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To the reader:

In June 2010, the Government of British Columbia approved the implementation of management activities for Boreal Caribou including: protecting Boreal Caribou and their habitat from industrial activities; managing the size of the industrial footprint; and mitigating the effects of the industrial footprint. The implementation of these activities has been described in the "Implementation Plan for the Management of Boreal Caribou (*Rangifer tarandus caribou* pop. 14) in British Columbia" (BCIP). This plan identifies Government's goals and objectives for Boreal Caribou management, as well as the roles and responsibilities of natural resource sector agencies and organizations participating in the delivery of the management activities.

One element of the BCIP is Resource Review Areas (RRA). The attached document, "Performance Measures for Resource Review Areas for Woodland Caribou in British Columbia" provides recommendations on performance to monitor and measure effectiveness of RRAs in Boreal caribou areas and for the Burnt Pine herd area.This report was completed under contract and received internal and external review. Government will need to consider recommendation in the report and decide where and when they are appropriate for use. The recommendations for monitoring RRAs will need to be incorporated into other caribou recovery activities.

This report is a significant accomplishment and will guide Government in moving forward with Boreal Caribou management. If you have any questions on the attached report or Boreal Caribou management, please feel free to contact me (250-614-9917).

Sincerely,

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Performance Measures for Resource Review Areas for Woodland Caribou in British Columbia

March 31, 2012

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Executive Summary

In June 2010, the provincial government established Resource Review Areas (RRAs) to support management of Boreal Caribou (*Rangifer tarandus caribou*) in northeastern BC and the Burnt Pine Caribou Herd (Northern Caribou) in north-central BC. No new oil and gas, mineral, placer or coals tenures are allowed in RRAs for a minimum of 5 years. Effectiveness of RRAs will be assessed in 2015. The role of RRAs is to provide conditions that are more favourable for caribou persistence than conditions that exist outside RRAs. This report recommends performance measures and monitoring plans for Boreal Caribou and Burnt Pine Caribou Herd RRAs based on goals and objectives from management plans for the two populations.

For Boreal Caribou, the overall goals of the Implementation Plan for the Ongoing Management of Boreal Caribou (*Rangifer tarandus caribou* pop. 14) in British Columbia are: to decrease the expected rate of decline in the Boreal Caribou population; and, to significantly reduce the risk of Boreal Caribou extirpation in the Calendar, Chinchaga, Maxhamish and Prophet ranges within 50 years. Two plans recently completed for the Burnt Pine Caribou Herd provide a recovery population objective of 50 caribou.

There are four RRAs in Boreal Caribou ranges in northeastern BC and one RRA in the Burnt Pine Caribou Herd Range. Boreal Caribou RRAs contain 13% of the overall range, 13% of Ungulate Winter Ranges, and 5% of radio-collared caribou locations. Extremely low gradient slopes (0-0.6°), which have been found to be a good predictor of Boreal Caribou habitat in northeastern BC, make up 74% of the combined RRA area. The industrial disturbance zone (area within 250 m of industrial features) covers 62% of the four Boreal Caribou RRA areas. The Burnt Pine RRA contains 47% of the Wildlife Habitat Areas, 36% of the Ungulate Winter Range, 42% of the winter core area, 37% of the summer core area, 43% of radio-collared caribou winter locations and 26% of summer locations. The industrial disturbance zone covers 11% of the Burnt Pine RRA.

We recommend using the following performance measures for assessing the effectiveness of RRAs: population rate of increase, adult mortality rate, calf recruitment rate, % area within 500 m of industrial activities, % area in burns <40 years, undisturbed patch size distribution, % area of undisturbed low gradient slope (Boreal Caribou), wolf (*Canis lupus*)

density, moose (*Alces alces*) density and white-tailed deer (*Odocoileus virginianus*) relative density.

