENR 2013b) and other meetings.

As presented in Adequacy response DAR-MVEIRB-12, Dominion Diamond has participated or contributed to regional wildlife monitoring initiatives intended for conservation and management including the GNWT's Barren-ground Caribou Management Strategy, the Bathurst Range Plan Working Group, and the Caribou Zone of Influence Technical Task Group. These programs include representatives from other operating mines and communities, and provide information to support cumulative effects assessment and management by the GNWT.

References:

ERM Rescan (ERM Rescan Environmental Services Ltd.). 2013. Back River Project: Wildlife Mitigation and Monitoring Plan. Draft Environmental Impact Statement Supporting Volume 10 Management Plans. Prepared for Sabina Gold and Silver Corp. by ERM Rescan Environmental Services Ltd., Vancouver, British Columbia.

GNWT-ENR (Government of the Northwest Territories, Department of Environment and Natural Resources) 2013a. Cumulative Effects Assessment and Management Workshop: Advancing a Framework for Managing Cumulative Effects in the NWT, February 5th to 7th, 2013. Prepared by Forcorp for the Department of Environment and Natural Resources, Government of the Northwest Territories. Yellowknife, NWT.

GNWT-ENR 2013b. Minutes of the 2013 Barren-ground Caribou Workshop, March 7th and 8th. Prepared by the Department of Environment and Natural Resources, Government of the Northwest Territories. Yellowknife NWT.

GNWT-ENR 2014. Zone of Influence Technical Task Group Terms of Reference. the Department of Environment and Natural Resources, Government of the Northwest Territories. August 12, 2014, Yellowknife, NWT.

Handley J. 2010. Diamond Mine Wildlife Monitoring Workshop Report. Prepared for Environment and Natural Resources. Yellowknife, NWT.

Marshall R. 2009. Diamond Mine Wildlife Monitoring Workshop Report. Prepared by Rob Marshall for Diavik Diamond Mines Inc.

MMG (Minerals and Metals Group). 2012. IZOK Corridor Project: Project Proposal. Vancouver, British Columbia.

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Information Request Number:	DAR-MVEIRB-15
Source:	MVEIRB Jay Project Adequacy Review Item 8.8
Subject:	Barren-Ground Caribou - Caribou mortality and population modelling
DAR Section(s):	12.2.2.4 and 12.3.2.2.2

Preamble (MVEIRB):

Section 12.2.2.4 of the DAR describes Bathurst caribou harvest levels from the Dogrib Harvest Study, resident hunters and non-resident hunters. Page 12-56 describes harvest along the Tibbitt to Contwoyto Winter Road. Both describe the current hunting ban and Aboriginal tag restrictions.

The DAR does not provide information that considers GNWT modelling of overall levels of adult and calf survival including all sources of mortality (such as harvesting, predation, etc.). Mortality from all sources is relevant in describing herd population dynamics and predicting cumulative impacts.

Request (MVEIRB):

1) Please update the description of harvest levels to include the WRRB Barren-Ground Caribou 2012/2013 Harvest and Monitoring Summary.

2) Please describe overall levels of adult and calf survival (including all sources of mortality) and model the herd population dynamics and demographics.

3) Please describe the levels of uncertainty of the population model, and the implications of that uncertainty. Describe how this relates to the mitigation of cumulative effects on caribou in light of the precautionary principle.

4) Please adjust models and predicted impacts to reflect the revised mortality rates for the herd.

Dominion is encouraged to discuss the above with the GNWT, IEMA and the WRRB while preparing its response.

Response:

The objective of this assessment was to evaluate the incremental effects of the Project, and cumulative effects of human land-use and natural disturbances on the viability of the Bathurst caribou herd using population viability analyses (PVA) in RAMAS 5.0® (Akçakaya 2005). The models were based on a commonly used software package (i.e., RAMAS) that provides transparency and repeatability of methods. The information presented here also fulfill the requests concerning population scenario modelling in Adequacy DAR-MVEIRB-13 (Adequacy Review Item 8.6). With respect to request 3 above, information on mitigation and monitoring of cumulative effects on the caribou is provided in the response to Adequacy DAR-MVEIRB-13. It is emphasized that the models are not used to predict the number of caribou in the future but as a comparison of relative trends under different scenarios. Based on the lack of information for survival and reproductive rates for all phases (increase, decrease, and no change) of the population cycle, the models should not be used to estimate future population sizes of the Bathurst herd.

The approach considered the latest information on adult female survival, pregnancy rate, body condition and herd composition (Boulanger et al. 2014a). From the results of the 2014 Bathurst herd calving ground reconnaissance survey Boulanger et al. (2014b) suggested an additional large decline may have occurred in the Bathurst herd from 2012 to 2014; however, no new vital rates were estimated.

The focus of the population models is to determine the relative changes in the Bathurst caribou population for different development and environmental scenarios. Local and regional effects from the Project and other developments on habitat quantity and quality, and caribou behaviour and vital rates were incorporated into model simulations. For example, results from the habitat quality analysis, which includes direct and indirect habitat effects from development (DAR Tables 12.4-19 and 12.4-23; Sable Addendum Tables 4.2-13 to 4.2-15) and the energetics model (DAR Table 12.4-27; Sable Addendum Tables 4.2-17) were linked to parameter inputs in the population models. The PVA was used to estimate the incremental effect from the Project, and the relative contribution of natural factors (insects, severe weather events) and human activities (previous, existing, and future developments, and hunting) on the population size and resilience of caribou.

