Simulated Effects of Forest Harvest on Grizzly Bear Populations

in the Prince George Timber Supply Area

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Executive Summary

The purpose of this analysis is to model the relationship between grizzly bear survival and forestry development in the Prince George timber supply area (TSA). The goal is to develop an understanding of how current and future road development for forestry might influence grizzly bear populations. The information could be used to support the allowable annual cut (AAC) determination by providing an assessment of current and potential future effects of forest harvest on grizzly bear. The model was also used to explore how access management restrictions on forestry might influence grizzly bear populations and timber supply. The model was created for grizzly bear population units (GBPUs), or portions of GBPUs, that occur within the Prince George timber supply area (TSA). There is a legal need to adequately consider the effects of land use and management decisions such as AAC determinations on Indigenous peoples' rights to harvest wildlife. Here I describe a model developed to consider the effects of road development from forestry on grizzly bear populations, which are highly valued by many Indigenous peoples.

Grizzly bear population models were completed for five separate GBPUs that overlap the Prince George TSA, including the Nation, Nulki, Omineca, Parsnip and Upper Skeena-Nass. Initial GBPU population sizes from government of British Columbia estimates were used as the model starting population, adjusted based on the proportion of the GBPU that occurred within the Prince George TSA. The grizzly bear population model included female grizzly bears only, and was sub-divided into five reproductive and age classes typical of grizzly populations in North America. The model transitioned female grizzly bears between age and reproductive classes annually. The recruitment of three year old female grizzly bears into the population from two year old grizzly bears was calculated based on measured female litter size, cub survival rate and yearling survival rate from grizzly bear populations in British Columbia. I averaged recent grizzly bear population estimates (i.e., 2004, 2008 and 2012) for the Nation, Nulki, Omineca, Parsnip and Upper Skeena – Nass GBPUs to estimate habitat carrying capacity. A density dependent recruitment rate was implemented in the model using a sigmoidal function. As population size decreased relative to the carrying capacity of the habitat, recruitment rate increased, and vice-versa. Female grizzly bear survival rate was calculated for each GBPU based on road density in the GBPU using an empirical relationship between grizzly bear survival and road density. Hunting mortality was implemented in the grizzly bear population model independent of survival rates estimated from road density, as hunting mortality is directly managed by the government of British Columbia through a limited entry system.

Future forestry was simulated in a timber supply model under five different scenarios, including a reference scenario, a mid-seral forest scenario and three access management scenarios. The reference scenario timber supply model was parameterized in a way to reflect the current, defined forest management regime in the Prince George TSA carried forward into the future. Mid-seral forest and access management timber supply scenarios were developed to test how management regimes to limit the effects of future forestry roads on grizzly bear survival could influence future timber supply and grizzly bear populations relative to the reference scenario. Priority landscape units for grizzly bear management (n = 33) were identified by provincial government grizzly bear biologists. Mid-seral forest

and access management regimes were applied to these priority landscape units. The mid-seral forest management timber supply scenario was simulated where a maximum of 30% mid-seral forest was allowed in priority landscape units. Access management was simulated by limiting the road density in priority landscape units, including one where all types of road density was limited to 0.6 km/km^2, one where forestry road density was limited to 0.6 km/km^2 and another where forestry road density was limited to 1.2 km/km^2 with the assumption that half of current and future forestry roads were "removed" (i.e., deactivated or reclaimed). I used a statistical model of the relationship between road density and cutblock density at the landscape unit scale to estimate and limit future road density in GBPUs based on future simulated forest harvest (i.e., cutblocks) from the timber supply models.

Sensitivity analyses of the grizzly bear population model under the reference timber supply scenario were completed to test how the input parameters influenced grizzly bear population simulations. In addition, where possible, model recruitment and mortality outputs were compared to measured grizzly bear population parameters in the study area or in other grizzly bear populations in North America to validate the model against actual population data.

The Nation GBPU had a high population decrease in all scenarios in 35 and 70 years. The Nulki GBPU had a high population decrease in all scenarios in the long-term (70 years), but only a high population decrease in the mid-term (35 years) in the reference scenario, otherwise it had a moderate decrease in the access management scenarios. The Omineca GBPU had a high population increase in the mid-term in all scenarios. However, in the long term the population had a low decrease in the reference scenario and access management scenario with a 0.6 km/km^2 cap on forestry roads. In the access management scenario with a 0.6 km/km^2 cap on all roads or a 1.2 km/km^2 cap on forestry roads the Omineca population had a moderate increase. The Parsnip GBPU had a moderate population increase in the mid-term in all scenarios except in the access management scenario with a 0.6 km/km^2 cap on forestry roads, which had a low population increase. In the reference scenario and access management scenario with a 0.6 km/km^2 cap on forestry roads, the Parsnip GBPU had no change in the long-term population compared to a moderate increase in the other scenarios. The Upper Skeena – Nass GBPU had a high population increase in all scenarios over the mid- and long-term.

The most restrictive access management scenario (i.e., 0.6 km/km^2 cap on all roads) had the greatest effect on timber supply, as timber supply had a high decrease in the short-term (1 year) and long-term compared to the reference scenario. The other two less restrictive access management scenarios had a moderate decrease on short-term timber supply. All access management scenarios resulted in at worst a low decease of mid-term timber supply and even a low increase in mid-term timber supply in the access management scenario with a 1.2 km/km^2 cap on forestry roads. The least restrictive access management scenario had a low decrease on long-term timber supply.

Model results may be most valuable to consider the relative effects of alternate forestry and access management regimes on grizzly bear populations. The grizzly bear population model appears to provide a useful tool for simulating the effects of forest harvest on grizzly bear populations. Results from the simulation model compare favourably with grizzly bear population data collected in the Prince George area and other regions of western North America. Sensitivity analysis of the Nation and Omineca GBPUs indicated that habitat carrying capacity and survival rate were the primary drivers of grizzly bear population abundance.

The Omineca, Parsnip and Upper Skeena - Nass GBPUs currently appear to be productive and sustainable grizzly bear population areas within the Prince George TSA. The Nation and Nulki GBPUs are in decline according to the models. Sustaining grizzly bear populations in the Nation, Nulki, and Omineca GBPUs may continue to be or may become an increasingly difficult challenge. However, the implementation of access management by limiting road density in priority landscape units may reduce the rate of decline or stabilize grizzly bear populations in many areas of the Prince George TSA relative to the reference scenario, but these improvements may come with significant costs to timber supply. Access management in priority grizzly bear landscape units may only partially mitigate existing and potential future negative effects of forestry road development on grizzly bear. Education programs for road and trail users to reduce the probability of negative human-grizzly bear interactions may also need to be developed.

Ultimately, the model results illustrate a straightforward and science-based relationship between forestry, roads and grizzly bears. We can be reasonably confident that future forestry is going to negatively influence grizzly bear populations in the Prince George TSA and that access management to sustain grizzly bear populations may reduce these negative effects but also have timber supply costs. If the government of British Columbia is serious about conserving grizzly bears in the region, they must consider ways to regulate human use of roads. This will likely require both limiting road development in some areas and implementing programs that educate the public so that the probability of negative human-grizzly bear encounters on roads is reduced. While there is currently limited pressure from grizzly bear management on timber supply in the Prince George TSA, the model results indicate that future negative pressure on timber supply is a likely outcome, especially given the potential for forestry to infringe on First Nations rights to harvest and appreciate wildlife such as grizzly bear.

Introduction

The purpose of this analysis is to model the relationship between grizzly bear survival and forestry development. The goal is to develop an understanding of how current and future road development for forestry might influence grizzly bear populations. The information could be used to support the allowable annual cut (AAC) determination by providing an assessment of current and potential future effects of forest harvest on grizzly bear. Model results indicate whether future grizzly bear population trends could ultimately put a downward, upward or no pressure on timber supply. The model was also used to explore how access management might influence grizzly bear populations and timber supply. The model was created for grizzly bear population units (GBPUs), or portions of GBPUs, that occur within the Prince George timber supply area (TSA).

There is a need to consider the effects of forestry on wildlife in AAC determinations. Forest harvest can have strong and complex effects on the distribution and abundance of many wildlife species. Biodiversity conservation is a goal under the *Forest and Range Practices Act* (FRPA), and specific management attention is given to conserving regionally important wildlife species (i.e., species that are important to a region that rely on habitats that are not otherwise protected under FRPA and may be adversely affected by forest practices) and wildlife species at risk (i.e., endangered, threatened or vulnerable species; BC MWLAP 2004). Most important is that there is a legal need to adequately consider the effects of land use and management decisions such as AAC determinations on Indigenous peoples rights to harvest wildlife.[1,2,3]

Grizzly bear are a focal management species in Canada and British Columbia because of their social, cultural and conservation value. They are listed as species of *Special Concern* in Canada by the Committee on the Status of Endangered Wildlife in Canada. In British Columbia they are blue listed (i.e., species of special concern because of characteristics that make them particularly sensitive to human activities or natural events) and have a S3 conservation status (i.e., rare and local, found only in a restricted range or susceptible to extirpation or extinction). Grizzly bear are also a harvested species in British Columbia, and hunting is regulated through a limited entry hunt system (Austin et al. 2004). They are managed within GBPUs, which are geographically unique, but not necessarily isolated populations, typically bounded by natural and human-created landscape barriers.

Grizzly bear are wide ranging species that use a variety of habitats for food and shelter. Forest cutblocks may provide foraging habitat for grizzly bear and thus may be selected for (Nielsen et al. 2004a), with benefits to individual fitness (Boulanger et al. 2013). However, despite the potential positive effects of cutblocks, the associated road development also needs to be considered when evaluating the effects of forest harvest on grizzly bears (Wielgus and Vernier 2003). Roads typically have a significant negative effect on grizzly bear survival. Throughout western North America (McLellan and Shackleton 1988; McLellan 1988; McLellan 1990; Mace et al. 1996; Nielsen et al. 2004b; Proctor et al. 2004; Boulanger and Stenhouse 2014), research shows that roads facilitate interactions between humans and grizzly bear

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[1] https://www.crownpub.bc.ca/Content/documents/williams_decision.pdf
[2] http://www.courts.gov.bc.ca/jdb-txt/CA/11/02/2011BCCA0247.htm
[3] http://www.courts.gov.bc.ca/jdb-txt/CA/13/00/2013BCCA0001.htm

that can result in grizzly bear mortalities. Grizzly bear mortality rates may reach unsustainable levels (i.e., causing population declines) once road density increases beyond 0.75 km/km^2 (Boulanger and Stenhouse 2014), and a road density less than 0.6 km/km^2 is a target for grizzly bear conservation units in Alberta (Alberta Grizzly Bear Recovery Plan 2008) and is a recognized threshold of concern in British Columbia.[4]

Here I describe a model developed to consider the effects of road development from forestry on grizzly bear populations. I apply this model within the Prince George timer supply review process to measure how grizzly bear populations might respond to projected future road development for forest harvest and assess how access management might affect grizzly bear populations and timber supply.

Methods

Study Area

Grizzly bear population models were completed for five separate GBPUs that overlap the Prince George TSA, including the Nation, Nulki, Omineca, Parsnip and Upper Skeena-Nass. I focused on these GBPUs because all or close to the majority (greater than 40%) of their area occurred within the Prince George TSA, i.e., the entirety of the Nulki GBPU and portions of the Nation (93% within the TSA), Parsnip (93% within the TSA), Upper Skeena-Nass (53% within the TSA) and Omineca (40% within the TSA) GBPUs.

Grizzly Bear Survival Rate and Population Model

Grizzly bear population models were mathematically implemented in the program Stella Professional version 1.0.3 (http://www.iseesystems.com/softwares/stella-pro/v1.aspx). Stella Professional software is designed to model dynamic systems over time. The temporal extent of the population model was 70 or 100 years, with an annual time step.

Initial Grizzly Bear Population Size

Grizzly bear population estimates were completed for each GBPU in 2012 by the government of British Columbia using DNA-based mark-recapture population inventories, a regression model or expert opinion.[5] They estimated 170 animals in the Nation, 44 animals in the Nulki, 455 animals in the Parsnip and 755 animals in the Upper Skeena-Nass (Table 1). Initial GBPU population sizes were used here and adjusted based on the proportion of the GBPU that occurred within the Prince George TSA. Therefore, the population estimate for the Nulki GBPU was 44 animals, and the initial model population sizes for the Nation, Parsnip and Upper Skeena-Nass GBPUs were 158, 399 and 159 individuals, respectively. However, I used a slightly different approach in the Omineca GBPU. In 2012 there was significant spatial variability in grizzly bear density measured within the Omineca GBPU compared to other GBPUs. I therefore used the 2012 grizzly bear population estimates from finer-scale management units (MUs) to estimate the initial population for the GBPU. Population estimates were adjusted based on the

[4] http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html
[5] ibid

Table 1. Proportion and area of grizzly bear population units (GBPUs), and grizzly bear population estimates and measured mortalities in GBPUs in the Prince George Timber Supply Area (TSA).

Grizzly Bear Population Unit	Total Area (ha)	Proportion in Prince George TSA	2012 Population Estimate	Proportion of Population in Prince George TSA	2002-2011 Average Female Annual Mortalities
Upper Skeena-Nass	1,699,932	0.53	755	399	3.5
Omineca[1]	3,002,176	0.40	402	126[1]	4.2
Nation	1,868,695	0.93	170	158	2.1
Nulki	1,679,753	1.00	44	44	2.3
Parsnip (outside of CSFN)	1,099,617	0.93	455	424	3.3

1. The Omineca estimate was calculated at the management unit scale; see text for details

proportion of the MU that occurred within the Omineca GBPU and Prince George TSA. The initial model population size for the Omineca was 126 individuals.

Model Reproductive and Age Class Structure

The grizzly bear population model included female grizzly bears only, because as with many large mammalian wildlife species, females are the primary driver of population dynamics. Grizzly bear populations typically have more female adults than male adults, and I assumed grizzly bear population in the study area were 55% female (McLellan 1989). Therefore, the initial female population size was 87 for the Nation, 24 for the Nulki, 69 for the Omineca, 233 for the Parsnip and 219 for the Upper Skeena-Nass GBPUs.

The female population was sub-divided into five reproductive and age classes typical of grizzly populations in North America (Wielgus et al. 1994; Wakkinen and Kasworm 2004; Mace et al. 2011; Boulanger and Stenhouse 2014; McLellan 2015). These included sub-adult females (i.e., female bears three to five years old that typically do not reproduce), adult females without cubs (i.e., female bears that are greater than six years old, sexually mature but do not reproduce in a given year), adult females with cubs (i.e., female bears with cubs of the year), adult females with yearlings and adult females with two year olds. Female grizzly bears were allocated to each group based on age class proportions measured by McLellan (2015) in southeast British Columbia, including 40% sub-adult females and adult females without cubs (split 30% and 10%, respectively), 25% adult females with cubs, 18% adult females with yearlings and 16% adult females with two year olds. These allocations are similar to those found in other nearby grizzly bear populations (Schwartz et al. 2003; Boulanger and Stenhouse 2014).

Reproductive Class Transition Rates

The model transitioned female grizzly bears between age and reproductive classes annually. Transition rates (Table 2) were obtained using data from Mace et al. (2011), who estimated transition probabilities for the northern continental divide grizzly bear population. These transition rates are also similar to what was found in the Greater Yellowstone Ecosystem (Schwartz and White 2008). The sub-adult female transition rate to adult females without cubs was set at 0.333, as that represented one third of three to five year old bears.

Recruitment Rate

The recruitment of three year old female grizzly bears into the population from two year old grizzly bears was calculated as:

$$R = fl \times cs \times ys$$

where R is the recruitment rate, fl is the female litter size, cs is cub survival rate and ys is yearling survival rate. Litter size was estimated at 1.8 in southeast British Columbia (McLellan 2015) and 1.9 to 2.0 cubs in the study area (Ciarniello et al. 2009), and litters typically consist of a 50/50 ratio of females and males (Boulanger and Stenhouse 2014; Schwartz and White 2008). Therefore, fl was set at 0.95. Cub survival and yearling survival were estimated at 0.70 and 0.86, respectively (McLellan 2015). This equals a recruitment rate of 0.572 three year old females per adult female with two year olds per year.

Table 2. Reproductive class transition rates used to model grizzly bear populations in the Prince George Timber Supply Area (from Mace et al. 2011).

	Female without Cubs	Female with Cubs	Female with Yearlings	Female with Two year olds
Female without Cubs	0.510	0.490	0.000	0.000
Female with Cubs	0.040	0.111	0.852	0.000
Female with Yearlings	0.333	0.167	0.000	0.500
Female with Two year olds	0.200	0.800	0.000	0.000

Habitat Carrying Capacity

I averaged recent grizzly bear population estimates (i.e., 2004, 2008 and 2012) for the Nation, Nulki, Omineca, Parsnip and Upper Skeena – Nass GBPUs to estimate habitat carrying capacity. Note that some estimates changed significantly between surveys, as much as 77%, and it is likely that changes to survey methods across the surveys was a significant factor in the different population size estimates. Habitat carrying capacity was estimated as 153 females in the Nation, 78 females in the Nulki, 118 females in the Omineca, 239 females in the Parsnip and 202 females in the Upper Skeena – Nass GBPUs.