For Boreal Caribou, effectiveness of RRAs will be assessed at 3 levels of spatial resolution: RRA, Boreal Caribou range, and Boreal Caribou population and distribution. The following questions will be used to evaluate effectiveness of RRAs at the three spatial scales.

1. Do the RRAs contain appropriate conditions for caribou?
2. Are caribou in RRAs better off than caribou outside of RRAs?
3. Are caribou in ranges with RRAs better off than caribou in ranges without RRAs?

Performance measures at the RRA level focus on range conditions (habitat and disturbance) while performance measures at the range and Boreal Caribou population levels include both range conditions (disturbance, predator abundance, alternate prey abundance) and caribou population condition. At the RRA level, targets for performance measures focus on no increase in the industrial disturbance zone within RRAs. Targets for performance measures for RRAs at the range scale are based on performance measure levels in RRAs compared to levels within the same range but outside the RRA, and targets for the Boreal Caribou population level are based on performance measure levels in ranges with RRAs versus ranges without RRAs.

RRAs were established in June 2010 with a 5-year window for evaluating their effectiveness. Therefore, monitoring and analysis must be completed in the next 3 years. The monitoring program for Boreal Caribou RRAs includes maintaining a sample of 20 radio-collared caribou in each of the following monitoring units: RRAs (4), non-RRA portions of ranges with RRAs (2), and, ranges without RRAs (3), to support collection of calf recruitment, adult mortality and population rate of increase performance measures. In addition to tracking performance measures, evaluation and monitoring of the Boreal Caribou RRA should include: the proportion of radio-collared caribou locations in RRAs, causes of adult mortality, beaver (*Castor canadensis*) density, and RRA shape.

The monitoring program recommended in this report is restricted to the three-year window still remaining before the effectiveness of RRAs has to be assessed. As more of the landscape is disturbed by development, the relative contribution of the RRAs to sustaining Boreal Caribou will likely increase as long as RRAs contain adequate conditions for Boreal Caribou to persist. When assessing the effectiveness of RRAs at the end of the 5-year evaluation period, the future effectiveness of RRAs should also be considered.

Due to the apparent lack of caribou in the Burnt Pine Caribou Herd, performance measures for the Burnt Pine RRA focus on habitat/range condition. We recommend assessing range conditions within the RRA and also specifically within the Mt. Stephenson portion of the RRA where the majority of use by the Burnt Pine Caribou Herd has occurred. Although the current contribution of the RRA to the population goal for the Burnt Pine Caribou Herd may not be possible to assess at this point in time, the contribution of the RRA to the population goal for the Kennedy-Siding caribou herd are possible and should be considered.

Performance measures for range conditions in the Burnt Pine RRA should be assessed in 2012 and in 2015. In addition, caribou that use the Mt. Stephenson area and the rest of the RRA should be monitored regardless of which herd they belong to. Surveys of the RRA (and non-RRA portion of the Mt. Stephenson area) should be conducted monthly from December to March each year and caribou found in the RRA should be radio-collared. As recovery of the Burnt Pine Caribou Herd progresses, performance measures for population condition similar to those recommended for Boreal Caribou RRAs should be included.

Acknowledgements

We would like to thank Chris Ritchie (Ministry of Forests, Lands and Natural Resource Operations [MFLNRO]), Chris Pasztor (Ministry of Environment [MOE]), Dale Seip (MOE), Conrad Thiessen (MFLNRO), Karen Price and Dave Daust for sharing their thoughts and insights on various aspects of the project. Chris Ritchie and Chris Pasztor also reviewed earlier drafts of the report. Dale Seip, Conrad Thiessen, Dave Hervieux (Alberta Sustainable Resource Development), Nic Larter (Northwest Territories Government), Craig DeMars (University of Alberta), Canadian Forest Products Ltd. and Nexen Inc. provided radio-collared caribou locations. Chris Pasztor provided the disturbance layer for the Boreal Caribou ranges. We would also like to thank Viktor Brumovsky (Wildlife Infometrics Inc.) for preparing the maps.