Methods

Structure of Initial (Base Case) Model and Alternate Scenarios

A 10-year projection was used to simulate population growth in the Bathurst caribou herd. Input parameters included survival and fecundity rates (vital rates), carrying capacity, initial population size, periodic extreme weather-related events, periodic extreme insect harassment, and level of hunter harvest of adult female caribou. In subsequent models (i.e., reference condition, Application Case, reasonably foreseeable development [RFD] Case) and sensitivity analyses, input parameters were changed through different modifier variables (Table 15-1).

Table 15-1 Input Parameters and Associated Modifier Variables for Simulations in the Population Models

Input Parameters	Modifier Variables
Survival, fecundity	habitat insect harassment index residency time in zones of influence
Carrying capacity (*K*)	habitat
Initial population size	current size reported in literature
Extreme weather-related event	frequency and intensity of insects, deep and hard snow
Management actions	Hunter harvest

The models projected population sizes for one population (i.e., not separate sub-populations). All simulations were run over a 10-year period and replicated 1,000 times. At each time step, the number of calves, yearlings, sub-adults, and adults were projected, using a set of vital rates drawn from a random normal distribution with mean values taken from the stage matrix and standard deviations taken from the standard deviation matrix. Standard deviations indicated both measurement error (uncertainty) in estimates and environmental variation associated with natural and human-related factors.

Survival and Fecundity

A Leslie matrix was used to model an age-structured caribou herd (16 x 16- dimension life stages): female calves (young-of-year), yearlings (age 1), sub-adults (age 2) and reproductively mature adults (ages 3 to 13) (Table 15-2). The Leslie matrix was based on a "post-breeding" census of caribou, with no mortality between breeding and the census. A "birth-pulse" population was used in which all breeding takes place in a short period of time. Modelling focused on the adult female segment of the population as this segment most directly influences herd productivity (Gaillard et al. 1998).

The initial population (*N*) of breeding females for all model runs was 15,935 (standard error [*SE*]=1,407) as reported by Boulanger et al. (2014a), based on the 2012 Bathurst herd calving ground photographic survey. The vital rates used to construct the initial stage matrix included the following values reported in Boulanger et al. (2014a):

- Adult female survival rate = 0.78
- Yearling survival rate = 0.78
- Calf survival rate range = 0.06 to 0.60
- Fecundity = 0.84

The following vital rates and standard deviations were derived from information in Boulanger et al. (2014a):

- Coefficient of variation of initial population estimate = *SE/N* = 0.09
- Standard deviation of adult female survival rate = (confidence interval range/4 = 0.05/4 = 0.013

The assumed sex ratio at birth was 1:1 and the minimum age of reproduction was two years. Age-2 productivity was estimated as being 65% of that for prime-age females (Bergerud et al. 2008); whereas age-14 and age-15 females were estimated to be 75% as productive as prime-age females (Adams and Dale 1998). To match the population fecundity rate of 0.84 reported by Boulanger et al. (2014a), fecundity for animals three years old and older were set at 0.94 while the fecundity of two-year old caribou was set at 0.55 and fecundity was reduced to 0.72 for animals of 14 and 15 years old. Together with 0.78 annual survival of animals in these age groups, the weighted fecundity matches the reported value 0.84. Following Bergerud et al. (2008, p. 273) standard deviation (*SD*) was set at 0.027. As all modelling was completed on the female portion of the population only, the fecundity rates in the stage matrix were divided by 2 to account for the assumed 1:1 sex ratio at birth. At the given fecundity and adult and yearling survival rates, a calf survival rate of 0.60 was selected as it yielded an annual rate of increase (lambda [λ]) of 0.97, slightly lower than the value of 0.99 reported by Boulanger et al. (2014a).

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Table 15-2: Stage Matrix Comprised of Fecundity (first row of table) and Survival Rates (± 1 *SD*) of Female Bathurst Caribou for the Base Case Model

Age Class	Calf	Yearling	Sub-adult	Adult (3-13 yr)	Adult (14 yr)	Adult (15 yr)
Calf	0	0	0.27 (0.05)[a]	0.47 (0.013)[a]	0.36 (0.013)[a]	0.36 (0.013)[a]
Yearling	0.60 (0.10)	0	0	0	0	0
Sub-adult	0	0.780 (0.013)[b]	0	0	0	0
Adult	0	0	0.780 (0.013)[b]	0	0	0
Adult	0	0	0	0.780 (0.013)[b]	0	0
Adult	0	0	0	0	0.780 (0.013)[b]	0

Note: Base Case Model conditions are for 2014 developments, low insect harassment, and annual harvest of 50 adult female caribou; the initial growth rate (lambda; λ) in the above stage matrix was calculated as 0.97.

a) Value is product of estimated fecundity rate for 2014 development level and low insect harassment multiplied by 0.5 (i.e., female population only assuming a 1:1 sex ratio at birth) and adult survival rate.

b) Adult survival rates followed Boulanger et al. (2014a).