Habitat carrying capacity was made stochastic in the model to acknowledge that habitat quality can vary annually, for example, in response to variability in climate. Habitat carrying capacity was therefore re-set each year by randomly drawing the carrying capacity from a normal distribution of carrying capacity values with the mean average carrying capacity (described above) and a standard deviation of 40% of the mean. For example, the initial Nation habitat carrying capacity was 153 females; therefore carrying capacity was set annually by randomly drawing it each year from a normal data distribution with a mean of 153 and standard deviation of 61. I used 40% because that was the mean variation between 2004, 2008 and 2012 population estimates.

Density Dependent Recruitment Rate

A density dependent recruitment rate was implemented in the grizzly bear population model using a sigmoidal function (Fig. 1). As population size decreased relative to the carrying capacity of the habitat, recruitment rate increased. Conversely as population size increased relative to habitat carrying capacity, recruitment rate decreased. Various slopes in the recruitment rate function were calculated and visually compared to identify a slope that might realistically portray grizzly bear recruitment response to habitat changes. Steeper slopes generate a larger adjustment in recruitment rate. Ultimately, an equation with a slope of 3 (orange line in Fig. 1) was used in this model. Sensitivity analysis were completed to test the effect of other slopes (described below) on population simulations. The equation for the density dependent recruitment rate is:

$$R_t = (1 - \left(\frac{1}{1 + e^{\left(-\left(\left(\frac{P_t}{K_t} \right) - 1 \right) \times s \right)}} \right)) + 0.0719$$

where density dependent recruitment rate at time *t* (R_t) is a function of female grizzly bear population size (P_t) and habitat carrying capacity (K_t) at time *t.* The slope of the curve (s) was set to 3. An adjustment of 0.0719 is added to R_t so that when the population is at its carrying capacity, recruitment rate is 0.5719, which is the recruitment rate based on litter size, cub survival and yearling survival used in the model (see *Recruitment Rate*, above). Therefore, the assumption is that this recruitment rate was the recruitment rate when the population was at its carrying capacity.

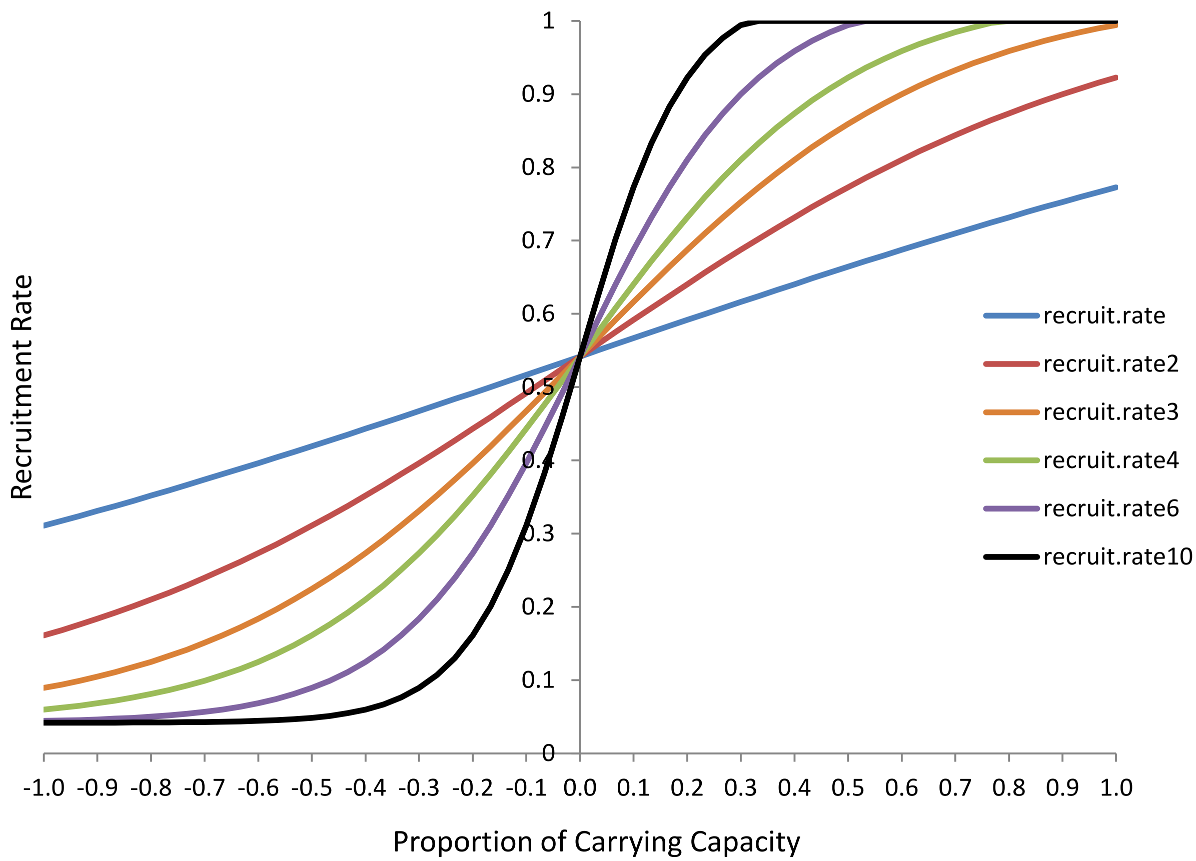

Figure 1. Recruitment rate calculated as a function of the proportional difference between the population size and habitat carrying capacity (i.e., proportion of carrying capacity, where negative values indicate the population is above carrying capacity) with a sigmoidal curve with different slopes. Slope values are indicated in the legend (e.g., recruit.rate2 indicates the slope was multiplied by 2).

Roads and Grizzly Bear Survival Rate

Female grizzly bear survival rate was calculated for each GBPU based on road density in the GBPU using an empirical relationship between grizzly bear survival and the average road density within 300 m of its location found by Boulanger and Stenhouse (2014). Boulanger and Stenhouse (2014) found that bears that spent more time within 300 m of higher road density areas were less likely to survive and they found different relationships for different reproductive classes of female grizzly bear. I used these empirical relationships to estimate grizzly bear survival rates in each GBPU based on the area of different road density classes in each GBPU.

I calculated road density within a 120 m radius at a 100 m spatial resolution across the Prince George TSA. I used digital road atlas data[6] merged with forest tenure roads data[7] to digitally map roads. To remove duplicate roads from the merged datasets, I first converted the linear road data into a 20 m spatial resolution raster. I then vectorised the raster back into line data using the ArcScan extension in ArcGIS 10.2. I calculated road density on this data using a 120 m radius rather than the 300 m radius used by Boulanger and Stenhouse (2014), as McLellan (2015) found that 84% of human-caused grizzly bear deaths were less than 120 m from a road in southeast British Columbia and Ciarniello et al. (2009) found that ten of thirteen human caused mortalities in the study area were less than 100 m from a road in the study area.

Road density measured in 100 m x 100 m areas (i.e., 'pixels') was classified into one of five grizzly bear survival rate classes (Table 3) using the results from Boulanger and Stenhouse (2014). Survival rates for each female grizzly bear reproductive class were calculated in each GBPU by multiplying the proportional area of each road density class in a GBPU by the survival rate for the reproductive class and summing them together (Table 4). Survival rates were implemented in the population model by multiplying each reproductive class population by its corresponding survival rate each year.

Mortality and Hunting

Hunting mortality was implemented in the grizzly bear population model independently of survival rates estimated from road density, as hunting mortality is directly managed by the government of British Columbia through a limited entry system. I assumed that hunter success rate was independent of roads, as grizzly bear are a highly desired and rare trophy animal, and therefore it is likely that grizzly bear hunters would make significant effort to harvest a bear, regardless of road access.

Only female grizzly bears that are greater than two years old and without young can be legally harvested in British Columbia (Austin et al. 2004). I therefore assumed that only sub-adult or adult females without cubs could be harvested. Annual maximum harvest was estimated in the population model based on historical female harvest rates for MUs from 2012 to 2015, corrected for the proportion of the MU within the GBPU and Prince George TSA. The Nation harvest rate was 1.0 bears/year, Nulki was 0 bears/year (no hunting was permitted), Omineca was 1.5 bears/year, Parsnip was 2.1 bears/year and Upper Skeena-Nass 0.8 bears/year. Annual hunter harvest was set as a probabilistic outcome based on

[6] http://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads
[7] http://catalogue.data.gov.bc.ca/dataset/forest-tenure-road-section-lines

Table 3. Female grizzly bear survival rates based on road density in 120 m radius areas. Survival rates were estimated using results from Boulanger and Stenhouse (2014).

		Survival Rate		
Class	Road Density (km/km^2)	Adult Female with Cubs or Yearlings	Adult Female with Two Year Olds or No Cubs	Sub-adult Female
5	>1.25	0.760	0.910	0.822
4	1.00 to 1.24	0.820	0.930	0.867
3	0.75 to 0.99	0.890	0.950	0.928
2	0.50 to 0.74	0.940	0.970	0.956
1	<0.50	0.970	0.980	0.978

Table 4. Estimated female survival rates in grizzly bear population units (GBPUs) in the Prince George timber supply area based on current mapped road density. Survival rate was calculated from road density using the statistical model provided by Boulanger and Stenhouse (2014).

GBPU	Adult Female with Cubs/Yearlings Survival Rate	Adult Female with 2 year olds or no cubs Survival Rate	Sub-adult Female Survival Rate
Nation	0.912	0.961	0.935
Nulki	0.893	0.954	0.921
Omineca	0.955	0.975	0.967
Parsnip	0.952	0.974	0.964
Upper Skeena - Nass	0.966	0.979	0.975

historical hunter harvest, and harvest was split equally between sub-adult females and adult females with no cubs. Government of British Columbia policy is to suspend hunting in a GBPU if it drops below 100 individuals (i.e., 55 females if we assume 55% of the population is female). Therefore, the model was implemented so that hunting would be stopped if the population went below 55 females (corrected for the proportion of the GBPU in the Prince George TSA).

Future Forestry, Road Density and Grizzly Bear Survival Rates

Future forestry was simulated in a timber supply model under five different scenarios, including a "reference" scenario, a mid-seral forest scenario and three access management scenarios. The reference scenario timber supply model was parameterized in a way to reflect the current, defined forest management regime in the Prince George TSA carried forward into the future. Alternate parametrizations for mid-seral and access management scenarios are described below.

Future road density and grizzly bear survival rates were estimated for each timber supply scenario. First, I used a statistical model of the relationship between road density and cutblock density at the landscape unit scale (Muhly 2016) to estimate future road density in GBPUs based on future simulated forestry, where:

$$RD = (CD * \ 3.36) + (CD^2 * -1.91) \ - 0.04$$

RD is estimated road density (km/km^2) and *CD* is cutblock density simulated in each landscape unit at each time interval from the timber supply model. Future forestry disturbance (i.e., cutblock) locations were simulated in the timber supply model at one year intervals in the first ten years and five year intervals over the next sixty years.

I assumed that roads that were previously developed to harvest cutblocks would be re-used, i.e., no new roads were created to cutblocks that were cut a second or more times. Thus, before I calculated future road density from simulated future cutblock density, I removed the area of simulated new cutblocks from the timber supply model that overlapped with areas of past known cutblocks[8] to avoid creating new roads into previously harvested areas. In addition, seventy years into the future were simulated in the grizzly bear population model, as this was the period of the timber supply model where any new simulated cutblocks would only be cut once. After seventy years, simulated cutblocks may be cut a second time, and thus counting these cutblocks would result in double-counting of newly developed roads.

Simulated road density in each landscape unit was multiplied by the area of each landscape unit to obtain total length of new roads at each time interval. The length of new roads in each GBPU at each interval was summed from the landscape units within the GBPU, adjusting for the proportion of each landscape unit within each GBPU. The total length of new roads simulated in each landscape unit and GBPU was divided by 240 m to calculate the number of 120 m radius areas with new roads. This value was then multiplied by 4.5239, which is the number of 100 m by 100 m pixels (i.e., the spatial resolution of the road density data, see above) within a 120 m radius area. These squares were all assumed to have

[8] https://catalogue.data.gov.bc.ca/dataset/harvested-areas-of-bc-consolidated-cutblocks-

a high road density (i.e., Class 5, Table 3), as a 120 m radius area bisected by a single road has a road density of 5.3 km/km^2, and the current road density data had a bimodal distribution of pixels with most pixels either having no roads or very high road densities. The number of new high road density class pixels was then summed for each landscape unit and GBPU and added to the highest road density class area in the landscape unit and GBPU, and subtracted from the lowest road density class, at each time interval. Area-weighted survival rates for each female grizzly bear reproductive class were then re-calculated at each interval to model survival rate through time. Annual or five-year survival rates were implemented in the grizzly bear population model for each scenario.

Model Sensitivity and Validation

Sensitivity analysis of the grizzly bear population model under the reference timber supply scenario was completed to test how the input parameters influenced grizzly bear population simulations. In addition, where possible, model outputs were compared to measured grizzly bear population parameters in the study area or in other grizzly bear populations in North America to validate the model against actual population data. For example, the mean annual number of simulated mortalities was compared to the mean number of documented and estimated undocumented mortalities by the government of British Columbia from 2002-2011.[9] Undetected mortalities were estimated by the government of British Columbia by assuming that undetected mortality rate was 40% of the detected mortality rate (Austin et al. 2004).

Sensitivity analyses were completed for the Nation and Omineca GBPUs. Sensitivity analyses included: doubling and halving carrying capacity, setting the density dependent recruitment slope (s) as 1 and 10, doubling hunter success and eliminating hunting, and increasing and decreasing survival rates on all reproductive classes by 5% (with a maximum survival rate 0f 0.999). Each sensitivity analysis was completed independently, holding the other parameters at the model settings described above. Model results were summarized by calculating mean values from 100 independent model runs.

Mid-Seral Forest and Access Management Scenarios

Mid-seral forest and access management timber supply scenarios were developed to test how management regimes to limit the effects of future forestry on grizzly bear could influence future timber supply and grizzly bear survival rates relative to the reference scenario. The application of mid-seral forest and access management across the entire Prince George TSA was acknowledged as likely having a significant negative effect on timber supply. Therefore, priority landscape units (n = 33) for grizzly bear management were identified by provincial government grizzly bear biologists (Fig. 2). Mid-seral forest and access management were limited to these priority landscape units. Landscape units were prioritized based on grizzly bear food quality and quantity. Specifically, priority units had either:

- greater than 50% of their area classified as high-value food vegetation, of which less than 60% occurred in existing protected areas, or
- greater than 10,000 kg estimated salmon biomass.

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1. [9] http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html

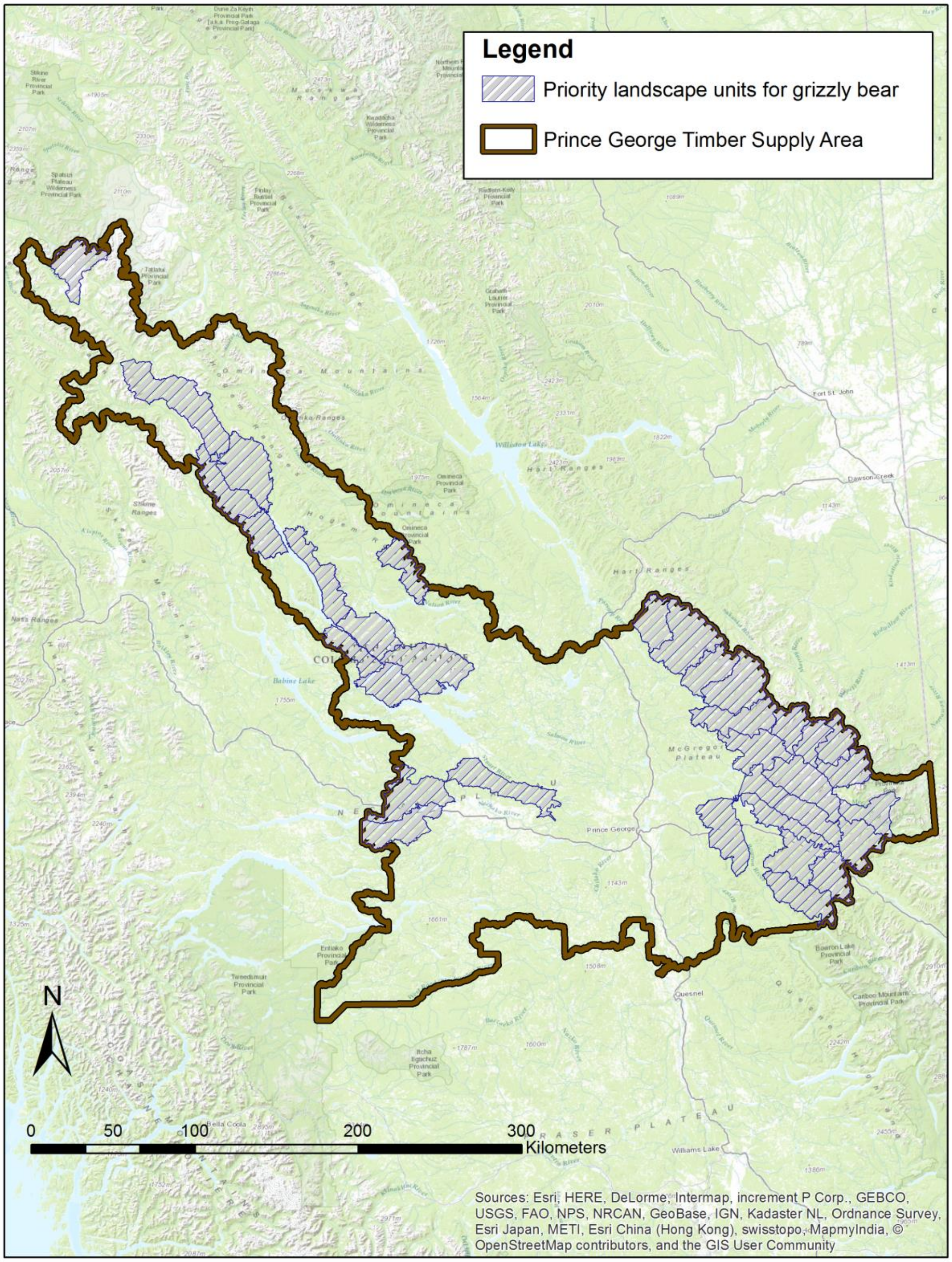


Figure 2. Location of priority landscape units for grizzly bear management used in timber supply analyses.