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1 Background/Context

In June 2010, the provincial government established Resource Review Areas (RRAs) to support management of Boreal Caribou (*Rangifer tarandus caribou*) in northeastern BC and the Burnt Pine Caribou Herd (Northern Caribou) in north-central BC. Both Boreal Caribou and the Burnt Pine Caribou Herd are designated as Threatened under the federal *Species at Risk Act*.

RRAs are located in areas within existing caribou ranges that currently do not contain any oil and gas, coal, mineral or placer tenures. A No Disposition Notation was placed over RRAs so that no new oil and gas tenure requests will be accepted in the RRAs for a minimum of 5 years. Mineral, placer and coal No Registration Reserves have also been placed over the RRAs under the *Mineral Tenure Act* and *Coal Act* for a minimum of 5 years. The effectiveness of RRAs will be reviewed after 5 years based on performance measures related to caribou population and range conditions.

The provincial government recently completed management plans for the two populations. The Implementation Plan for the Ongoing Management of Boreal Caribou (*Rangifer tarandus caribou* pop. 14) in British Columbia (henceforth the Boreal Caribou Implementation Plan) was completed in 2011 (Ministry of Environment 2011). Two plans were prepared for guiding management of the Burnt Pine Caribou Herd: the Recovery and Augmentation Plan for Woodland Caribou in the Central Rocky Mountains of British Columbia (henceforth the Central Rockies Caribou Plan) provides objectives and strategies for managing 7 caribou populations in the central Rocky Mountains in British Columbia, including the Burnt Pine Caribou Herd (Seip et al. 2010); and, the Burnt Pine Caribou Augmentation Plan , which was prepared specifically for the Burnt Pine Caribou Herd (Ministry of Forests, Lands and Natural Resource Operations 2011).

This report recommends performance measures and monitoring plans for Boreal Caribou and Burnt Pine Caribou Herd RRAs based on goals and objectives from the management plans for the two populations.

1.1 Requirements of Woodland Caribou

Caribou found in the boreal zone in northeastern BC belong to the "boreal" ecotype of woodland caribou (Heard and Vagt 1998). In general, Boreal Caribou requirements include (Ministry of Environment 2010, Environment Canada 2008, 2011a):

- large range areas comprised of continuous tracts of undisturbed habitat where caribou can:
  - reduce predation risk by: maintaining low population densities throughout the range; and, avoiding areas of high predation risk, such as areas with high densities of alternate prey species (e.g. moose [*Alces alces*] and white-tailed deer [*Odocoileus virginianus*]); and,
  - shift their range use in response to various natural processes (e.g. fire, weather/snow conditions, food availability) and human activities (e.g. disturbance from oil and gas development, forest harvesting, recreation);
- adequate areas of important habitats such as:
  - large patches of low gradient (<0.6° slope) peatlands; and,
  - mature to old-growth coniferous forest with abundant lichens;
- adequate forage quality and quantity to allow breeding and recruitment of calves, including bog and fen habitats that offer access to seasonally important forage species (e.g. wintergreen vascular plants, and sedges and rushes associated with lake margins);
- snow conditions during winter that allow access to terrestrial lichen forage and that provide unimpeded movements;
- minimal amounts of early successional forests and recently disturbed areas that attract other ungulates;
- isolated, relatively predator-free areas (e.g. treed peatlands, islands in lakes) that allow individual female caribou to space out at low densities for calving;
- areas surrounding ranges with relatively low intensity of human activity to buffer effects of areas with intensive human activities;
- connectivity between ranges:
  - to enable immigration and emigration between local populations to maintain or increase genetic diversity; and,
  - to provide potential movement corridors to facilitate response to changing conditions cause by climate change; and,
- ranges that represent the full ecological gradient necessary to capture local adaptations that arise from adaptive variation.