SD = standard deviation; yr = years.

Density Dependence, Carrying Capacity, Initial Population Size

Some studies have shown that density-dependent effects of overgrazing on calving, summer, and winter ranges can result in periodic range shifts and population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). In this assessment, a simple ceiling model was used that affected all vital rates and was based on the abundance of all stages (Akçakaya et al. 2004). Under the ceiling type of density dependence, the population grows exponentially until it reaches carrying capacity. A population that reaches carrying capacity remains at that level until a factor or set of factors causes the abundance of animals to drop below carrying capacity.

Bergerud et al. (2008) proposed that a density of five caribou per km^2 on the summer range (100,000 km^2) is the point at which calf recruitment of a caribou herd could be affected. Assuming that the proportion of females in a stable or increasing population is 64% (see Bergerud et al. 2008), then the carrying capacity of the annual range of the Bathurst herd may be as high as 320,000 female caribou. However, the approximate size of the largest recorded population of female caribou is 259,000 female caribou (in 1986; see Boulanger and Gunn 2007). Thus, for this assessment, a carrying capacity of 290,000 caribou was selected, which was the approximate mid-point between the largest recorded population size and the density proposed by Bergerud et al. (2008).

A coefficient of variation equal to 0.20 was applied to *K* to increase confidence that potential variation in *K* was captured in the models. Carrying capacity was reduced in the landscape simulations (see below) to reflect losses of preferred habitat. The proportional reduction in *K* was the mean reduction in preferred habitat across all seasons (DAR Tables 12.4-19 and 12.4-23; Sable Addendum Tables 4.2-13 to 4.2-15). All simulations started with 15,935 female caribou, which was the estimate of the population of female caribou greater than one year old on the calving grounds in 2012 (Boulanger et al. 2014a).

Stochasticity, Extreme Weather Events, and High Insect Harassment

Random events associated with environmental variation and the unpredictable nature of demographic variation can also influence population size. Demographic stochasticity is the sampling variation in the number of survivors and the number of offspring that occurs (even if survival rates and fecundities were constant) because a population is made up of a finite, integer number of individuals. Thus, the demographic stochasticity option in RAMAS was used for all models (Akçakaya et al. 2004). In addition, environmental stochasticity was modelled by drawing values randomly from lognormal distributions described by fecundity and survival values and their associated standard deviations.

The effects of stochasticity on fecundity, survival, and carrying capacity (*K)* were assumed to be correlated within the herd. Modelling incorporated a coefficient of variation (*CV*) of 0.09 on population size (*N*) to increase confidence that the temporal variation in *N* was not underestimated. In addition, an extreme weather-related event (e.g., insect harassment, deep, hard-packed snow years) was modelled as reducing the abundance of calves and older females (age 14 to 15) by 50% once every 10 years (Tews et al. 2007). The year of application was modelled as a stochastic function with 10% probability of occurrence in each year. It was assumed that the effect of an extreme weather-related event on the Bathurst herd was less severe than that observed for insular populations, such as the Peary caribou (*Rangifer tarandus pearyi)* (Bergerud et al. 2008). Finally, high levels of insect harassment were modelled as reducing calf survival and adult fecundity by values modelled in the DAR (Table 12.4-27) and the Sable Addendum (Table 4.2-17). The year of application of high insect harassment was modelled as a stochastic function with 20% probability of occurrence in each year.

Management Actions

An annual hunter kill of 50 adult female caribou was applied in all models except RFD-5. This value of 50 adult female caribou is in the range of reports of female caribou killed from the Bathurst herd for 2011 to 2013 (BGTWG 2014a, 2014b). For the RFD-5 model the harvest rate was set at 4% of the adult females annually.

Model Scenarios and Comparisons of Cumulative Effects

A suite of models describing various landscape conditions and insect harassment levels were examined (Table 15-3). Cumulative effects analyses were completed to evaluate the relative changes in modelled population changes under different scenarios of development, insect harassment, and harvest rate. At each of the two levels of insect harassment, the incremental effects from the Project on the population were examined by comparing threshold abundance probabilities and associated risk curves between the reference condition with low insect harassment against Base Case (2014 conditions), Application Case (with the addition of the Jay Project), and RFD Case.

All comparisons were made using two measurements of the viability of the population: 1) the projected final abundance at the end (year 10) of the simulation; and 2) threshold abundance probabilities and associated risk curves (Akçakaya et al. 2004). Threshold abundance probability is defined as the probability that the number of caribou will be below a specific abundance at the end of the simulation.The Kolmogorov-Smirnov test statistic (*D*) was used for identifying statistical significance ($P < 0.05$), which is the maximum reported difference in the probability of population decline between risk curves for each simulation. High values of *D* suggest that the shapes and slopes of two risk curves are different.