Mid-seral, conifer-dominant dense forest has low habitat value for grizzly bear, as it provides limited forage. Specifically, areas with greater than 30% closed canopy, conifer-dominated mid-seral forest are considered poor grizzly bear habitat. Therefore, a timber supply scenario was simulated where a maximum of 30% mid-seral forest was permitted in priority landscape units.

Access management was simulated by limiting the road density in priority landscape units. Three access management scenarios were simulated: one where all road density was limited to 0.6 km/km^2 in priority landscape units, one where forestry road density was limited to 0.6 km/km^2 in priority landscape units and another where forestry road density was limited to 1.2 km/km^2 with the assumption that half of current and future forestry roads were "removed" (i.e., deactivated or reclaimed). Road density was limited to 0.6 km/km^2, as that has been identified as a threshold over which grizzly bear may no longer use an area, and as a management target in British Columbia[10] and Alberta (Alberta Grizzly Bear Recovery Plan 2008; Nielsen et al. 2009). Boulanger and Stenhouse (2014) found a similar threshold (i.e., 0.75 km/km^2) over which mortality rates may be unsustainable for grizzly bear populations in Alberta.

Road density was limited in priority landscape units by capping the amount of THLB in those units. The cap for THLB was set using the statistical relationship between road density and cutblock density (see above) and limiting the THLB to the cutblock density equivalent to the road density cap. Thus, the THLB cap was set at 12.1% for the all road density less than 0.6 km/km^2 scenario, 21.7% for the forestry road density less than 0.6 km/km^2 scenario and 43.4% for the forestry road density less than 1.2 km/km^2 scenario. For the latter scenario, the THLB threshold was doubled rather than using the statistical relationship, as I assumed that half the roads were removed and thus unavailable for accessing new cutblocks. In the former scenario, I assumed forestry roads made up 56% of roads in an area (Forest Practices Board 2015). Thus, maximum forestry road density in priority landscape units was capped at 0.34 km/km^2, which is a cutblock density of 0.121 km^2/km^2.

Results

Nation Grizzly Bear Population Unit Sensitivity Analysis

Sensitivity analysis for the Nation GBPU showed the relative effects of different habitat carrying capacities and hunting, recruitment and survival rates on a simulated declining grizzly bear population (Fig. 3). Halving habitat carrying capacity resulted in a steep population decline (approximately 40%) within 20 years, and then the population stabilized over the next 90 years. Doubling habitat carrying capacity resulted in a slight population increase. Doubling the average number of female grizzly bears harvested per year also resulted in a steep population decline (approximately 40%) within 20 years. Restricting grizzly bear hunting resulted in a stable population over 100 years. Increasing the slope of the recruitment rate (s = 10; Fig. 1) resulted in a stable population. Decreasing the slope of the recruitment rate (s = 1; Fig. 1) increased the rate of population decline to approximately 40% over 30 years. Decreasing the survival rate of all age classes by 5% resulted in a steep population decline to approximately 0 within 100 years. Increasing the survival rate of all age classes by 5% resulted in an approximately threefold population increase over a 100 year period.

[10] http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html

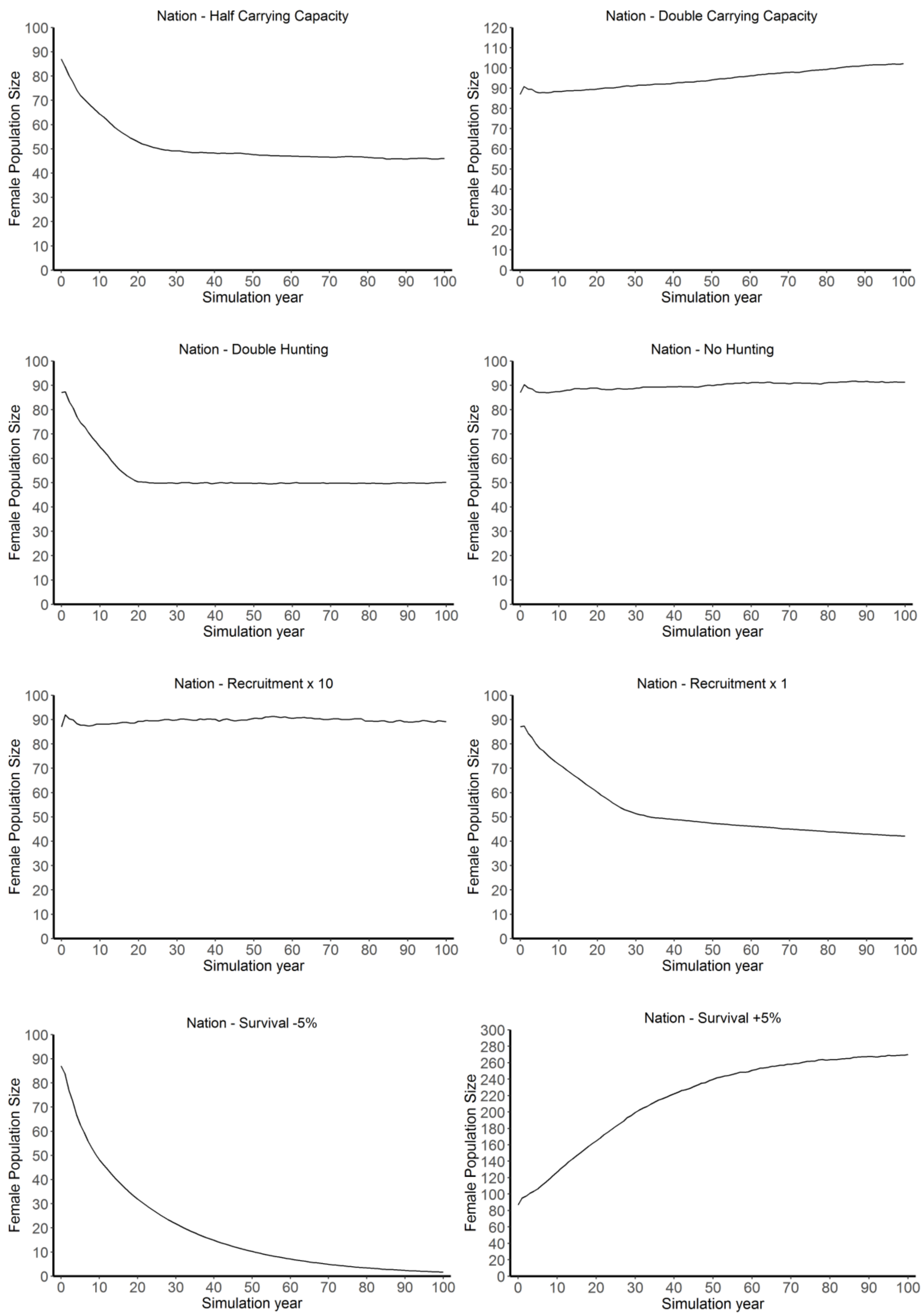


Figure 3. Annual mean number of female grizzly bear simulated at different habitat carrying capacities and hunting, recruitment and survival rates in the Nation grizzly bear population unit from 100 simulations over a 100 year simulation period assuming all other model parameters remained at initial values.

Omineca Grizzly Bear Population Unit Sensitivity Analysis

Sensitivity analysis for the Omineca GBPU showed the relative effects of habitat carrying capacity and hunting, recruitment and survival rates on a simulated increasing grizzly bear population (Fig. 4). Halving habitat carrying capacity resulted in a steady population decline (approximately 30%) over 100 years. Doubling habitat carrying capacity resulted in a steady increase in the population by approximately four times in 100 years. Doubling the average number of female grizzly bears harvested per year resulted in an approximately 70% population decrease in sixty years. Restricting grizzly bear hunting resulted in a steady population increase by approximately double in 50 years. Increasing the slope of the recruitment rate (s = 10; Fig. 1) resulted in an initial slight population increase followed by a stable population at approximately 120 females. Decreasing the slope of the recruitment rate (s = 1; Fig. 1) resulted in a close to doubling of the population in approximately 100 years. Decreasing the survival rate of all age classes by 5% resulted in a rapid population decline of approximately 70% within 30 years. Increasing the survival rate of all age classes by 5% resulted in a large population increase of approximately five times over 100 years.

Comparison of Simulated and Documented Grizzly Bear Moralities and Recruitment Rates

Simulated average annual female grizzly bear deaths over the first 10 years of the reference model simulation period in the Nation, Omineca, Parsnip and Upper Skeena–Nass were two to three times higher than the average number of female grizzly mortalities estimated (i.e., documented and undocumented mortalities) by the government of British Columbia from 2002 to 2011 (Table 5). The number of simulated mortalities in the Nulki GBPU was two thirds less than the number of estimated mortalities. Mean simulated recruitment rate (R_m) in the first 10 years of the model varied across the five GBPUs. Recruitment rates were: Nation (R_m = 0.779), Nulki (R_m = 0.933), Omineca (R_m = 0.751), Parsnip (R_m = 0.547), and Upper Skeena-Nass (R_m = 0.445).

Effects of Timber Harvest Scenarios on Grizzly Bear Populations and Timber Supply

I summarized the relative effects of each timber harvest simulation scenario on grizzly bear population abundance and timber supply (Table 6). For the former, I compared the percent change in grizzly bear population abundance in the mid-term (35 years) and long-term (70 years) to initial population estimates within each scenario. For the latter, I compared the percent change in timber supply of each access management scenario to the reference scenario in the short-term (1 year), mid-term and long-term. Both positive and negative effects are indicated (increases and decreases, respectively), and changes were classified as high (25% to 50% change), moderate (10% to 25% change) or low (less than 10% change).

The Nation GBPU had a high population decrease in all scenarios in 35 and 70 years (Table 6). The Nulki GBPU had a high decrease in all scenarios in the long-term (70 years), but only a high decrease in the mid-term (35 years) in the reference scenario. In the access management scenarios, the Nulki GBPU had a moderate decrease in the mid-term population. The Omineca GBPU had a high population increase in the mid-term in all scenarios. However, in the long term the population had a low decrease in the reference scenario and access management scenario with a 0.6 km/km^2 cap on forestry roads. In the access management scenario with a 0.6 km/km^2 cap on all roads or a 1.2 km/km^2 cap on forestry roads the population had a moderate increase. The Parsnip GBPU had a moderate population increase in the

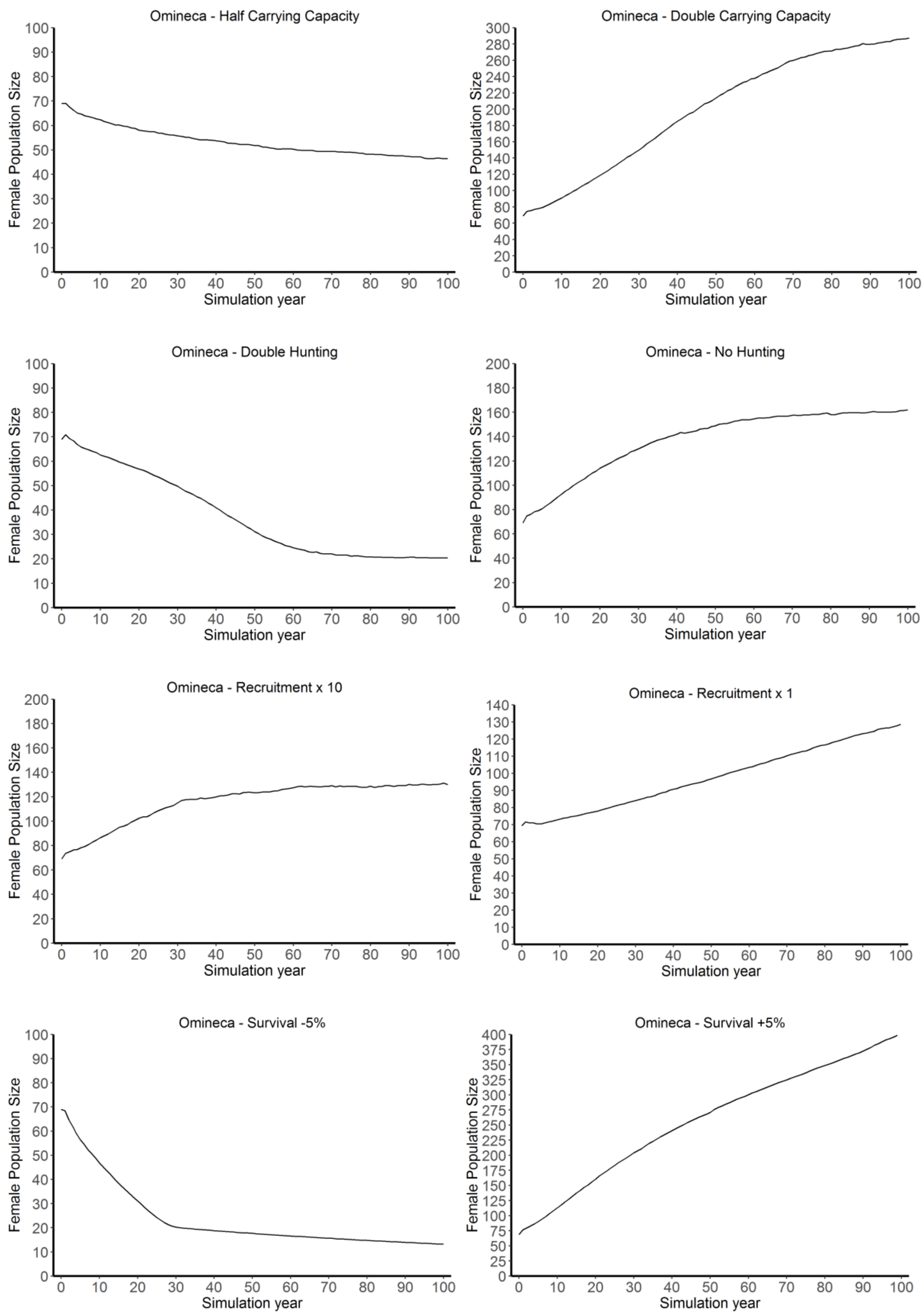


Figure 4. Annual mean number of female grizzly bear simulated at different habitat carrying capacities and hunting, recruitment and survival rates in the Omineca grizzly bear population unit from 100 simulations over a 100 year simulation period assuming other model parameters remained at initial values.

Table 5. Mean number of documented and estimated undocumented female grizzly bear mortalities in each grizzly bear population unit (GBPU) from 2002 to 2011[1] and the mean number of mortalities simulated in the first 10 years of 100 simulations from a grizzly bear population model. The number of documented mortalities was adjusted in proportion to the area of the GBPU in the Prince George TSA.

	Total Female Mortalities		
GBPU	Mean Documented 2002 - 2011	Mean Documented and Undocumented 2002 - 2011	Mean Simulated
Nation	2.0	2.8	7.6
Nulki	2.3	3.3	2.2
Omineca	1.7	2.3	4.7
Parsnip	3.1	4.3	12.5
Upper Skeena-Nass	1.8	2.6	8.1

1. http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html

Table 6. Relative effects of each timber harvest simulation scenario on grizzly bear populations and timber supply at 1, 35 and 70 year time intervals.