The Burnt Pine Caribou Herd belongs to the "northern" ecotype of woodland caribou (Stevenson and Hatler 1985, Heard and Vagt 1998). In general, Northern Caribou require (Northern Caribou Technical Advisory Committee 2004, Environment Canada 2011b):

- large tracts of range where caribou can space away from other prey and predators (horizontally and vertically);
- adequate forage quality and quantity to allow breeding and recruitment of calves;
- high quality undisturbed calving areas where caribou can space away from other prey and predators (e.g. high elevation alpine, subalpine parkland, subalpine forests, islands in lakes);
- access to an adequate supply of terrestrial and arboreal lichens during winter;
- large patches of high quality winter habitat:
    - low elevation mature pine forests with abundant terrestrial lichens;
    - low elevation mature forests (pine or spruce) or forested wetlands with abundant arboreal lichens;
    - high elevation windswept alpine ridges with abundant terrestrial lichens;
    - high elevation subalpine forests with abundant arboreal lichens; and,
- relatively undisturbed matrix habitat for seasonal migrations and connectivity between ranges.

1.2 Boreal Caribou

1.2.1 Implementation Plan for the Ongoing Management of Boreal Caribou in British Columbia (2011)

Boreal Caribou require large areas of contiguous habitat to avoid predators (Ministry of Environment 2010). Disturbance from human activities indirectly affects Boreal Caribou through habitat loss, fragmentation and alteration, and resulting changes in predator/prey relationships (Ministry of Environment 2010, 2011). RRAs were established to protect portions of Boreal Caribou range in northeastern BC from further disturbance for a minimum of 5 years.

In the Boreal Caribou Implementation Plan, RRAs contribute to Objective #1 (Figure 1):

- protect sufficient Boreal Caribou habitat to provide the opportunities to recover populations in all six ranges within 50 years;

and, ultimately to both of the plan goals:

- to decrease the expected rate of decline in the Boreal Caribou population; and,
- to significantly reduce the risk of Boreal Caribou extirpation in the Calendar, Chinchaga, Maxhamish and Prophet ranges within 50 years.

Strategies such as habitat restoration, fire suppression and predator management that will be used to achieve the other plan objectives will also affect conditions within RRAs (Figure 2) and contribute to the overall plan goals. Each Boreal Caribou range contains a specific combination of strategies to meet plan objectives and range-specific population targets (Table 1). Strategies used to achieve other plan objectives will be applied at the same level of effort in RRAs and outside of RRAs within individual ranges.

The role of additional protection afforded by RRAs is to provide conditions that are more favourable for caribou persistence than conditions that exist outside RRAs, now and in the future (if the moratorium on new oil and gas tenures continues beyond 5 years).