Table 15-3 Simulation Scenarios for Population Viability Analysis of Bathurst Caribou Herd

Simulation	Input Parameters	Condition of Modifier Variable
Reference 1 - No development - Low insect harassment	survival	3.6% increase in calf survival above base case
	fecundity	1.8% increase in fecundity above base case
	carrying capacity (*K*)	290,000
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals in10% of years
	management action	Absolute harvest rate of 50 adult females
Reference 2 - No development - Periodic high insect harassment	survival	3.6% increase in calf survival above base case
	fecundity	1.8% increase in fecundity above base case
	carrying capacity (*K*)	290,000
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals in10% of years
	Periodic high insect levels	26.8% decrease in fecundity and calf survival every 5 years
	management action	Absolute harvest rate of 50 adult females
Base Case 1 - 2014 development - Low insect harassment	survival	no change in stage matrix
	fecundity	no change in stage matrix
	carrying capacity (*K*)	4.4% reduction from Reference condition (*K* = 277,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	management action	Absolute harvest rate of 50 adult females
Base Case 2 - 2014 development - Periodic high insect harassment	survival	no change from stage matrix
	fecundity	no change from stage matrix
	carrying capacity (*K*)	4.4% reduction from Reference condition (*K* = 277,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	Periodic high insect levels	26.8% decrease in fecundity and calf survival every 5 years
	management action	Absolute harvest rate of 50 adult females
Application 1 - 2014 development plus Jay Project - Low insect harassment	survival	0.3% decrease in calf survival from stage matrix
	fecundity	0.15% decrease in fecundity from stage matrix
	carrying capacity (*K*)	4.5% reduction from reference condition (*K* = 274,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	management action	Absolute harvest rate of 50 adult females
Application 2 - 2014 development plus Jay Project - Periodic high insect harassment	survival	0.3% decrease in calf survival from stage matrix
	fecundity	0.15% decrease in fecundity from stage matrix
	carrying capacity (*K*)	4.5% reduction from reference condition (*K* = 274,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	Periodic high insect levels	27.2% decrease in fecundity and calf survival every 5 years
	management action	Absolute harvest rate of 50 adult females
RFD 1 - 2014 development plus Jay Project and RFDs - Low insect harassment	survival	3.9% decrease in calf survival from stage matrix
	fecundity	2.0% decrease in fecundity from stage matrix
	carrying capacity (*K*)	8.4% reduction from reference condition (*K* = 266,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	management action	Absolute harvest rate of 50 adult females

Table 15-3 Simulation Scenarios for Population Viability Analysis of Bathurst Caribou Herd

Simulation	Input Parameters	Condition of Modifier Variable
RFD 2 - 2014 development plus Jay Project and RFDs - Periodic high insect harassment	survival	3.9% decrease in calf survival from stage matrix
	fecundity	2.0% decrease in fecundity from stage matrix
	carrying capacity (*K*)	8.4% reduction from reference condition (*K* = 266,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	Periodic high insect levels	30.8% decrease in fecundity and calf survival every 5 years
	management action	Absolute harvest rate of 50 adult females

K = carrying capacity; % = percent; RFD = Reasonably Foreseeable Development.

Increasing Population Phase Analyses

Boulanger et al. (2014a) used empirical data collected from the Bathurst herd that represent exposure of the herd to the current level of development, climate and range conditions, predation and harvesting. The resulting vital rates were considered as those consistent with the Base Case assessment of the DAR. As noted by Boulanger et al. (2014a), the adult female survival rates their modelling revealed is below levels required for a stable herd. Therefore the Base Case model is one that shows the Bathurst caribou during a decline phase of the population cycle. To provide a comparison with vital rates that may be more representative of the Bathurst herd in an increasing population phase, the stage and standard deviation matrix values for modelling the Bathurst herd in the Gahcho Kué Environmental Impact Statement (De Beers 2010) were used. Vital rates for the stage matrices in the Gahcho Kué reference model were taken from a variety of sources (Case et al. 1996; Gunn et al. 2005; Boulanger and Gunn 2007; Adamczewski et al. 2009). The values used for that model appear in Table 15-4; complete details appear in De Beers 2010 (p. 7-130). Other modelling inputs match those used for the RFD Case analyses described above. An additional scenario was created to allow for increased hunting in the RFD Case. The set of models examining the increasing population phase are described fully in Table 15-5.

The RFD Case was selected for these analyses as it represents the maximum effects of previous, exisiting, and reasonably foreseeable developments, including the Jay Project. Hence, it is the assessment case with the maximum effect on habitat and caribou behaviour and energetics.

Table 15-4: Stage Matrix Comprised of Fecundity (first row of table) and Survival Rates (± 1 *SD*) of Female Bathurst Caribou for the Increasing Population Phase Reasonably Foreseeable Development Models.

Age Class	Calf	Yearling	Sub-adult	Adult (3-13 yr)	Adult (14 yr)	Adult (15 yr)
Calf	0	0	0.27 (0.009)	0.416 (0.014)	0.312 (0.01)	0.312 (0.01)
Yearling	0.804 (0.102)	0	0	0	0	0
Sub-adult	0	0.905 (0.115)	0	0	0	0
Adult	0	0	0.905 (0.115)	0	0	0
Adult	0	0	0	0.905 (0.115)	0	0
Adult	0	0	0	0	0.905 (0.115)	0

a) For complete details see De Beers (2010, page 7-130)

SD = standard deviation; yr = years.