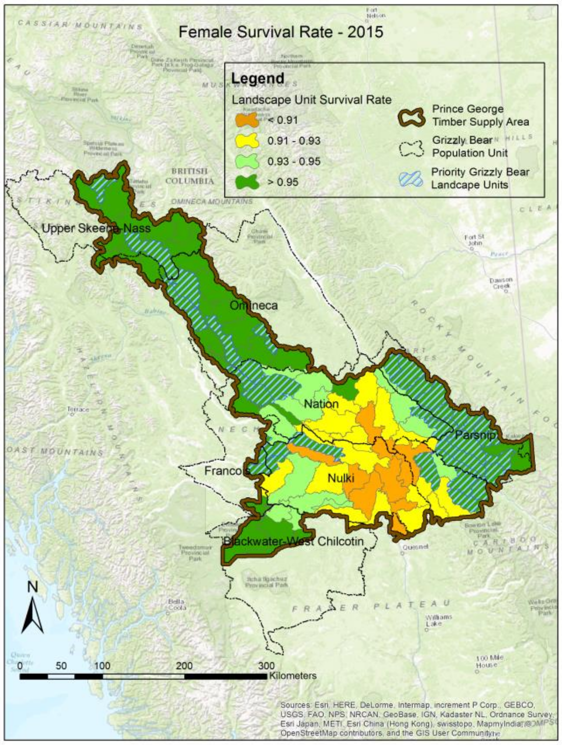
		GBPU Population Change (%)					
Scenario	Years into Future	Nation	Nulki	Omineca	Parsnip	Upper Skeena - Nass	Timber Supply Change (%)
Reference	1						
	35	High Decrease	High Decrease	High Increase	Moderate Increase	High Increase	
	70	High Decrease	High Decrease	Low Decrease	No change	High Increase	
All roads <0.6km/km^2	1						High Decrease
	35	High Decrease	Moderate Decrease	High Increase	Moderate Increase	High Increase	Low Decrease
	70	High Decrease	High Decrease	Moderate Increase	Moderate Increase	High Increase	High Decrease
Forestry roads <0.6km/km^2	1						Moderate Decrease
	35	High Decrease	Moderate Decrease	High Increase	Low Increase	High Increase	Low Decrease
	70	High Decrease	High Decrease	Low Decrease	No change	High Increase	High Decrease
Forestry roads <1.2km/km^2	1						Moderate Decrease
	35	High Decrease	Moderate Decrease	High Increase	Moderate Increase	High Increase	Low Increase
	70	High Decrease	High Decrease	Moderate Increase	Moderate Increase	High Increase	Low Decrease

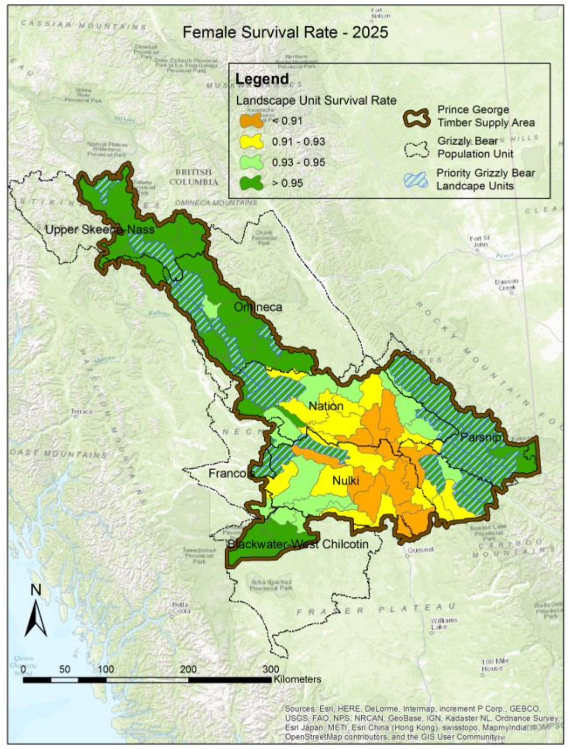
High Change = 25 - 50%; Moderate Change = 10 - 25%; Low Change = <10%

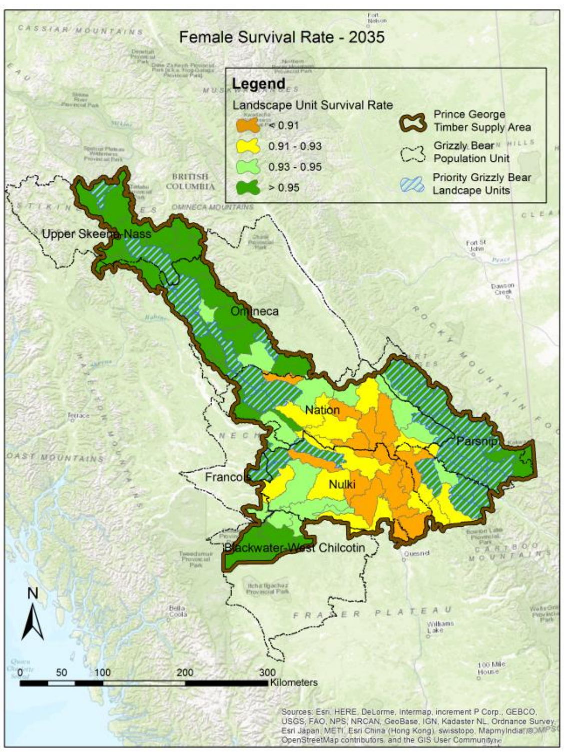
mid-term in all scenarios except in the access management scenario with a 0.6 km/km^2 cap on forestry roads, which had a low population increase. In the reference scenario and access management scenario with a 0.6 km/km^2 cap on forestry roads, the Parsnip GBPU had no change in the long-term population compared to a moderate increase in the other scenarios. The Upper Skeena – Nass GBPU had a high population increase in all scenarios over the mid- and long-term.

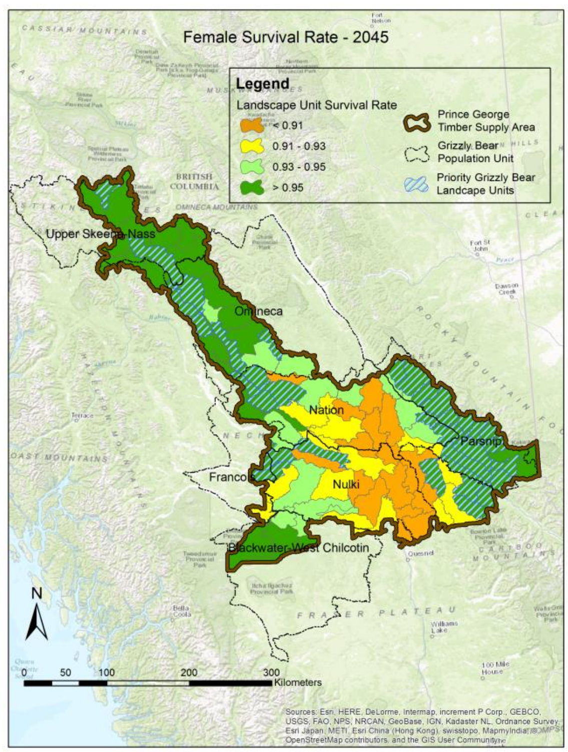
Modeled grizzly bear survival rate by landscape unit for the most restrictive access management scenario (i.e., 0.6 km/km^2 cap on all roads) is illustrated in Fig. 5. Initially, as in all scenarios, mortality rates in central portions of the Prince George TSA, particularly in the Nulki and Nation GBPUs were relatively high. Over time, survival rates of landscape units in the Omineca GBPU begin to decline as forest harvest increased in those areas. The biggest changes in survival rate occurred in landscape units in the western portions of the Nation and Nulki GBPUs and landscape units in the southern portions of the Omineca GBPU.

The most restrictive access management scenario (i.e., 0.6 km/km^2 cap on all roads) had the greatest effect on timber supply, as timber supply had a high decrease in the short-term (1 year) and long-term compared to the reference scenario (Table 6; Fig. 6). The other two less restrictive access management scenarios had a moderate decrease on short-term timber supply. All access management scenarios resulted in at worst a low decease of mid-term timber supply and even a low increase in mid-term timber supply in the access management scenario with a 1.2 km/km^2 cap on forestry roads. The least restrictive access management scenario had a low decrease on long-term timber supply.


Female Survival Rate - 2015
Legend
Landscape Unit Survival Rate
< 0.91
0.91 - 0.93
0.93 - 0.95
> 0.95
Prince George Timber Supply Area
Grizzly Bear Population Unit
Priority Grizzly Bear Landcape Units
Upper Skeena-Nass
Omineca
Nation
Parsnip
Francois
Nulki
Blackwater-West Chilcotin
N
0 50 100 200 300
Kilometers
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Female Survival Rate - 2025
Legend
Landscape Unit Survival Rate
< 0.91
0.91 - 0.93
0.93 - 0.95
> 0.95
Prince George Timber Supply Area
Grizzly Bear Population Unit
Priority Grizzly Bear Landcape Units
Upper Skeena-Nass
Omineca
Nation
Parsnip
Francois
Nulki
Blackwater-West Chilcotin
N
0 50 100 200 300
Kilometers
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Female Survival Rate - 2035
Legend
Landscape Unit Survival Rate
< 0.91
0.91 - 0.93
0.93 - 0.95
> 0.95
Prince George Timber Supply Area
Grizzly Bear Population Unit
Priority Grizzly Bear Landcape Units
Upper Skeena-Nass
Omineca
Nation
Parsnip
Francois
Nulki
Blackwater-West Chilcotin
N
0 50 100 200 300
Kilometers
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Female Survival Rate - 2045
Legend
Landscape Unit Survival Rate
< 0.91
0.91 - 0.93
0.93 - 0.95
> 0.95
Prince George Timber Supply Area
Grizzly Bear Population Unit
Priority Grizzly Bear Landcape Units
Upper Skeena-Nass
Omineca
Nation
Parsnip
Francois
Nulki
Blackwater-West Chilcotin
N
0 50 100 200 300
Kilometers
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

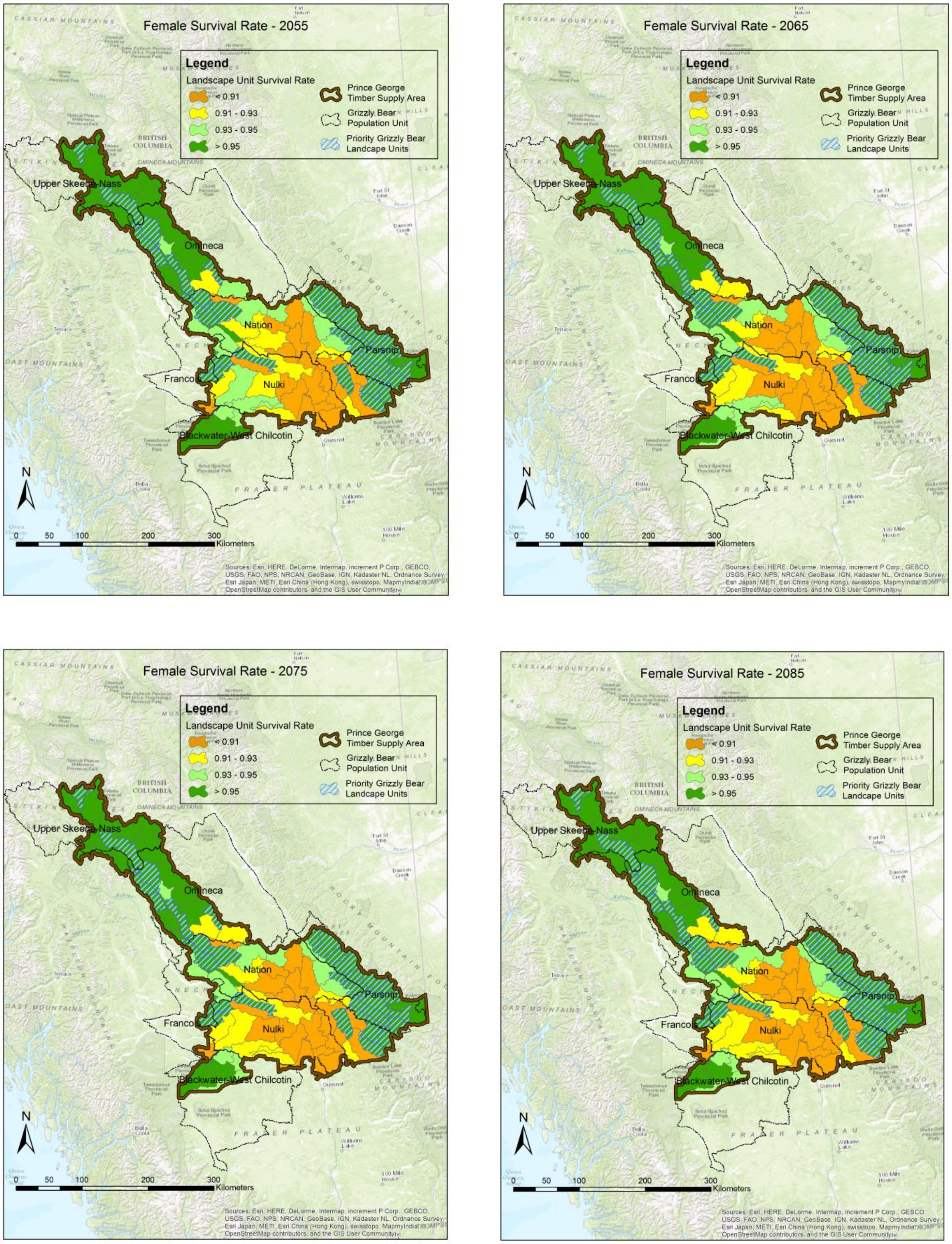


Figure 5. Simulated female grizzly bear survival rate by decade and landscape unit in the Prince George timber supply area in a scenario where all road density is limited to 0.6 km/km^2 in priority grizzly bear landscape units.

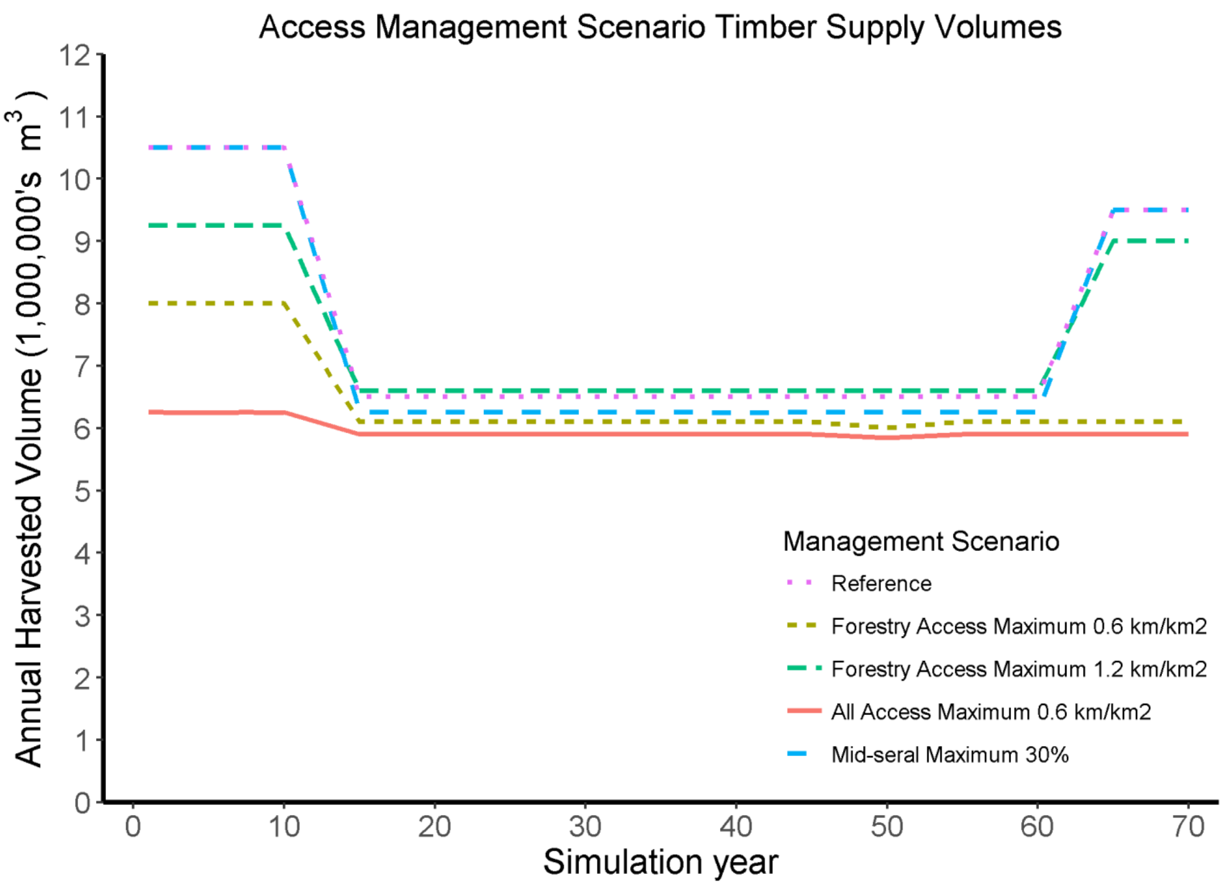


Figure 6. Volume of timber harvested under the reference and various grizzly bear management timber supply scenarios.