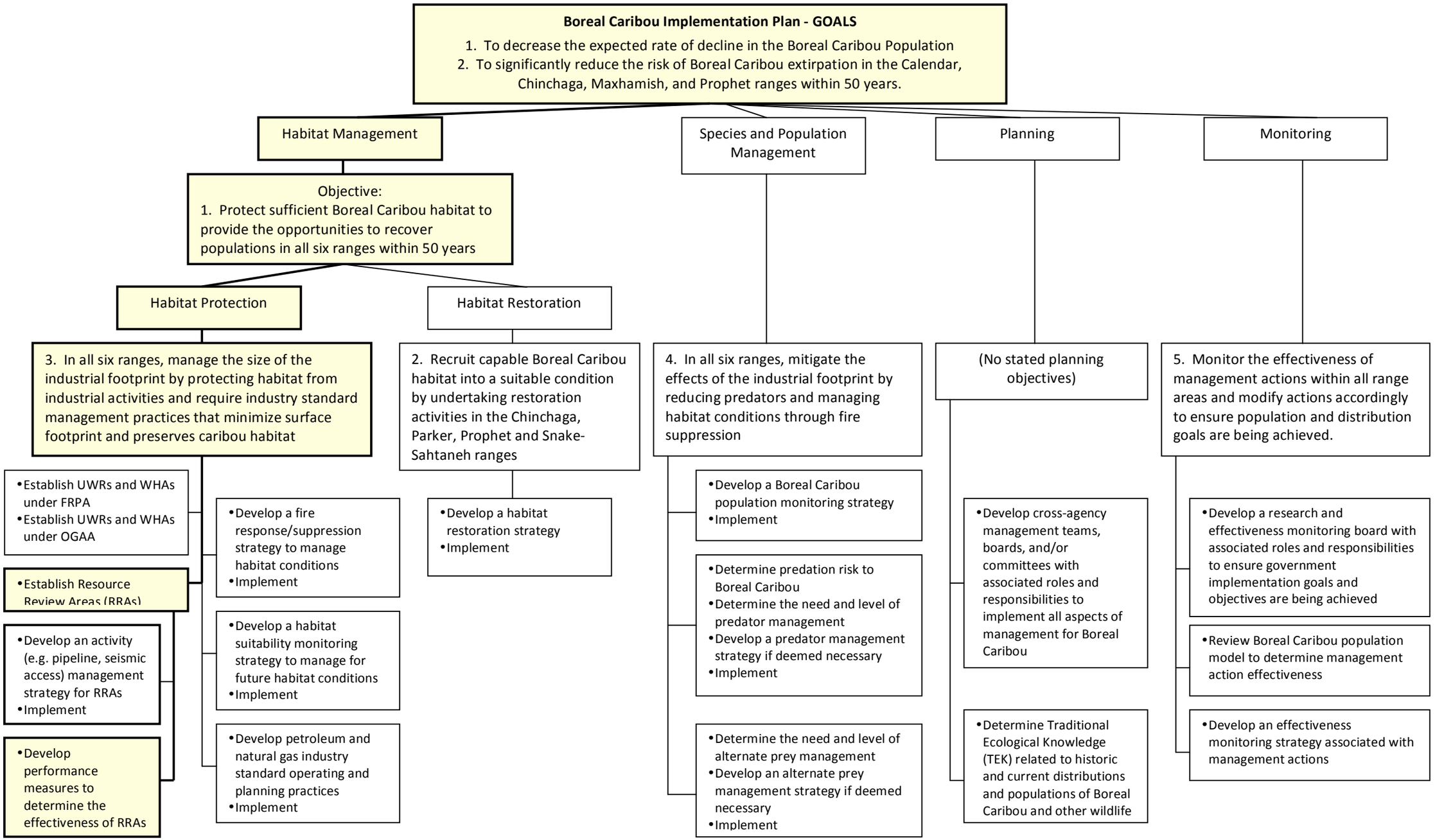

Figure 1. Role of Resource Review Areas in the Boreal Caribou Implementation Plan.