Table 15-5 Simulation Scenarios for Population Viability Analysis of Bathurst Caribou Herd in an Increasing Population Phase

Simulation	Input Parameters	Condition of Modifier Variable
RFD 3 - Increasing population stage matrix - 2014 development plus Jay Project and RFDs - Low insect harassment	survival	3.9% decrease in calf survival from stage matrix
	fecundity	2.0% decrease in fecundity from stage matrix
	carrying capacity (*K*)	8.4% reduction from reference condition (*K* = 266,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	management action	Absolute harvest rate of 50 adult females
RFD 4 - Increasing population stage matrix - 2014 development plus Jay Project and RFDs - Periodic high insect harassment	survival	3.9% decrease in calf survival from stage matrix
	fecundity	2.0% decrease in fecundity from stage matrix
	carrying capacity (*K*)	8.4% reduction from reference condition (*K* = 266,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	Periodic high insect levels	30.8% decrease in fecundity and calf survival every 5 years
	management action	Absolute harvest rate of 50 adult females
RFD 5 - Increasing population stage matrix - 2014 development plus Jay Project and RFDs - Periodic high insect harassment - Increased hunting	survival	3.9% decrease in calf survival from stage matrix
	fecundity	2.0% decrease in fecundity from stage matrix
	carrying capacity (*K*)	8.4% reduction from reference condition (*K* = 266,000)
	initial abundance	15,935
	weather event	50% decrease in abundance of calves and 14 and 15 year old individuals every 10 years
	Periodic high insect levels	30.8% decrease in fecundity and calf survival every 5 years
	management action	Annual harvest of 4% of adult females

K = carrying capacity; % = percent; RFD = Reasonably Foreseeable Development.

For the Bathurst herd, there is not enough information on vital rates during the phases when caribou population size is increasing, decreasing, or remains stable to accurately predict the number of animals in the near or distant future. In this assessment, 10-year final abundance projections and threshold abundance probabilities were used only for relative comparisons of input parameters among models.

Results

Using the input parameters for the reference condition (i.e., no development on the landscape) with low insect harassment and low levels of hunting (Table 15-3, Reference 1) resulted in a declining population trajectory (Figure 15-1) consistent with the stage matrix whose vital rates indicate $\lambda = 0.97$, as noted above. The decline in the reference condition model is not a consequence of catastrophes or stochasticity in the model but arises from current survival and fecundity rates of the Bathurst herd that are consistent with population decline (Boulanger et al. 2014a).

Considering cumulative effects of development, the population trajectories of all models with low insect harassment levels, representing the four assessment cases documented in the DAR, all show declines over the 10-year period specified (Figure 15-1). The influence of development from reference conditions to Base Case (2014 conditions) resulted in a lower population throughout the 10-year period modelled (Table 15-6). The incremental change from the Base Case to the application of the Project was small by comparison, with a larger increase in cumulative effects on the Bathurst caribou herd in the RFD Case (Figure 15-1, Table 15-6). The population trend for each assessment case is statistically different from the trend for the reference condition, with a 27.5% predicted difference in the population between reference conditions and RFD Case (Table 15-6).

The predicted effect of the addition of the Jay Project is a slight decline in population below that predicted for the Base Case. The modelled magnitude was an additional 1.2% of the reference condition population projection.

Figure 15-1 Comparison of results of various assessment cases with low insect harassment and annual harvest = 50 adult female caribou. For each assessment case the figure shows the Mean Abundance of Female Bathurst Caribou for a 10-Year period. Error bars are mean ± 1 *SD*. Circles represent extreme simulation values. Abundance is expressed in thousands of caribou.