Conclusions

Context for Considering Model Results

Model results may be most valuable to consider the relative effects of alternate forestry and access management regimes on grizzly bear survival and populations. They should be considered as simulations of the potential effects of current and future forestry development on grizzly bear populations. They should not be considered as accurate or absolute representations of future forestry or grizzly bear population trends. Some specific considerations when considering model results include:

- Only the effects of roads from forestry activities were simulated into the future. The effects of future roads developed for other land use activities were not considered.
- In most cases, only portions of GBPUs were simulated and therefore forestry disturbances (or lack of disturbance) outside of those areas were not factored into population estimates.
- The model assumes a habitat carrying capacity for each GBPU based on previous population estimates. It is unknown whether this is an accurate representation of habitat carrying capacity and thus the effect of habitat on recruitment rate remains a key uncertainty in the model. In addition, the relationship between recruitment rate and carrying capacity remains a key uncertainty.

Model Validity

The grizzly bear population model appears to provide a useful tool for simulating the effects of forest harvest on grizzly bear populations. Results from the simulation model compare favourably with grizzly bear population data collected in the Prince George area and other regions of western North America. Average annual model recruitment rates over the first 10 years of the simulation period in each GBPU were mostly within the range of recruitment rates measured in British Columbia grizzly bear populations. For example, data from McLellan (2015) on reproductive rates and cub and yearling survival would produce a recruitment rate as calculated in this model that ranged between 0.690 and 1.407 female cubs per adult female with two year olds from 1989 to 2010 in southeast British Columbia. Garshelis et al. (2005) measured a recruitment rate of 0.172 recruits per adult female per year in the Rocky Mountains of Alberta, which is equivalent to 0.538 female recruits per adult female with two year olds per year, assuming a reproductive class structure similar to the one modeled here. Mowat and Lamb (2016) measured a recruitment rate of approximately 0.14 recruits per adult in the South Rockies GBPU and approximately 0.21 recruits per adult in the Flathead GBPU, which is equivalent to 0.80 and 1.19 sub-adult females per adult female with two years olds, respectively, assuming a similar age and sex structure as we used in our model.

The model results suggest the density dependent recruitment rate function that I used was reasonable. However, I again caution that the slope of the recruitment rate was subjectively determined and thus there remains uncertainty around recruitment rate in the model. In some simulations, populations exceeded habitat carrying capacity. A shallower recruitment rate slope decreases the resiliency of populations below their habitat carrying capacity, as recruitment rate increases less as populations decrease below their carrying capacity. However, as populations increase above habitat carrying capacity, recruitment rate remains relatively high, allowing the population to exceed carrying capacity. A steeper slope would increase resiliency of the population, as recruitment rate will increase more as population size drops relative to carrying capacity. However, a steeper slope means that recruitment rate will decline more rapidly as population size increases relative to carrying capacity. The slope currently implemented in the model is a compromise between maintaining resilience at low population numbers and preventing the population from surpassing habitat carrying capacity.

The model appeared to overestimate grizzly bear mortality in several of the GBPUs. However, survival rates estimated in the model were based on empirical measurements of the relationship between grizzly bear survival and road density measured in a nearby area (Boulanger and Stenhouse 2014), which were similar to what has been measured in other parts of western North America (Wielgus et al. 1994; Mace et al. 2012; McLellan 2015), including the study area, where an adult (greater than six year old) female survival rate of 0.96 was found in the Parsnip GBPU area and a survival rate of 0.92 was found in the Nation GBPU area (Ciarniello et al. 2009). Furthermore, model grizzly bear hunting rates were based off of documented recent hunting rates, and hunting was stopped in the model if population numbers declined below 55 females. Therefore, the mortality settings in the model do not appear to be unrealistically high. Rather, it is equally plausible that undetected mortality is higher than what has been previously estimated (Mowat and Lamb 2016). Indeed, unrecorded deaths in British Columbia may be particularly high for female grizzly bears relative to males (McLellan et al. In Press).

Overall, the model approach and simulation results appear reasonable and can be used to make management decisions with some confidence. However, they should only be used in consideration of their limitations (described in the previous section). Furthermore, as with most models, they should ideally be validated further and adjusted where necessary as more data on grizzly bear populations in the region becomes available.

Model Sensitivity

Sensitivity analysis of the Nation and Omineca GBPUs indicated that carrying capacity and survival rate were the primary drivers of grizzly bear population abundance. Female survival rates greater than 0.91 may be required to sustain grizzly bear populations (Garsehlis et al. 2005; Harris et al. 2006). However, mortality rates greater than 3% (survival rate less than 0.970) can cause population declines when food is scarce (Mowat and Lamb 2016). McLellan et al. (In Press) found that hunter kill rates of 4-10%, or perhaps more, are sustainable, although that is assuming approximately two thirds of the kill are males. Thus, an adult female survival rate less than approximately 0.980 to 0.960 may not be sustainable.

While the grizzly bear population model mortality rates (Appendix A) are based on an empirical relationship between road density and mortality (Boulanger and Stenhouse 2014), the model lacks data on habitat carrying capacity. Data on habitat carrying capacity would likely improve the accuracy of model results. Recent data from Ciarniello et al. (2009) indicated that bears in the Nation area were in better physical shape than bears in the Parsnip area, suggesting that the Parsnip GBPU may have recently been at or above carrying capacity, whereas the Nation may have been below carrying capacity. The habitat carrying capacity I used for the Parsnip may therefore be accurate.

Additive hunting mortality was an important factor in the population model. The Omineca GBPU population increased and the Nation GBPU stabilized when hunting was not permitted in the model compared to models where hunting was permitted. Modeling hunting mortality as additive has the potential to overestimate the effect of hunting on the population, as population survival rates from Boulanger and Stenhouse (2014) were not measured in exclusion of hunting mortalities. However, harvesting one animal in a population of 50 animals decreases survival rates by 2%, which still produces model mortality rates that are consistent with rates measured in studied grizzly bear populations (see above). Thus, the model as it currently is parametrized does not appear to unrealistically overestimate hunting mortality in the region.

Model Limitations

Some potentially important aspects of the relationship between road density and grizzly bear mortality that are not directly addressed in the model are:

1. The relationship between roads and habitat quality, and;
2. The relationship between human behaviour and grizzly bear mortality.

In the former case, research has shown that the location of roads relative to grizzly bear habitat is an important factor in grizzly bear survival rate (Nielsen et al. 2006; Lamb et al. 2016). Mortality risk from roads is higher in areas of higher quality grizzly bear habitat, as bears will be more likely to use those habitats. The model described here does not consider the location of roads relative to grizzly bear habitat within landscape units. The model attempts to consider this factor in the access management scenarios by limiting road developed in priority landscape units, which have high-quality habitat. However, the model does not consider road placement at finer scales, nor does it consider the distribution of bears and roads within GBPUs when estimating survival rates. Finer-scale information on road and grizzly bear distribution could be incorporated into the model to more accurately estimate grizzly bear population abundance.

In the latter case, grizzly bears that live in areas with high road densities may have higher survival rates if people using the roads have a high tolerance for grizzly bear presence or are more capable of avoiding encounters with bears. Education programs to increase human tolerance for grizzly bear or that teach people to avoid encounters with bears could increase grizzly bear survival rates even in high-road density areas. However, there is currently no empirical data to support this relationship and thus it is not currently included in the model.

Implications of Model Results for Forestry and Timber Supply

Here I primarily focus on the effects of forestry on grizzly bear at a GBPU scale, as GBPUs are the current administrative boundaries used for managing grizzly bear throughout British Columbia. However, at least some, if not most of the GBPUs were not isolated, as grizzly bear could move among GBPUs. Therefore, some GBPU populations that were declining according to the model (i.e., sinks) could potentially be maintained by immigrants from nearby GBPUs that are highly productive (i.e., sources). The model results provide an indication of the suitability of a GBPU (within the Prince George TSA) as a source or sink area for grizzly bears under current and simulated future forestry practices.

The Omineca, Parsnip and Upper Skeena - Nass GBPUs currently appear to be productive and sustainable grizzly bear population areas within the Prince George TSA. Indeed, these GBPUs may currently produce a surplus of grizzly bears, which may emigrate to neighbouring GBPUs. However, Ciarniello et al. (2009) found that no female bears moved between the Nation and Parsnip GBPUs, indicating the Parsnip GBPU would not be a source population for the Nation GBPU. Nevertheless, the Omineca and Upper Skeena - Nass GBPUs may be particularly important in the region because they were simulated as having increasing population trends, thus potentially acting as source populations for the region.

Sustaining grizzly bears in the Nation, Nulki, and Omineca GBPUs may continue to be or may become an increasingly difficult challenge. However, the implementation of access management by limiting road density in priority landscape units may reduce the rate of decline or stabilize grizzly bear populations in many areas of the Prince George TSA relative to the reference scenario, but these improvements may come with significant costs to timber supply. Compared to the reference scenario, restricting the density of roads in priority grizzly bear landscape units slowed the rate of simulated population decline in the Nulki GBPU. Similarly, a 0.6 km/km^2 cap on road density in priority landscape units would support an increasing population in the Omineca GBPU over the long-term, compared to a decline in the reference scenario. However, this level of road density management would significantly reduce timber supply in the short- and long-term. Less restrictive road density management (i.e., 1.2 km/km^2 in priority grizzly bear landscape units) would also support a slower population decline in the Omineca and Nulki GBPUs, but at a lesser reduction in timber supply over the short-, mid- and long-term.

Access control by limiting road density in priority grizzly bear landscape units may only partially mitigate existing and the potential future negative effects of forestry road development on grizzly bear survival. In addition to road density management, education programs for road and trail users that reduce the probability of negative human-grizzly bear interactions could be implemented. WildSafe BC[11] is a program designed to reduce negative human-wildlife interactions in general. Such programs may need to be developed specifically for grizzly bear.

Ultimately, the model results illustrate a straightforward relationship between forestry, roads and grizzly bears. The specific results of the model may not be accurate, but the general relationships and trends are supported by research and information from grizzly bear populations throughout western North America (Ciarniello et al. 2009; Boulanger and Stenhouse 2014; McLellan 2015). Thus, we can be reasonably confident that future forestry is going to negatively influence grizzly bear populations in the Prince George TSA and that access management may reduce these negative effects but also have timber supply costs.

If the government of British Columbia is serious about conserving grizzly bears in the region, they must consider ways to regulate human use of roads. This will likely require both limiting road development in some areas and implementing programs that educate the public so that the probability of negative human-grizzly bear encounters on roads is reduced. Education programs may have little or no effect on

[11] https://wildsafebc.com/

timber supply, as they do not require restrictions on road development. However, significant effort must be made to enforce and measure the effectiveness of these programs for them to be considered viable management options. While there is currently limited pressure from grizzly bear management on timber supply in the Prince George TSA, the model results indicate that future negative pressure on timber supply is likely, especially given the potential for forestry to infringe on First Nations rights to harvest and appreciate wildlife such as grizzly bear. There is a risk that in the future significant downward pressure could be put on timber supply if grizzly bear become a higher priority management concern for the government of British Columbia.

Literature Cited

Alberta Grizzly Bear Recovery Plan: 2008-2013. 2008. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species Recovery Plan No. 15. Edmonton, AB. 68 pp. Available from: http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/mammals/documents/SAR-GrizzlyBearRecoveryPlan2008-2013-Dec2008.pdf

Austin, M.A., D.C. Heard and N.N. Hamilton 2004. Grizzly Bear (*Ursus arctos*) Harvest Management in British Columbia. Available from: http://www.env.gov.bc.ca/wld/documents/gb_harvest_mgmt.pdf

BC Ministry of Water, Land and Air Protection (MWLAP). 2004. Identified Wildlife Management Strategy Procedures for Managing Identified Wildlife. Pp. 52. Available from: http://www.env.gov.bc.ca/wld/documents/identified/IWMS%20Procedures.pdf

Boulanger, J., & Stenhouse, G. B. (2014). The impact of roads on the demography of grizzly bears in Alberta. PloS one, 9(12), e115535.

Boulanger, J., Cattet, M., Nielsen, S. E., Stenhouse, G., & Cranston, J. (2013). Use of multi-state models to explore relationships between changes in body condition, habitat and survival of grizzly bears Ursus arctos horribilis. Wildlife Biology, 19(3), 274-288.

Forest Practices Board. 2015. Access management and Resource Roads: 2015 Update. Special Report. FPBSR/49. Available from: https://www.bcfpb.ca/sites/default/files/reports/SR49-Access-Management.pdf

Garshelis, D. L., Gibeau, M. L., & Herrero, S. (2005). Grizzly bear demographics in and around Banff National Park and Kananaskis country, Alberta. Journal of Wildlife Management, 69(1), 277-297.

Gyug, L., T. Hamilton, and M. Austin. 2004. Accounts and Measures for Managing Identified Wildlife: Grizzly Bear (*Ursus arctos*). Available from: http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Mammals/m_grizzlybear.pdf

Harris, R. B., Schwartz, C. C., Haroldson, M. A., & White, G. C. (2006). Trajectory of the Yellowstone grizzly bear population under alternative survival rates. Wildlife Monographs, (161), 44.

Lamb, C. T., Mowat, G., McLellan, B. N., Nielsen, S. E., & Boutin, S. (2016). Forbidden fruit: human settlement and abundant fruit create an ecological trap for an apex omnivore. Journal of Animal Ecology. In Press.

Mace, R. D., Waller, J. S., Manley, T. L., Lyon, L. J., & Zuuring, H. (1996). Relationships among grizzly bears, roads and habitat in the Swan Mountains Montana. Journal of Applied ecology, 1395-1404.

Mace, R. D., Carney, D. W., Chilton-Radandt, T., Courville, S. A., Haroldson, M. A., Harris, R. B., ... & Schwartz, C. C. (2011). Grizzly bear population vital rates and trend in the Northern Continental Divide Ecosystem, Montana. The Journal of Wildlife Management, 76(1), 119-128.

McLellan, B. N. (1989). Dynamics of a grizzly bear population during a period of industrial resource extraction. I. Density and age-sex composition. Canadian Journal of Zoology, 67(8), 1856-1860.

McLellan, B. N. (1990). Relationships between human industrial activity and grizzly bears. Bears: Their Biology and Management, 57-64.

McLellan, B. N. (2015). Some mechanisms underlying variation in vital rates of grizzly bears on a multiple use landscape. The Journal of Wildlife Management, 79(5), 749-765.

McLellan, B. N., & Shackleton, D. M. (1988). Grizzly bears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology, 451-460.

Mowat, G. and Lamb, C. (2016). Population status of the South Rockies and Flathead grizzly bear populations in British Columbia, 2006---2014

Nielsen, S. E., Boyce, M. S., & Stenhouse, G. B. (2004a). Grizzly bears and forestry: I. Selection of clearcuts by grizzly bears in west-central Alberta, Canada. Forest Ecology and Management, 199(1), 51-65.

Nielsen, S. E., Stenhouse, G. B., & Boyce, M. S. (2006). A habitat-based framework for grizzly bear conservation in Alberta. Biological Conservation, 130(2), 217-229.

Nielsen, S. E., Cranston, J., & Stenhouse, G. B. (2009). Identification of priority areas for grizzly bear conservation and recovery in Alberta, Canada. Journal of Conservation Planning, 5, 38-60.

Proctor, M. F., McLellan, B. N., Strobeck, C., & Barclay, R. M. (2005). Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society of London B: Biological Sciences, 272(1579), 2409-2416.

Proctor, M. F., Servheen, C., Miller, S. D., Kasworm, W. F., & Wakkinen, W. L. (2004). A comparative analysis of management options for grizzly bear conservation in the US-Canada trans-border area. Ursus, 15(2), 145-160.

Schwartz, C. C., & White, G. C. (2008). Estimating reproductive rates for female bears: Proportions versus transition probabilities. Ursus, 19(1), 1-12.

Schwartz, C. C., Keating, K. A., Reynolds III, H. V., Barnes Jr, V. G., Sellers, R. A., Swenson, J. E., ... & Gibeau, M. (2003). Reproductive maturation and senescence in the female brown bear. Ursus, 109-119.

Schwartz, C. C., Haroldson, M. A., White, G. C., Harris, R. B., Cherry, S., Keating, K. A., ... & Servheen, C. (2006). Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs, 161(1), 1-8.

Wakkinen, W. L., & Kasworm, W. F. (2004). Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus, 15(1), 65-75.

Wielgus, R.B., F.L. Bunnell, W.L. Wakkinen, and P.E. Zager. 1994. Population dynamics of Selkirk Mountain grizzly bears. Journal of Wildlife Management 58:266-272.

Wielgus, R. B., & Vernier, P. R. (2003). Grizzly bear selection of managed and unmanaged forests in the Selkirk Mountains. Canadian Journal of Forest Research, 33(5), 822-829.

Appendix A. Simulated future estimated survival rates of female grizzly bear reproductive classes in grizzly bear population units. Future survival rates were estimated based on future simulated cutblocks and roads in grizzly bear population units in the Prince George Timber Supply Area of British Columbia.