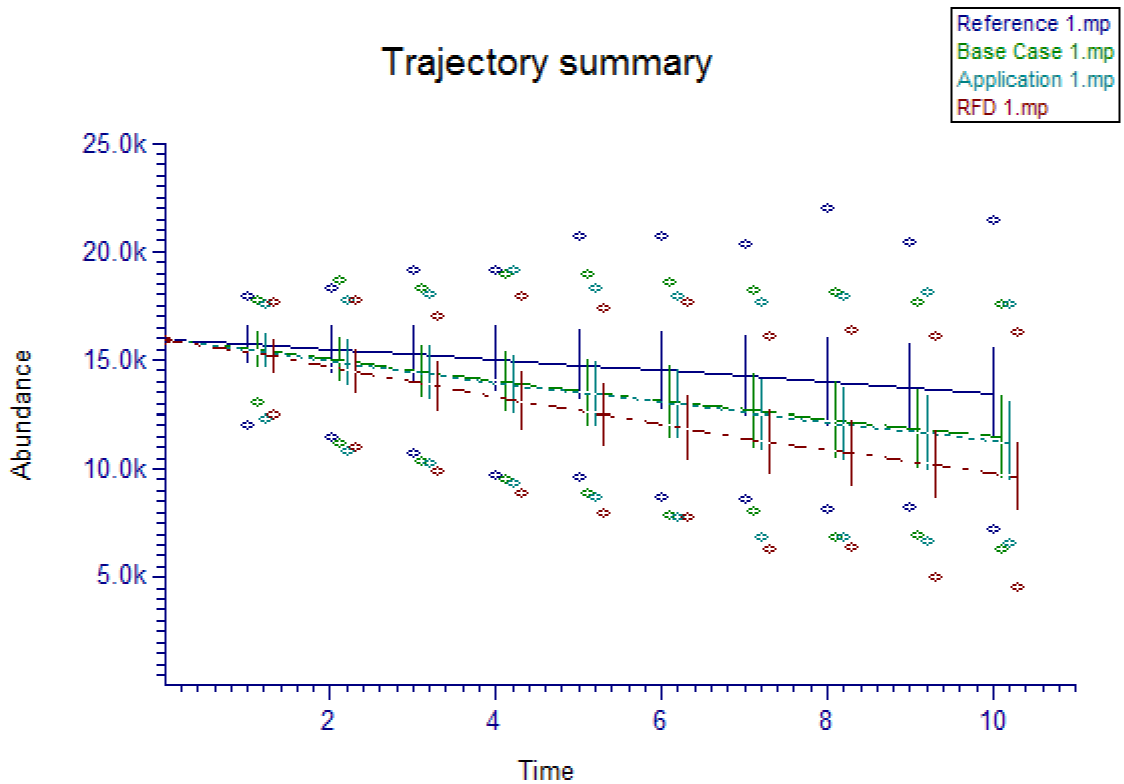


Table 15-6 Sensitivity Analyses of Parameter Inputs and Effects Analyses of Various Landscape Scenarios and Insect Harassment Levels for the Bathurst Herd Population Viability Analysis

Simulation	Projected Final Abundance (*SD*)	% Change in Final Abundance from Reference	Maximum Difference in Probability of Threshold Abundance between Risk Curves (*D*)[a]	Kolmogorov-Smirnov P-value[b]
Low Insect Harassment Scenarios				
Reference 1 (no development)	13,174 (2,077)	n/a	n/a	n/a
Base Case 1 (2014 development)	11,375 (1,850)	-13.7	0.40	<0.0001
Application- 1 (Base Case development + Jay Project)	11,210 (1,712)	-14.9	0.45	<0.0001
RFD-1 (Application + RFD developments)	9,545 (1,527)	-27.5	0.72	<0.0001
High Insect Harassment Scenarios				
Reference 2 (no development)	11,363 (2,190)	n/a	n/a	n/a
Base Case 2 (2014 development)	9,656 (1,969)	-15.0	0.33	<0.0001
Application- 2 (Base Case development + Jay Project)	9,609 (1,822)	-15.4	0.34	<0.0001
RFD-2 (Application + RFD developments)	8,124 (1,654)	-28.5	0.60	<0.0001
Additional Scenarios comparing Reference Case with Increasing Population Phase stage matrix				
Reference 1 (no development)	13,174 (2,077)	n/a	n/a	n/a
RFD 3 (Increasing population phase matrix, low insect harassment)	37,693 (6,812)	186.1	0.912	<0.0001
RFD 4 (Increasing population phase matrix, high periodic insect harassment)	31,296 (7,396)	137.6	0.838	<0.0001
RFD 5 (Increasing population phase matrix, high periodic insect harassment, harvest = 4% of population annually)	25,534 (5,968)	93.6	0.764	<0.0001

a) Compared to reference condition

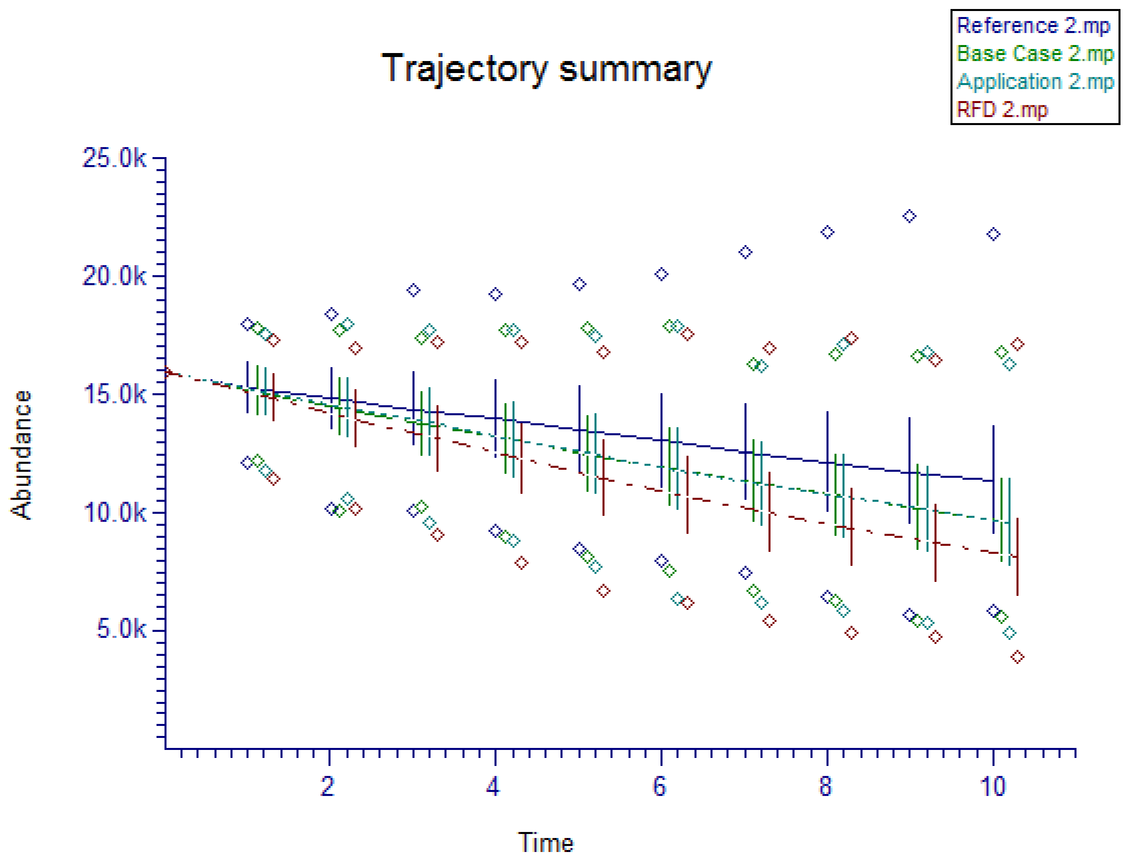
b) statistical significance accepted at an alpha level of 0.05.