	Nation GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.912	0.961	0.935
2017	0.912	0.960	0.935
2018	0.910	0.960	0.934
2019	0.909	0.960	0.933
2020	0.908	0.959	0.932
2021	0.906	0.959	0.931
2022	0.906	0.959	0.930
2023	0.905	0.958	0.930
2024	0.905	0.958	0.929
2025	0.904	0.958	0.929
2026	0.904	0.958	0.929
2027	0.904	0.958	0.929
2028	0.904	0.958	0.929
2029	0.904	0.958	0.929
2030	0.903	0.958	0.928
2031	0.903	0.958	0.928
2032	0.903	0.958	0.928
2033	0.903	0.958	0.928
2034	0.903	0.958	0.928
2035	0.901	0.957	0.927
2036	0.901	0.957	0.927
2037	0.901	0.957	0.927
2038	0.901	0.957	0.927
2039	0.901	0.957	0.927
2040	0.899	0.956	0.925
2041	0.899	0.956	0.925
2042	0.899	0.956	0.925
2043	0.899	0.956	0.925
2044	0.899	0.956	0.925
2045	0.896	0.955	0.923
2046	0.896	0.955	0.923
2047	0.896	0.955	0.923
2048	0.896	0.955	0.923

	Nation GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2049	0.896	0.955	0.923
2050	0.894	0.955	0.922
2051	0.894	0.955	0.922
2052	0.894	0.955	0.922
2053	0.894	0.955	0.922
2054	0.894	0.955	0.922
2055	0.893	0.954	0.921
2056	0.893	0.954	0.921
2057	0.893	0.954	0.921
2058	0.893	0.954	0.921
2059	0.893	0.954	0.921
2060	0.891	0.954	0.919
2061	0.891	0.954	0.919
2062	0.891	0.954	0.919
2063	0.891	0.954	0.919
2064	0.891	0.954	0.919
2065	0.890	0.953	0.919
2066	0.890	0.953	0.919
2067	0.890	0.953	0.919
2068	0.890	0.953	0.919
2069	0.890	0.953	0.919
2070	0.889	0.953	0.918
2071	0.889	0.953	0.918
2072	0.889	0.953	0.918
2073	0.889	0.953	0.918
2074	0.889	0.953	0.918
2075	0.887	0.952	0.917
2076	0.887	0.952	0.917
2077	0.887	0.952	0.917
2078	0.887	0.952	0.917
2079	0.887	0.952	0.917
2080	0.886	0.952	0.915
2081	0.886	0.952	0.915
2082	0.886	0.952	0.915
2083	0.886	0.952	0.915
2084	0.886	0.952	0.915
2085	0.884	0.951	0.914

	Nulki GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.893	0.954	0.921
2017	0.892	0.954	0.920
2018	0.891	0.954	0.919
2019	0.889	0.953	0.918
2020	0.888	0.953	0.917
2021	0.886	0.952	0.916
2022	0.886	0.952	0.916
2023	0.885	0.952	0.915
2024	0.885	0.952	0.915
2025	0.884	0.951	0.914
2026	0.884	0.951	0.914
2027	0.884	0.951	0.914
2028	0.884	0.951	0.914
2029	0.884	0.951	0.914
2030	0.884	0.951	0.914
2031	0.884	0.951	0.914
2032	0.884	0.951	0.914
2033	0.884	0.951	0.914
2034	0.884	0.951	0.914
2035	0.882	0.951	0.913
2036	0.882	0.951	0.913
2037	0.882	0.951	0.913
2038	0.882	0.951	0.913
2039	0.882	0.951	0.913
2040	0.881	0.950	0.912
2041	0.881	0.950	0.912
2042	0.881	0.950	0.912
2043	0.881	0.950	0.912
2044	0.881	0.950	0.912
2045	0.879	0.950	0.910
2046	0.879	0.950	0.910
2047	0.879	0.950	0.910
2048	0.879	0.950	0.910
2049	0.879	0.950	0.910
2050	0.877	0.949	0.909
2051	0.877	0.949	0.909
2052	0.877	0.949	0.909
2053	0.877	0.949	0.909
2054	0.877	0.949	0.909

	Nulki GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.876	0.949	0.908
2056	0.876	0.949	0.908
2057	0.876	0.949	0.908
2058	0.876	0.949	0.908
2059	0.876	0.949	0.908
2060	0.875	0.948	0.907
2061	0.875	0.948	0.907
2062	0.875	0.948	0.907
2063	0.875	0.948	0.907
2064	0.875	0.948	0.907
2065	0.874	0.948	0.907
2066	0.874	0.948	0.907
2067	0.874	0.948	0.907
2068	0.874	0.948	0.907
2069	0.874	0.948	0.907
2070	0.873	0.948	0.906
2071	0.873	0.948	0.906
2072	0.873	0.948	0.906
2073	0.873	0.948	0.906
2074	0.873	0.948	0.906
2075	0.871	0.947	0.905
2076	0.871	0.947	0.905
2077	0.871	0.947	0.905
2078	0.871	0.947	0.905
2079	0.871	0.947	0.905
2080	0.869	0.946	0.903
2081	0.869	0.946	0.903
2082	0.869	0.946	0.903
2083	0.869	0.946	0.903
2084	0.869	0.946	0.903
2085	0.867	0.946	0.901

	Omineca GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.955	0.975	0.967
2017	0.955	0.975	0.967
2018	0.955	0.975	0.967
2019	0.954	0.975	0.966
2020	0.954	0.975	0.966
2021	0.954	0.975	0.966
2022	0.953	0.974	0.966
2023	0.953	0.974	0.965
2024	0.953	0.974	0.965
2025	0.952	0.974	0.965
2026	0.952	0.974	0.965
2027	0.952	0.974	0.965
2028	0.952	0.974	0.965
2029	0.952	0.974	0.965
2030	0.951	0.974	0.964
2031	0.951	0.974	0.964
2032	0.951	0.974	0.964
2033	0.951	0.974	0.964
2034	0.951	0.974	0.964
2035	0.949	0.973	0.962
2036	0.949	0.973	0.962
2037	0.949	0.973	0.962
2038	0.949	0.973	0.962
2039	0.949	0.973	0.962
2040	0.945	0.972	0.960
2041	0.945	0.972	0.960
2042	0.945	0.972	0.960
2043	0.945	0.972	0.960
2044	0.945	0.972	0.960
2045	0.942	0.971	0.957
2046	0.942	0.971	0.957
2047	0.942	0.971	0.957
2048	0.942	0.971	0.957
2049	0.942	0.971	0.957
2050	0.938	0.969	0.954
2051	0.938	0.969	0.954
2052	0.938	0.969	0.954
2053	0.938	0.969	0.954
2054	0.938	0.969	0.954

	Omineca GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.932	0.967	0.950
2056	0.932	0.967	0.950
2057	0.932	0.967	0.950
2058	0.932	0.967	0.950
2059	0.932	0.967	0.950
2060	0.926	0.965	0.945
2061	0.926	0.965	0.945
2062	0.926	0.965	0.945
2063	0.926	0.965	0.945
2064	0.926	0.965	0.945
2065	0.920	0.963	0.941
2066	0.920	0.963	0.941
2067	0.920	0.963	0.941
2068	0.920	0.963	0.941
2069	0.920	0.963	0.941
2070	0.918	0.963	0.940
2071	0.918	0.963	0.940
2072	0.918	0.963	0.940
2073	0.918	0.963	0.940
2074	0.918	0.963	0.940
2075	0.916	0.962	0.938
2076	0.916	0.962	0.938
2077	0.916	0.962	0.938
2078	0.916	0.962	0.938
2079	0.916	0.962	0.938
2080	0.915	0.962	0.937
2081	0.915	0.962	0.937
2082	0.915	0.962	0.937
2083	0.915	0.962	0.937
2084	0.915	0.962	0.937
2085	0.914	0.961	0.936

	Parsnip GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.952	0.974	0.964
2017	0.952	0.974	0.964
2018	0.952	0.974	0.964
2019	0.952	0.974	0.964
2020	0.952	0.974	0.964
2021	0.952	0.974	0.964
2022	0.951	0.974	0.964
2023	0.951	0.974	0.964
2024	0.951	0.974	0.964
2025	0.950	0.973	0.963
2026	0.950	0.973	0.963
2027	0.950	0.973	0.963
2028	0.950	0.973	0.963
2029	0.950	0.973	0.963
2030	0.950	0.973	0.963
2031	0.950	0.973	0.963
2032	0.950	0.973	0.963
2033	0.950	0.973	0.963
2034	0.950	0.973	0.963
2035	0.949	0.973	0.962
2036	0.949	0.973	0.962
2037	0.949	0.973	0.962
2038	0.949	0.973	0.962
2039	0.949	0.973	0.962
2040	0.947	0.972	0.961
2041	0.947	0.972	0.961
2042	0.947	0.972	0.961
2043	0.947	0.972	0.961
2044	0.947	0.972	0.961
2045	0.946	0.972	0.960
2046	0.946	0.972	0.960
2047	0.946	0.972	0.960
2048	0.946	0.972	0.960
2049	0.946	0.972	0.960
2050	0.945	0.972	0.959
2051	0.945	0.972	0.959
2052	0.945	0.972	0.959
2053	0.945	0.972	0.959
2054	0.945	0.972	0.959

	Parsnip GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.944	0.971	0.959
2056	0.944	0.971	0.959
2057	0.944	0.971	0.959
2058	0.944	0.971	0.959
2059	0.944	0.971	0.959
2060	0.943	0.971	0.958
2061	0.943	0.971	0.958
2062	0.943	0.971	0.958
2063	0.943	0.971	0.958
2064	0.943	0.971	0.958
2065	0.942	0.971	0.957
2066	0.942	0.971	0.957
2067	0.942	0.971	0.957
2068	0.942	0.971	0.957
2069	0.942	0.971	0.957
2070	0.942	0.971	0.957
2071	0.942	0.971	0.957
2072	0.942	0.971	0.957
2073	0.942	0.971	0.957
2074	0.942	0.971	0.957
2075	0.941	0.970	0.957
2076	0.941	0.970	0.957
2077	0.941	0.970	0.957
2078	0.941	0.970	0.957
2079	0.941	0.970	0.957
2080	0.941	0.970	0.956
2081	0.941	0.970	0.956
2082	0.941	0.970	0.956
2083	0.941	0.970	0.956
2084	0.941	0.970	0.956
2085	0.940	0.970	0.956

	Upper Skeena - Nass GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.966	0.979	0.975
2017	0.966	0.979	0.975
2018	0.966	0.979	0.975
2019	0.966	0.979	0.975
2020	0.966	0.979	0.975
2021	0.966	0.979	0.975
2022	0.966	0.979	0.975
2023	0.966	0.979	0.975
2024	0.966	0.979	0.975
2025	0.966	0.979	0.975
2026	0.966	0.979	0.975
2027	0.966	0.979	0.975
2028	0.966	0.979	0.975
2029	0.966	0.979	0.975
2030	0.966	0.979	0.975
2031	0.966	0.979	0.975
2032	0.966	0.979	0.975
2033	0.966	0.979	0.975
2034	0.966	0.979	0.975
2035	0.966	0.979	0.975
2036	0.966	0.979	0.975
2037	0.966	0.979	0.975
2038	0.966	0.979	0.975
2039	0.966	0.979	0.975
2040	0.966	0.979	0.975
2041	0.966	0.979	0.975
2042	0.966	0.979	0.975
2043	0.966	0.979	0.975
2044	0.966	0.979	0.975
2045	0.966	0.979	0.975
2046	0.966	0.979	0.975
2047	0.966	0.979	0.975
2048	0.966	0.979	0.975
2049	0.966	0.979	0.975
2050	0.966	0.979	0.975
2051	0.966	0.979	0.975
2052	0.966	0.979	0.975
2053	0.966	0.979	0.975
2054	0.966	0.979	0.975

	Upper Skeena - Nass GBPU Reference Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.965	0.978	0.975
2056	0.965	0.978	0.975
2057	0.965	0.978	0.975
2058	0.965	0.978	0.975
2059	0.965	0.978	0.975
2060	0.965	0.978	0.974
2061	0.965	0.978	0.974
2062	0.965	0.978	0.974
2063	0.965	0.978	0.974
2064	0.965	0.978	0.974
2065	0.963	0.978	0.973
2066	0.963	0.978	0.973
2067	0.963	0.978	0.973
2068	0.963	0.978	0.973
2069	0.963	0.978	0.973
2070	0.963	0.978	0.973
2071	0.963	0.978	0.973
2072	0.963	0.978	0.973
2073	0.963	0.978	0.973
2074	0.963	0.978	0.973
2075	0.963	0.978	0.973
2076	0.963	0.978	0.973
2077	0.963	0.978	0.973
2078	0.963	0.978	0.973
2079	0.963	0.978	0.973
2080	0.963	0.978	0.973
2081	0.963	0.978	0.973
2082	0.963	0.978	0.973
2083	0.963	0.978	0.973
2084	0.963	0.978	0.973
2085	0.963	0.978	0.973

	Nation GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.912	0.961	0.935
2017	0.912	0.961	0.935
2018	0.912	0.961	0.935
2019	0.911	0.960	0.934
2020	0.911	0.960	0.934
2021	0.910	0.960	0.933
2022	0.910	0.960	0.933
2023	0.909	0.960	0.933
2024	0.909	0.959	0.932
2025	0.908	0.959	0.932
2026	0.908	0.959	0.932
2027	0.908	0.959	0.932
2028	0.908	0.959	0.932
2029	0.908	0.959	0.932
2030	0.907	0.959	0.931
2031	0.907	0.959	0.931
2032	0.907	0.959	0.931
2033	0.907	0.959	0.931
2034	0.907	0.959	0.931
2035	0.905	0.958	0.929
2036	0.905	0.958	0.929
2037	0.905	0.958	0.929
2038	0.905	0.958	0.929
2039	0.905	0.958	0.929
2040	0.902	0.957	0.927
2041	0.902	0.957	0.927
2042	0.902	0.957	0.927
2043	0.902	0.957	0.927
2044	0.902	0.957	0.927
2045	0.899	0.956	0.926
2046	0.899	0.956	0.926
2047	0.899	0.956	0.926
2048	0.899	0.956	0.926
2049	0.899	0.956	0.926
2050	0.897	0.956	0.924
2051	0.897	0.956	0.924
2052	0.897	0.956	0.924
2053	0.897	0.956	0.924
2054	0.897	0.956	0.924

	Nation GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.895	0.955	0.922
2056	0.895	0.955	0.922
2057	0.895	0.955	0.922
2058	0.895	0.955	0.922
2059	0.895	0.955	0.922
2060	0.893	0.954	0.921
2061	0.893	0.954	0.921
2062	0.893	0.954	0.921
2063	0.893	0.954	0.921
2064	0.893	0.954	0.921
2065	0.892	0.954	0.920
2066	0.892	0.954	0.920
2067	0.892	0.954	0.920
2068	0.892	0.954	0.920
2069	0.892	0.954	0.920
2070	0.891	0.954	0.920
2071	0.891	0.954	0.920
2072	0.891	0.954	0.920
2073	0.891	0.954	0.920
2074	0.891	0.954	0.920
2075	0.890	0.953	0.918
2076	0.890	0.953	0.918
2077	0.890	0.953	0.918
2078	0.890	0.953	0.918
2079	0.890	0.953	0.918
2080	0.888	0.953	0.917
2081	0.888	0.953	0.917
2082	0.888	0.953	0.917
2083	0.888	0.953	0.917
2084	0.888	0.953	0.917
2085	0.887	0.952	0.917

	Nation GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.912	0.961	0.935
2017	0.912	0.961	0.935
2018	0.912	0.961	0.935
2019	0.912	0.961	0.935
2020	0.912	0.961	0.935
2021	0.912	0.961	0.935
2022	0.912	0.961	0.935
2023	0.912	0.961	0.935
2024	0.912	0.961	0.935
2025	0.911	0.960	0.935
2026	0.911	0.960	0.935
2027	0.911	0.960	0.935
2028	0.911	0.960	0.935
2029	0.911	0.960	0.935
2030	0.911	0.960	0.934
2031	0.911	0.960	0.934
2032	0.911	0.960	0.934
2033	0.911	0.960	0.934
2034	0.911	0.960	0.934
2035	0.909	0.960	0.933
2036	0.909	0.960	0.933
2037	0.909	0.960	0.933
2038	0.909	0.960	0.933
2039	0.909	0.960	0.933
2040	0.907	0.959	0.931
2041	0.907	0.959	0.931
2042	0.907	0.959	0.931
2043	0.907	0.959	0.931
2044	0.907	0.959	0.931
2045	0.904	0.958	0.929
2046	0.904	0.958	0.929
2047	0.904	0.958	0.929
2048	0.904	0.958	0.929
2049	0.904	0.958	0.929
2050	0.902	0.957	0.928
2051	0.902	0.957	0.928
2052	0.902	0.957	0.928
2053	0.902	0.957	0.928

	Nation GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.902	0.957	0.928
2055	0.900	0.957	0.926
2056	0.900	0.957	0.926
2057	0.900	0.957	0.926
2058	0.900	0.957	0.926
2059	0.900	0.957	0.926
2060	0.898	0.956	0.925
2061	0.898	0.956	0.925
2062	0.898	0.956	0.925
2063	0.898	0.956	0.925
2064	0.898	0.956	0.925
2065	0.898	0.956	0.924
2066	0.898	0.956	0.924
2067	0.898	0.956	0.924
2068	0.898	0.956	0.924
2069	0.898	0.956	0.924
2070	0.897	0.956	0.924
2071	0.897	0.956	0.924
2072	0.897	0.956	0.924
2073	0.897	0.956	0.924
2074	0.897	0.956	0.924
2075	0.895	0.955	0.922
2076	0.895	0.955	0.922
2077	0.895	0.955	0.922
2078	0.895	0.955	0.922
2079	0.895	0.955	0.922
2080	0.894	0.955	0.922
2081	0.894	0.955	0.922
2082	0.894	0.955	0.922
2083	0.894	0.955	0.922
2084	0.894	0.955	0.922
2085	0.893	0.954	0.921

	Nation GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.915	0.962	0.937
2017	0.915	0.962	0.937
2018	0.914	0.961	0.937
2019	0.914	0.961	0.936
2020	0.913	0.961	0.936
2021	0.912	0.961	0.935
2022	0.912	0.961	0.935
2023	0.911	0.960	0.934
2024	0.911	0.960	0.934
2025	0.910	0.960	0.934
2026	0.910	0.960	0.934
2027	0.910	0.960	0.934
2028	0.910	0.960	0.934
2029	0.910	0.960	0.934
2030	0.910	0.960	0.933
2031	0.910	0.960	0.933
2032	0.910	0.960	0.933
2033	0.910	0.960	0.933
2034	0.910	0.960	0.933
2035	0.908	0.959	0.932
2036	0.908	0.959	0.932
2037	0.908	0.959	0.932
2038	0.908	0.959	0.932
2039	0.908	0.959	0.932
2040	0.905	0.958	0.930
2041	0.905	0.958	0.930
2042	0.905	0.958	0.930
2043	0.905	0.958	0.930
2044	0.905	0.958	0.930
2045	0.903	0.958	0.928
2046	0.903	0.958	0.928
2047	0.903	0.958	0.928
2048	0.903	0.958	0.928
2049	0.903	0.958	0.928
2050	0.900	0.957	0.926
2051	0.900	0.957	0.926
2052	0.900	0.957	0.926
2053	0.900	0.957	0.926
2054	0.900	0.957	0.926

	Nation GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.899	0.956	0.925
2056	0.899	0.956	0.925
2057	0.899	0.956	0.925
2058	0.899	0.956	0.925
2059	0.899	0.956	0.925
2060	0.897	0.956	0.924
2061	0.897	0.956	0.924
2062	0.897	0.956	0.924
2063	0.897	0.956	0.924
2064	0.897	0.956	0.924
2065	0.896	0.955	0.923
2066	0.896	0.955	0.923
2067	0.896	0.955	0.923
2068	0.896	0.955	0.923
2069	0.896	0.955	0.923
2070	0.895	0.955	0.923
2071	0.895	0.955	0.923
2072	0.895	0.955	0.923
2073	0.895	0.955	0.923
2074	0.895	0.955	0.923
2075	0.894	0.955	0.921
2076	0.894	0.955	0.921
2077	0.894	0.955	0.921
2078	0.894	0.955	0.921
2079	0.894	0.955	0.921
2080	0.892	0.954	0.920
2081	0.892	0.954	0.920
2082	0.892	0.954	0.920
2083	0.892	0.954	0.920
2084	0.892	0.954	0.920
2085	0.891	0.954	0.920

	Nulki GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.893	0.954	0.921
2017	0.893	0.954	0.921
2018	0.893	0.954	0.921
2019	0.893	0.954	0.921
2020	0.893	0.954	0.921
2021	0.892	0.954	0.920
2022	0.892	0.954	0.920
2023	0.892	0.954	0.920
2024	0.892	0.954	0.920
2025	0.891	0.954	0.920
2026	0.891	0.954	0.920
2027	0.891	0.954	0.920
2028	0.891	0.954	0.920
2029	0.891	0.954	0.920
2030	0.891	0.954	0.919
2031	0.891	0.954	0.919
2032	0.891	0.954	0.919
2033	0.891	0.954	0.919
2034	0.891	0.954	0.919
2035	0.889	0.953	0.918
2036	0.889	0.953	0.918
2037	0.889	0.953	0.918
2038	0.889	0.953	0.918
2039	0.889	0.953	0.918
2040	0.886	0.952	0.916
2041	0.886	0.952	0.916
2042	0.886	0.952	0.916
2043	0.886	0.952	0.916
2044	0.886	0.952	0.916
2045	0.884	0.951	0.914
2046	0.884	0.951	0.914
2047	0.884	0.951	0.914
2048	0.884	0.951	0.914
2049	0.884	0.951	0.914
2050	0.882	0.951	0.912
2051	0.882	0.951	0.912
2052	0.882	0.951	0.912
2053	0.882	0.951	0.912

	Nulki GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.882	0.951	0.912
2055	0.880	0.950	0.911
2056	0.880	0.950	0.911
2057	0.880	0.950	0.911
2058	0.880	0.950	0.911
2059	0.880	0.950	0.911
2060	0.878	0.949	0.910
2061	0.878	0.949	0.910
2062	0.878	0.949	0.910
2063	0.878	0.949	0.910
2064	0.878	0.949	0.910
2065	0.877	0.949	0.909
2066	0.877	0.949	0.909
2067	0.877	0.949	0.909
2068	0.877	0.949	0.909
2069	0.877	0.949	0.909
2070	0.877	0.949	0.909
2071	0.877	0.949	0.909
2072	0.877	0.949	0.909
2073	0.877	0.949	0.909
2074	0.877	0.949	0.909
2075	0.875	0.948	0.907
2076	0.875	0.948	0.907
2077	0.875	0.948	0.907
2078	0.875	0.948	0.907
2079	0.875	0.948	0.907
2080	0.873	0.948	0.906
2081	0.873	0.948	0.906
2082	0.873	0.948	0.906
2083	0.873	0.948	0.906
2084	0.873	0.948	0.906
2085	0.871	0.947	0.905

	Nulki GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.893	0.954	0.921
2017	0.893	0.954	0.921
2018	0.893	0.954	0.921
2019	0.893	0.954	0.921
2020	0.893	0.954	0.921
2021	0.893	0.954	0.921
2022	0.893	0.954	0.921
2023	0.893	0.954	0.921
2024	0.893	0.954	0.921
2025	0.893	0.954	0.921
2026	0.893	0.954	0.921
2027	0.893	0.954	0.921
2028	0.893	0.954	0.921
2029	0.893	0.954	0.921
2030	0.893	0.954	0.921
2031	0.893	0.954	0.921
2032	0.893	0.954	0.921
2033	0.893	0.954	0.921
2034	0.893	0.954	0.921
2035	0.892	0.954	0.920
2036	0.892	0.954	0.920
2037	0.892	0.954	0.920
2038	0.892	0.954	0.920
2039	0.892	0.954	0.920
2040	0.889	0.953	0.918
2041	0.889	0.953	0.918
2042	0.889	0.953	0.918
2043	0.889	0.953	0.918
2044	0.889	0.953	0.918
2045	0.887	0.952	0.916
2046	0.887	0.952	0.916
2047	0.887	0.952	0.916
2048	0.887	0.952	0.916
2049	0.887	0.952	0.916
2050	0.885	0.952	0.915
2051	0.885	0.952	0.915
2052	0.885	0.952	0.915
2053	0.885	0.952	0.915

	Nulki GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.885	0.952	0.915
2055	0.883	0.951	0.913
2056	0.883	0.951	0.913
2057	0.883	0.951	0.913
2058	0.883	0.951	0.913
2059	0.883	0.951	0.913
2060	0.881	0.950	0.912
2061	0.881	0.950	0.912
2062	0.881	0.950	0.912
2063	0.881	0.950	0.912
2064	0.881	0.950	0.912
2065	0.880	0.950	0.911
2066	0.880	0.950	0.911
2067	0.880	0.950	0.911
2068	0.880	0.950	0.911
2069	0.880	0.950	0.911
2070	0.879	0.950	0.911
2071	0.879	0.950	0.911
2072	0.879	0.950	0.911
2073	0.879	0.950	0.911
2074	0.879	0.950	0.911
2075	0.877	0.949	0.909
2076	0.877	0.949	0.909
2077	0.877	0.949	0.909
2078	0.877	0.949	0.909
2079	0.877	0.949	0.909
2080	0.876	0.949	0.908
2081	0.876	0.949	0.908
2082	0.876	0.949	0.908
2083	0.876	0.949	0.908
2084	0.876	0.949	0.908
2085	0.874	0.948	0.907

	Nulki GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.898	0.956	0.925
2017	0.898	0.956	0.924
2018	0.897	0.956	0.924
2019	0.896	0.955	0.923
2020	0.896	0.955	0.923
2021	0.895	0.955	0.922
2022	0.895	0.955	0.922
2023	0.894	0.955	0.922
2024	0.894	0.955	0.922
2025	0.894	0.955	0.921
2026	0.894	0.955	0.921
2027	0.894	0.955	0.921
2028	0.894	0.955	0.921
2029	0.894	0.955	0.921
2030	0.893	0.954	0.921
2031	0.893	0.954	0.921
2032	0.893	0.954	0.921
2033	0.893	0.954	0.921
2034	0.893	0.954	0.921
2035	0.892	0.954	0.920
2036	0.892	0.954	0.920
2037	0.892	0.954	0.920
2038	0.892	0.954	0.920
2039	0.892	0.954	0.920
2040	0.890	0.953	0.919
2041	0.890	0.953	0.919
2042	0.890	0.953	0.919
2043	0.890	0.953	0.919
2044	0.890	0.953	0.919
2045	0.888	0.953	0.917
2046	0.888	0.953	0.917
2047	0.888	0.953	0.917
2048	0.888	0.953	0.917
2049	0.888	0.953	0.917
2050	0.886	0.952	0.916
2051	0.886	0.952	0.916
2052	0.886	0.952	0.916
2053	0.886	0.952	0.916
2054	0.886	0.952	0.916

	Nulki GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.885	0.952	0.915
2056	0.885	0.952	0.915
2057	0.885	0.952	0.915
2058	0.885	0.952	0.915
2059	0.885	0.952	0.915
2060	0.883	0.951	0.914
2061	0.883	0.951	0.914
2062	0.883	0.951	0.914
2063	0.883	0.951	0.914
2064	0.883	0.951	0.914
2065	0.883	0.951	0.913
2066	0.883	0.951	0.913
2067	0.883	0.951	0.913
2068	0.883	0.951	0.913
2069	0.883	0.951	0.913
2070	0.882	0.951	0.913
2071	0.882	0.951	0.913
2072	0.882	0.951	0.913
2073	0.882	0.951	0.913
2074	0.882	0.951	0.913
2075	0.880	0.950	0.911
2076	0.880	0.950	0.911
2077	0.880	0.950	0.911
2078	0.880	0.950	0.911
2079	0.880	0.950	0.911
2080	0.879	0.950	0.911
2081	0.879	0.950	0.911
2082	0.879	0.950	0.911
2083	0.879	0.950	0.911
2084	0.879	0.950	0.911
2085	0.878	0.949	0.910

	Omineca GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.955	0.975	0.967
2017	0.955	0.975	0.967
2018	0.955	0.975	0.967
2019	0.955	0.975	0.967
2020	0.954	0.975	0.966
2021	0.954	0.975	0.966
2022	0.954	0.975	0.966
2023	0.954	0.975	0.966
2024	0.953	0.974	0.966
2025	0.953	0.974	0.965
2026	0.953	0.974	0.965
2027	0.953	0.974	0.965
2028	0.953	0.974	0.965
2029	0.953	0.974	0.965
2030	0.953	0.974	0.965
2031	0.953	0.974	0.965
2032	0.953	0.974	0.965
2033	0.953	0.974	0.965
2034	0.953	0.974	0.965
2035	0.951	0.974	0.964
2036	0.951	0.974	0.964
2037	0.951	0.974	0.964
2038	0.951	0.974	0.964
2039	0.951	0.974	0.964
2040	0.947	0.972	0.961
2041	0.947	0.972	0.961
2042	0.947	0.972	0.961
2043	0.947	0.972	0.961
2044	0.947	0.972	0.961
2045	0.944	0.971	0.959
2046	0.944	0.971	0.959
2047	0.944	0.971	0.959
2048	0.944	0.971	0.959
2049	0.944	0.971	0.959
2050	0.940	0.970	0.956
2051	0.940	0.970	0.956
2052	0.940	0.970	0.956
2053	0.940	0.970	0.956

	Omineca GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.940	0.970	0.956
2055	0.935	0.968	0.952
2056	0.935	0.968	0.952
2057	0.935	0.968	0.952
2058	0.935	0.968	0.952
2059	0.935	0.968	0.952
2060	0.929	0.966	0.948
2061	0.929	0.966	0.948
2062	0.929	0.966	0.948
2063	0.929	0.966	0.948
2064	0.929	0.966	0.948
2065	0.922	0.964	0.942
2066	0.922	0.964	0.942
2067	0.922	0.964	0.942
2068	0.922	0.964	0.942
2069	0.922	0.964	0.942
2070	0.921	0.964	0.941
2071	0.921	0.964	0.941
2072	0.921	0.964	0.941
2073	0.921	0.964	0.941
2074	0.921	0.964	0.941
2075	0.919	0.963	0.940
2076	0.919	0.963	0.940
2077	0.919	0.963	0.940
2078	0.919	0.963	0.940
2079	0.919	0.963	0.940
2080	0.917	0.962	0.939
2081	0.917	0.962	0.939
2082	0.917	0.962	0.939
2083	0.917	0.962	0.939
2084	0.917	0.962	0.939
2085	0.916	0.962	0.938

	Omineca GBPU Forestry Road < 1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.955	0.975	0.967
2017	0.955	0.975	0.967
2018	0.955	0.975	0.967
2019	0.955	0.975	0.967
2020	0.954	0.975	0.966
2021	0.954	0.975	0.966
2022	0.954	0.975	0.966
2023	0.954	0.975	0.966
2024	0.954	0.975	0.966
2025	0.953	0.974	0.966
2026	0.953	0.974	0.966
2027	0.953	0.974	0.966
2028	0.953	0.974	0.966
2029	0.953	0.974	0.966
2030	0.953	0.974	0.965
2031	0.953	0.974	0.965
2032	0.953	0.974	0.965
2033	0.953	0.974	0.965
2034	0.953	0.974	0.965
2035	0.951	0.974	0.964
2036	0.951	0.974	0.964
2037	0.951	0.974	0.964
2038	0.951	0.974	0.964
2039	0.951	0.974	0.964
2040	0.947	0.972	0.961
2041	0.947	0.972	0.961
2042	0.947	0.972	0.961
2043	0.947	0.972	0.961
2044	0.947	0.972	0.961
2045	0.943	0.971	0.958
2046	0.943	0.971	0.958
2047	0.943	0.971	0.958
2048	0.943	0.971	0.958
2049	0.943	0.971	0.958
2050	0.939	0.970	0.955
2051	0.939	0.970	0.955
2052	0.939	0.970	0.955
2053	0.939	0.970	0.955

	Omineca GBPU Forestry Road < 1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.939	0.970	0.955
2055	0.933	0.968	0.950
2056	0.933	0.968	0.950
2057	0.933	0.968	0.950
2058	0.933	0.968	0.950
2059	0.933	0.968	0.950
2060	0.926	0.965	0.945
2061	0.926	0.965	0.945
2062	0.926	0.965	0.945
2063	0.926	0.965	0.945
2064	0.926	0.965	0.945
2065	0.918	0.963	0.939
2066	0.918	0.963	0.939
2067	0.918	0.963	0.939
2068	0.918	0.963	0.939
2069	0.918	0.963	0.939
2070	0.917	0.962	0.938
2071	0.917	0.962	0.938
2072	0.917	0.962	0.938
2073	0.917	0.962	0.938
2074	0.917	0.962	0.938
2075	0.914	0.961	0.936
2076	0.914	0.961	0.936
2077	0.914	0.961	0.936
2078	0.914	0.961	0.936
2079	0.914	0.961	0.936
2080	0.913	0.961	0.935
2081	0.913	0.961	0.935
2082	0.913	0.961	0.935
2083	0.913	0.961	0.935
2084	0.913	0.961	0.935
2085	0.911	0.960	0.934

	Omineca GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.955	0.975	0.967
2017	0.955	0.975	0.967
2018	0.955	0.975	0.967
2019	0.955	0.975	0.967
2020	0.955	0.975	0.967
2021	0.955	0.975	0.967
2022	0.955	0.975	0.967
2023	0.955	0.975	0.967
2024	0.954	0.975	0.966
2025	0.954	0.975	0.966
2026	0.954	0.975	0.966
2027	0.954	0.975	0.966
2028	0.954	0.975	0.966
2029	0.954	0.975	0.966
2030	0.954	0.975	0.966
2031	0.954	0.975	0.966
2032	0.954	0.975	0.966
2033	0.954	0.975	0.966
2034	0.954	0.975	0.966
2035	0.953	0.974	0.965
2036	0.953	0.974	0.965
2037	0.953	0.974	0.965
2038	0.953	0.974	0.965
2039	0.953	0.974	0.965
2040	0.950	0.973	0.963
2041	0.950	0.973	0.963
2042	0.950	0.973	0.963
2043	0.950	0.973	0.963
2044	0.950	0.973	0.963
2045	0.948	0.973	0.961
2046	0.948	0.973	0.961
2047	0.948	0.973	0.961
2048	0.948	0.973	0.961
2049	0.948	0.973	0.961
2050	0.945	0.972	0.959
2051	0.945	0.972	0.959
2052	0.945	0.972	0.959
2053	0.945	0.972	0.959
2054	0.945	0.972	0.959