D = Kolmogorov-Smirnov test statistic; *SD* = standard deviation; RFD = Reasonably Foreseeable Development; n/a = not applicable; % = percent; <= greater than.

The scenarios including periodic high insect harassment followed the same relative pattern as those including only low insect harassment, but the magnitudes of decline and the differences between assessment cases were greater. The population trajectories of models, representing the four assessment cases documented in the DAR, all show declines over the 10-year period specified (Figure 15-2). The influence of development from reference Conditions to Base Case (2014 conditions) resulted in a lower population throughout the 10-year period modelled (Table 15-6). The incremental change from the Base Case to the application of the Project was small by comparison, with a larger increase in cumulative effects on the Bathurst caribou herd in the RFD Case (Figure 15-2, Table 15-6). The population trend for each assessment case is statistically different from the trend for the reference condition, with a 28.5% predicted difference in the population between reference conditions and RFD Case (Table 15-6).

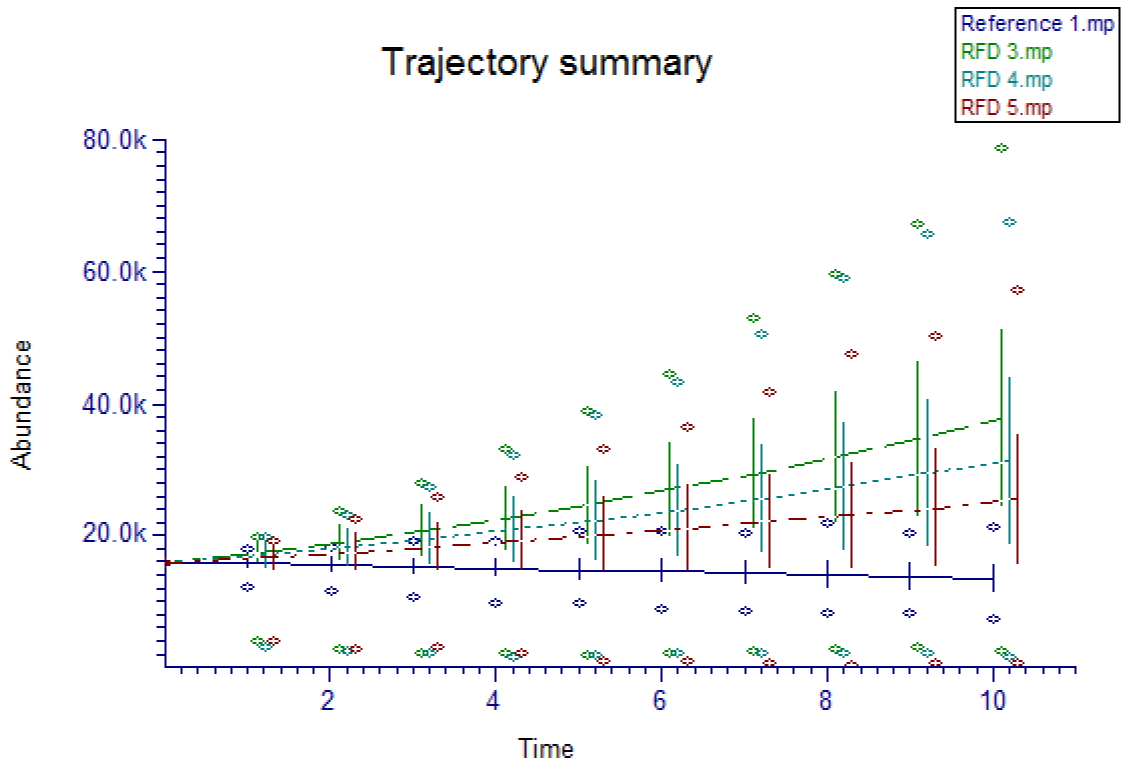
As for the low insect harassment scenarios, the incremental effect predicted from the addition of the Jay Project is a slight decline in population below that predicted for the Base Case. In the scenarios with periodic high insect harassment, the modelled magnitude was an additional decline of 0.4% of the reference condition population projection.