	Omineca GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.941	0.970	0.956
2056	0.941	0.970	0.956
2057	0.941	0.970	0.956
2058	0.941	0.970	0.956
2059	0.941	0.970	0.956
2060	0.937	0.969	0.953
2061	0.937	0.969	0.953
2062	0.937	0.969	0.953
2063	0.937	0.969	0.953
2064	0.937	0.969	0.953
2065	0.932	0.967	0.950
2066	0.932	0.967	0.950
2067	0.932	0.967	0.950
2068	0.932	0.967	0.950
2069	0.932	0.967	0.950
2070	0.931	0.967	0.949
2071	0.931	0.967	0.949
2072	0.931	0.967	0.949
2073	0.931	0.967	0.949
2074	0.931	0.967	0.949
2075	0.929	0.966	0.948
2076	0.929	0.966	0.948
2077	0.929	0.966	0.948
2078	0.929	0.966	0.948
2079	0.929	0.966	0.948
2080	0.929	0.966	0.947
2081	0.929	0.966	0.947
2082	0.929	0.966	0.947
2083	0.929	0.966	0.947
2084	0.929	0.966	0.947
2085	0.928	0.966	0.947

	Parsnip GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.952	0.974	0.964
2017	0.952	0.974	0.964
2018	0.952	0.974	0.964
2019	0.952	0.974	0.964
2020	0.952	0.974	0.964
2021	0.952	0.974	0.964
2022	0.951	0.974	0.964
2023	0.951	0.974	0.964
2024	0.951	0.974	0.964
2025	0.951	0.974	0.964
2026	0.951	0.974	0.964
2027	0.951	0.974	0.964
2028	0.951	0.974	0.964
2029	0.951	0.974	0.964
2030	0.950	0.973	0.964
2031	0.950	0.973	0.964
2032	0.950	0.973	0.964
2033	0.950	0.973	0.964
2034	0.950	0.973	0.964
2035	0.949	0.973	0.963
2036	0.949	0.973	0.963
2037	0.949	0.973	0.963
2038	0.949	0.973	0.963
2039	0.949	0.973	0.963
2040	0.948	0.973	0.962
2041	0.948	0.973	0.962
2042	0.948	0.973	0.962
2043	0.948	0.973	0.962
2044	0.948	0.973	0.962
2045	0.947	0.972	0.961
2046	0.947	0.972	0.961
2047	0.947	0.972	0.961
2048	0.947	0.972	0.961
2049	0.947	0.972	0.961
2050	0.945	0.972	0.960
2051	0.945	0.972	0.960
2052	0.945	0.972	0.960
2053	0.945	0.972	0.960

	Parsnip GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.945	0.972	0.960
2055	0.944	0.971	0.959
2056	0.944	0.971	0.959
2057	0.944	0.971	0.959
2058	0.944	0.971	0.959
2059	0.944	0.971	0.959
2060	0.943	0.971	0.958
2061	0.943	0.971	0.958
2062	0.943	0.971	0.958
2063	0.943	0.971	0.958
2064	0.943	0.971	0.958
2065	0.942	0.971	0.957
2066	0.942	0.971	0.957
2067	0.942	0.971	0.957
2068	0.942	0.971	0.957
2069	0.942	0.971	0.957
2070	0.942	0.971	0.957
2071	0.942	0.971	0.957
2072	0.942	0.971	0.957
2073	0.942	0.971	0.957
2074	0.942	0.971	0.957
2075	0.941	0.970	0.957
2076	0.941	0.970	0.957
2077	0.941	0.970	0.957
2078	0.941	0.970	0.957
2079	0.941	0.970	0.957
2080	0.941	0.970	0.957
2081	0.941	0.970	0.957
2082	0.941	0.970	0.957
2083	0.941	0.970	0.957
2084	0.941	0.970	0.957
2085	0.941	0.970	0.956

	Parsnip GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.952	0.974	0.964
2017	0.952	0.974	0.964
2018	0.952	0.974	0.964
2019	0.952	0.974	0.964
2020	0.952	0.974	0.964
2021	0.952	0.974	0.964
2022	0.952	0.974	0.964
2023	0.952	0.974	0.964
2024	0.952	0.974	0.964
2025	0.952	0.974	0.964
2026	0.952	0.974	0.964
2027	0.952	0.974	0.964
2028	0.952	0.974	0.964
2029	0.952	0.974	0.964
2030	0.952	0.974	0.964
2031	0.952	0.974	0.964
2032	0.952	0.974	0.964
2033	0.952	0.974	0.964
2034	0.952	0.974	0.964
2035	0.952	0.974	0.964
2036	0.952	0.974	0.964
2037	0.952	0.974	0.964
2038	0.952	0.974	0.964
2039	0.952	0.974	0.964
2040	0.952	0.974	0.964
2041	0.952	0.974	0.964
2042	0.952	0.974	0.964
2043	0.952	0.974	0.964
2044	0.952	0.974	0.964
2045	0.952	0.974	0.964
2046	0.952	0.974	0.964
2047	0.952	0.974	0.964
2048	0.952	0.974	0.964
2049	0.952	0.974	0.964
2050	0.952	0.974	0.964
2051	0.952	0.974	0.964
2052	0.952	0.974	0.964
2053	0.952	0.974	0.964

	Parsnip GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2054	0.952	0.974	0.964
2055	0.952	0.974	0.964
2056	0.952	0.974	0.964
2057	0.952	0.974	0.964
2058	0.952	0.974	0.964
2059	0.952	0.974	0.964
2060	0.952	0.974	0.964
2061	0.952	0.974	0.964
2062	0.952	0.974	0.964
2063	0.952	0.974	0.964
2064	0.952	0.974	0.964
2065	0.952	0.974	0.964
2066	0.952	0.974	0.964
2067	0.952	0.974	0.964
2068	0.952	0.974	0.964
2069	0.952	0.974	0.964
2070	0.951	0.974	0.964
2071	0.951	0.974	0.964
2072	0.951	0.974	0.964
2073	0.951	0.974	0.964
2074	0.951	0.974	0.964
2075	0.951	0.974	0.964
2076	0.951	0.974	0.964
2077	0.951	0.974	0.964
2078	0.951	0.974	0.964
2079	0.951	0.974	0.964
2080	0.951	0.974	0.964
2081	0.951	0.974	0.964
2082	0.951	0.974	0.964
2083	0.951	0.974	0.964
2084	0.951	0.974	0.964
2085	0.951	0.974	0.964

	Parsnip GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.953	0.974	0.966
2017	0.953	0.974	0.966
2018	0.953	0.974	0.966
2019	0.953	0.974	0.966
2020	0.953	0.974	0.966
2021	0.953	0.974	0.966
2022	0.953	0.974	0.966
2023	0.953	0.974	0.966
2024	0.953	0.974	0.966
2025	0.953	0.974	0.966
2026	0.953	0.974	0.966
2027	0.953	0.974	0.966
2028	0.953	0.974	0.966
2029	0.953	0.974	0.966
2030	0.953	0.974	0.966
2031	0.953	0.974	0.966
2032	0.953	0.974	0.966
2033	0.953	0.974	0.966
2034	0.953	0.974	0.966
2035	0.953	0.974	0.966
2036	0.953	0.974	0.966
2037	0.953	0.974	0.966
2038	0.953	0.974	0.966
2039	0.953	0.974	0.966
2040	0.953	0.974	0.965
2041	0.953	0.974	0.965
2042	0.953	0.974	0.965
2043	0.953	0.974	0.965
2044	0.953	0.974	0.965
2045	0.953	0.974	0.965
2046	0.953	0.974	0.965
2047	0.953	0.974	0.965
2048	0.953	0.974	0.965
2049	0.953	0.974	0.965
2050	0.953	0.974	0.965
2051	0.953	0.974	0.965
2052	0.953	0.974	0.965
2053	0.953	0.974	0.965
2054	0.953	0.974	0.965

	Parsnip GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.953	0.974	0.965
2056	0.953	0.974	0.965
2057	0.953	0.974	0.965
2058	0.953	0.974	0.965
2059	0.953	0.974	0.965
2060	0.953	0.974	0.965
2061	0.953	0.974	0.965
2062	0.953	0.974	0.965
2063	0.953	0.974	0.965
2064	0.953	0.974	0.965
2065	0.952	0.974	0.965
2066	0.952	0.974	0.965
2067	0.952	0.974	0.965
2068	0.952	0.974	0.965
2069	0.952	0.974	0.965
2070	0.952	0.974	0.965
2071	0.952	0.974	0.965
2072	0.952	0.974	0.965
2073	0.952	0.974	0.965
2074	0.952	0.974	0.965
2075	0.952	0.974	0.965
2076	0.952	0.974	0.965
2077	0.952	0.974	0.965
2078	0.952	0.974	0.965
2079	0.952	0.974	0.965
2080	0.952	0.974	0.965
2081	0.952	0.974	0.965
2082	0.952	0.974	0.965
2083	0.952	0.974	0.965
2084	0.952	0.974	0.965
2085	0.952	0.974	0.965

	Upper Skeena - Nass GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.966	0.979	0.975
2017	0.966	0.979	0.975
2018	0.966	0.979	0.975
2019	0.966	0.979	0.975
2020	0.966	0.979	0.975
2021	0.966	0.979	0.975
2022	0.966	0.979	0.975
2023	0.966	0.979	0.975
2024	0.966	0.979	0.975
2025	0.966	0.979	0.975
2026	0.966	0.979	0.975
2027	0.966	0.979	0.975
2028	0.966	0.979	0.975
2029	0.966	0.979	0.975
2030	0.966	0.979	0.975
2031	0.966	0.979	0.975
2032	0.966	0.979	0.975
2033	0.966	0.979	0.975
2034	0.966	0.979	0.975
2035	0.966	0.979	0.975
2036	0.966	0.979	0.975
2037	0.966	0.979	0.975
2038	0.966	0.979	0.975
2039	0.966	0.979	0.975
2040	0.966	0.979	0.975
2041	0.966	0.979	0.975
2042	0.966	0.979	0.975
2043	0.966	0.979	0.975
2044	0.966	0.979	0.975
2045	0.966	0.979	0.975
2046	0.966	0.979	0.975
2047	0.966	0.979	0.975
2048	0.966	0.979	0.975
2049	0.966	0.979	0.975
2050	0.966	0.979	0.975

	Upper Skeena - Nass GBPU Forestry Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2051	0.966	0.979	0.975
2052	0.966	0.979	0.975
2053	0.966	0.979	0.975
2054	0.966	0.979	0.975
2055	0.965	0.978	0.975
2056	0.965	0.978	0.975
2057	0.965	0.978	0.975
2058	0.965	0.978	0.975
2059	0.965	0.978	0.975
2060	0.965	0.978	0.974
2061	0.965	0.978	0.974
2062	0.965	0.978	0.974
2063	0.965	0.978	0.974
2064	0.965	0.978	0.974
2065	0.964	0.978	0.973
2066	0.964	0.978	0.973
2067	0.964	0.978	0.973
2068	0.964	0.978	0.973
2069	0.964	0.978	0.973
2070	0.964	0.978	0.973
2071	0.964	0.978	0.973
2072	0.964	0.978	0.973
2073	0.964	0.978	0.973
2074	0.964	0.978	0.973
2075	0.964	0.978	0.973
2076	0.964	0.978	0.973
2077	0.964	0.978	0.973
2078	0.964	0.978	0.973
2079	0.964	0.978	0.973
2080	0.964	0.978	0.973
2081	0.964	0.978	0.973
2082	0.964	0.978	0.973
2083	0.964	0.978	0.973
2084	0.964	0.978	0.973
2085	0.964	0.978	0.973

	Upper Skeena - Nass GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.966	0.979	0.975
2017	0.966	0.979	0.975
2018	0.966	0.979	0.975
2019	0.966	0.979	0.975
2020	0.966	0.979	0.975
2021	0.966	0.979	0.975
2022	0.966	0.979	0.975
2023	0.966	0.979	0.975
2024	0.966	0.979	0.975
2025	0.966	0.979	0.975
2026	0.966	0.979	0.975
2027	0.966	0.979	0.975
2028	0.966	0.979	0.975
2029	0.966	0.979	0.975
2030	0.966	0.979	0.975
2031	0.966	0.979	0.975
2032	0.966	0.979	0.975
2033	0.966	0.979	0.975
2034	0.966	0.979	0.975
2035	0.966	0.979	0.975
2036	0.966	0.979	0.975
2037	0.966	0.979	0.975
2038	0.966	0.979	0.975
2039	0.966	0.979	0.975
2040	0.966	0.979	0.975
2041	0.966	0.979	0.975
2042	0.966	0.979	0.975
2043	0.966	0.979	0.975
2044	0.966	0.979	0.975
2045	0.966	0.979	0.975
2046	0.966	0.979	0.975
2047	0.966	0.979	0.975
2048	0.966	0.979	0.975
2049	0.966	0.979	0.975
2050	0.966	0.979	0.975
2051	0.966	0.979	0.975
2052	0.966	0.979	0.975

	Upper Skeena - Nass GBPU Forestry Road <1.2 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2053	0.966	0.979	0.975
2054	0.966	0.979	0.975
2055	0.965	0.978	0.975
2056	0.965	0.978	0.975
2057	0.965	0.978	0.975
2058	0.965	0.978	0.975
2059	0.965	0.978	0.975
2060	0.965	0.978	0.974
2061	0.965	0.978	0.974
2062	0.965	0.978	0.974
2063	0.965	0.978	0.974
2064	0.965	0.978	0.974
2065	0.964	0.978	0.973
2066	0.964	0.978	0.973
2067	0.964	0.978	0.973
2068	0.964	0.978	0.973
2069	0.964	0.978	0.973
2070	0.964	0.978	0.973
2071	0.964	0.978	0.973
2072	0.964	0.978	0.973
2073	0.964	0.978	0.973
2074	0.964	0.978	0.973
2075	0.964	0.978	0.973
2076	0.964	0.978	0.973
2077	0.964	0.978	0.973
2078	0.964	0.978	0.973
2079	0.964	0.978	0.973
2080	0.964	0.978	0.973
2081	0.964	0.978	0.973
2082	0.964	0.978	0.973
2083	0.964	0.978	0.973
2084	0.964	0.978	0.973
2085	0.964	0.978	0.973

	Upper Skeena - Nass GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2016	0.966	0.979	0.975
2017	0.966	0.979	0.975
2018	0.966	0.979	0.975
2019	0.966	0.979	0.975
2020	0.966	0.979	0.975
2021	0.966	0.979	0.975
2022	0.966	0.979	0.975
2023	0.966	0.979	0.975
2024	0.966	0.979	0.975
2025	0.966	0.979	0.975
2026	0.966	0.979	0.975
2027	0.966	0.979	0.975
2028	0.966	0.979	0.975
2029	0.966	0.979	0.975
2030	0.966	0.979	0.975
2031	0.966	0.979	0.975
2032	0.966	0.979	0.975
2033	0.966	0.979	0.975
2034	0.966	0.979	0.975
2035	0.966	0.979	0.975
2036	0.966	0.979	0.975
2037	0.966	0.979	0.975
2038	0.966	0.979	0.975
2039	0.966	0.979	0.975
2040	0.966	0.979	0.975
2041	0.966	0.979	0.975
2042	0.966	0.979	0.975
2043	0.966	0.979	0.975
2044	0.966	0.979	0.975
2045	0.966	0.979	0.975
2046	0.966	0.979	0.975
2047	0.966	0.979	0.975
2048	0.966	0.979	0.975
2049	0.966	0.979	0.975
2050	0.966	0.979	0.975
2051	0.966	0.979	0.975
2052	0.966	0.979	0.975
2053	0.966	0.979	0.975
2054	0.966	0.979	0.975

	Upper Skeena - Nass GBPU All Road <0.6 km/km^2 Scenario		
Year	Adult female with cubs or yearling	Adult female with two year old or no cubs	Sub-adult female
2055	0.966	0.979	0.975
2056	0.966	0.979	0.975
2057	0.966	0.979	0.975
2058	0.966	0.979	0.975
2059	0.966	0.979	0.975
2060	0.965	0.978	0.975
2061	0.965	0.978	0.975
2062	0.965	0.978	0.975
2063	0.965	0.978	0.975
2064	0.965	0.978	0.975
2065	0.965	0.978	0.974
2066	0.965	0.978	0.974
2067	0.965	0.978	0.974
2068	0.965	0.978	0.974
2069	0.965	0.978	0.974
2070	0.964	0.978	0.974
2071	0.964	0.978	0.974
2072	0.964	0.978	0.974
2073	0.964	0.978	0.974
2074	0.964	0.978	0.974
2075	0.964	0.978	0.974
2076	0.964	0.978	0.974
2077	0.964	0.978	0.974
2078	0.964	0.978	0.974
2079	0.964	0.978	0.974
2080	0.964	0.978	0.974
2081	0.964	0.978	0.974
2082	0.964	0.978	0.974
2083	0.964	0.978	0.974
2084	0.964	0.978	0.974
2085	0.964	0.978	0.974