Figure 15-2 Comparison of results of various assessment cases with high periodic insect harassment and annual harvest = 50 adult female caribou. For each assessment case the figure shows the Mean Abundance of Female Bathurst Caribou for a 10-Year period. Error bars are mean ± 1 *SD*. Circles represent extreme simulation values. Abundance is expressed in thousands of caribou.



The final set of scenarios were those that examined RFD cases built on a population stage matrix of vital rates that may be closer to those expected during an increasing population phase. The RFD Case was selected for comparison as it is the assessment case with the highest predicted effects on the Bathurst caribou herd. Consequently, adverse cumulative effects from development and insect harassment are maximized. As expected, the population trends are increasing for the low insect harassment case (RFD 3, Figure 15-3, Table 15-6). Results also show potential for population increase with higher levels of insect harassment (RFD 4) even when considering maximum levels of disturbance in the RFD Case and harvesting opportunities are increased from 50 adult females to 4% of the population annually (RFD 5). Thus, using survival and reproduction rates that are higher than those currently observed demonstrates that caribou herds can absorb the negative effects from human development activities, climate conditions and harvesting, and still maintain positive population growth (Bergerud et al. 2008).

Figure 15-3 Comparison of results of reference condition assessment cases with low periodic insect harassment and annual harvest = 50 adult female caribou against RFD cases with Increasing Population Phase stage matrix. For each assessment case the figure shows the Mean Abundance of Female Bathurst Caribou for a 10-Year period. Error bars are mean ± 1 *SD*. Circles represent extreme simulation values. Abundance is expressed in thousands of caribou.



The decline observed in the 2014 calving ground reconnaissance survey (Boulanger et al. 2014b) is consistent with $\lambda = 0.52$, a loss of 48% of the population in each year. Any such decline would arise from a combination of reductions in female survival and calf production. Vital rates for modelling that are consistent with 2014 survey observations are hypothetical and range between an absolute failure of recruitment (fecundity × calf survival = 0), where adult survival would need to be 62% to achieve the observed decline, to maintaining current birth and calf survival rates, where adult survival would need to decline to 51% to achieve the observed decline. Any set of vital rates consistent with the 2014 reconnaissance survey results will show rapid decline in the population for all assessment cases.

Though all models were constructed with density-dependent functions, no density-dependent response was observed for any of the model outputs. The Bathurst herd is currently near its lowest recorded population level and the effects of reduced carrying capacity were not expected to be evident in model outputs. Density-dependent resource selection in a declining population should allow more selective use of habitat and use of smaller seasonal ranges (McLoughlin et al. 2006), which suggests habitat should be less limiting at the low phase of a population cycle. Additional analysis provided in response to Adequacy Review DAR-MVEIRB-9 detected decreasing trends in the size of post-calving and autumn seasonal ranges. Russell (2014) also demonstrated a significant increasing trend in total annual cumulative biomass on the Bathurst caribou spring to autumn ranges for shrub, herb-shrub, and lichen vegetation types.

In the absence of a density-dependent effect of a reduction in habitat, the effect of development in the population models arose from reduced fecundity and calf survival rates. Compared with the reference condition, these vital rates were lower for the Base Case, Application Case, and RFD Cases (Tables 15-3 and 15-5). The reduction in calf survival and fecundity used in the population models was based on body mass loss calculated from an energetics model that incorporated several conservative assumptions. These assumptions were made so that body mass loss would not be underestimated across the post-calving to autumn period.

For example, the energetics model assumed that a 20 kg loss by a 100 kg caribou cow would result in no calf production. In contrast, the Cameron and Ver Hoef (1994) model predicts that a caribou cow at 80 kg in autumn would have a parturition rate of 0.52, and demonstrates that caribou can still produce calves at lower weights than conditions set in the current analysis. The model also included a deflection cost that assumed caribou would not cross the Misery and Jay roads (i.e., a complete barrier effect), and would be required to travel using longer alternate routes to continue migration through the Lac de Gras area. Results of camera monitoring at the Ekati Mine from 2011 to 2013 indicate that caribou do cross the Misery Road, which suggests that it is not acting as a complete barrier to caribou movements (ERM Rescan 2014). Calculations of energetic costs used higher than average encounter rates and assumed no compensatory feeding by caribou outside of ZOIs, resulting in larger body mass loss than might be expected (Dale et al. 2008). Finally, the calculations do not account for possible habituation to disturbances as reported for other migratory caribou populations (Haskell and Ballard 2008; Johnson and Russell 2014). In summary, the energetic costs have been estimated at the maximum effect on vital rates.

The additional energetic costs from changes in movement and behaviour associated with the Project and other developments are not expected to decrease population resilience and increase the risk to the viability of the Bathurst herd at any phase of the population cycle. The negative trend in population growth associated with the current estimates of vital rates for reference conditions is predicted to be similar with and without the development-related cumulative changes in habitat quantity and quality, and caribou behaviour and energetics. Adamczewski et al. (2009) indicated that effects from the previous and existing mines are limited and unlikely a major contributing factor in the recent decline of the Bathurst caribou herd. Boulanger et al. (2011) noted that the vital rates required for the recovery of the Bathurst herd are similar to those that have been observed in the Western Arctic caribou herd and the Porcupine caribou herd.

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