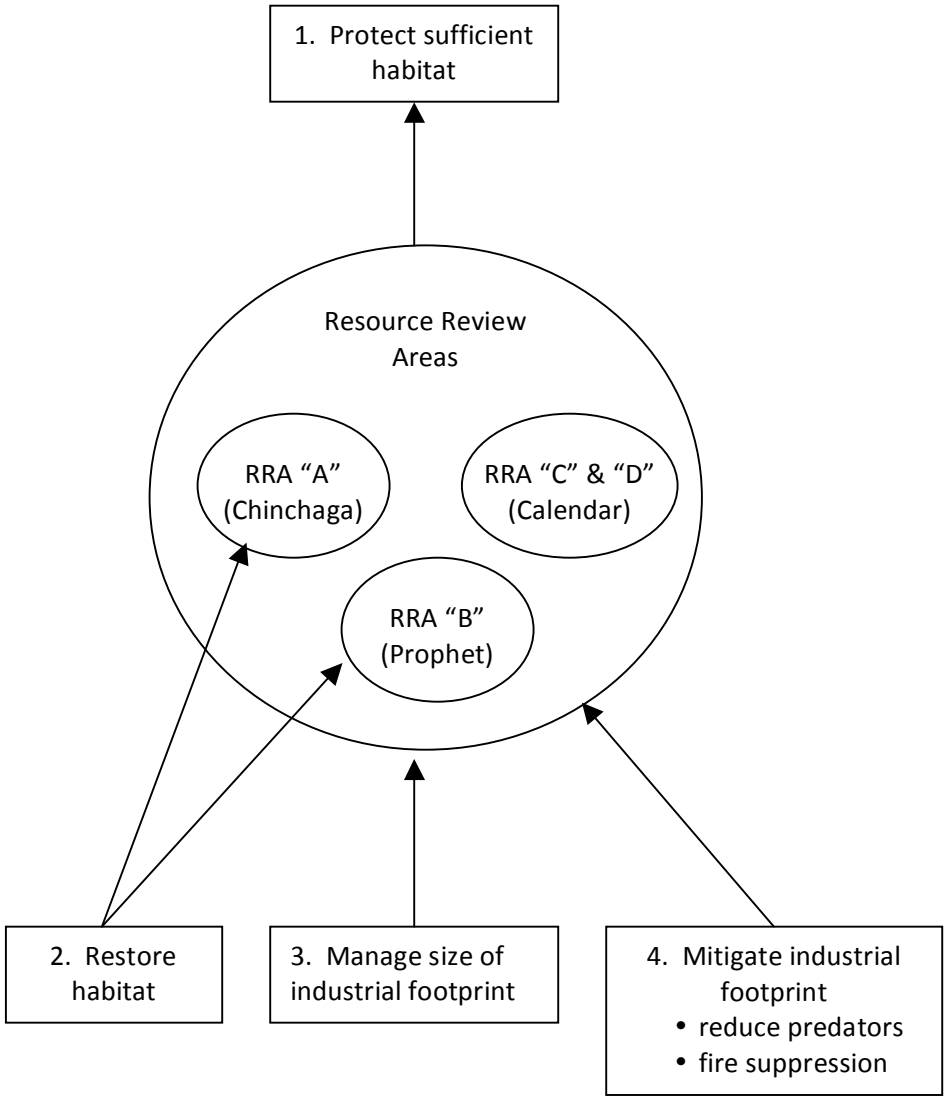

Figure 2. Relationship between Resource Review Areas (RRAs) and objectives from the Boreal Caribou Implementation Plan. Range names are in parentheses.

Table 1. Management and population targets for Boreal Caribou ranges.

Range	Management Guidance from Boreal Caribou Implementation Plan[1]	Current Estimated Population[2]	Expected Target[3]
Chinchaga	• Establish RRA • Reduce risk of extirpation within 50 years • Restore habitat • Manage footprint • Mitigate (predator management, fire suppression)	483	110
Maxhamish	• Reduce risk of extirpation within 50 years • Manage footprint • Mitigate	306	201
Calendar	• Establish 2 RRAs • Reduce risk of extirpation within 50 years • Manage footprint • Mitigate	291	106
Snake Sahtaneh	• Restore habitat • Manage footprint • Mitigate	365	11
Prophet	• Establish RRA • Reduce risk of extirpation within 50 years • Restore habitat • Manage footprint • Mitigate	54	97
Parker	• Restore habitat • Manage footprint • Mitigate	13	6
Total		1512	531

[1] See Figure 1 to see how individual management elements fit in the broader plan for Boreal Caribou
[2] From Ministry of Environment 2010
[3] From "Summary of Boreal Caribou Management Plan – September 2010"

1.2.2 Boreal Caribou Resource Review Areas

There are four RRAs in Boreal Caribou ranges: two in the Calendar Range, one in the Chinchaga Range and one in the Prophet Range (Figure 3). The two RRAs in the Calendar Range cover 41% of that range and core habitat, the Prophet RRA covers 73% of the range and core habitat, and

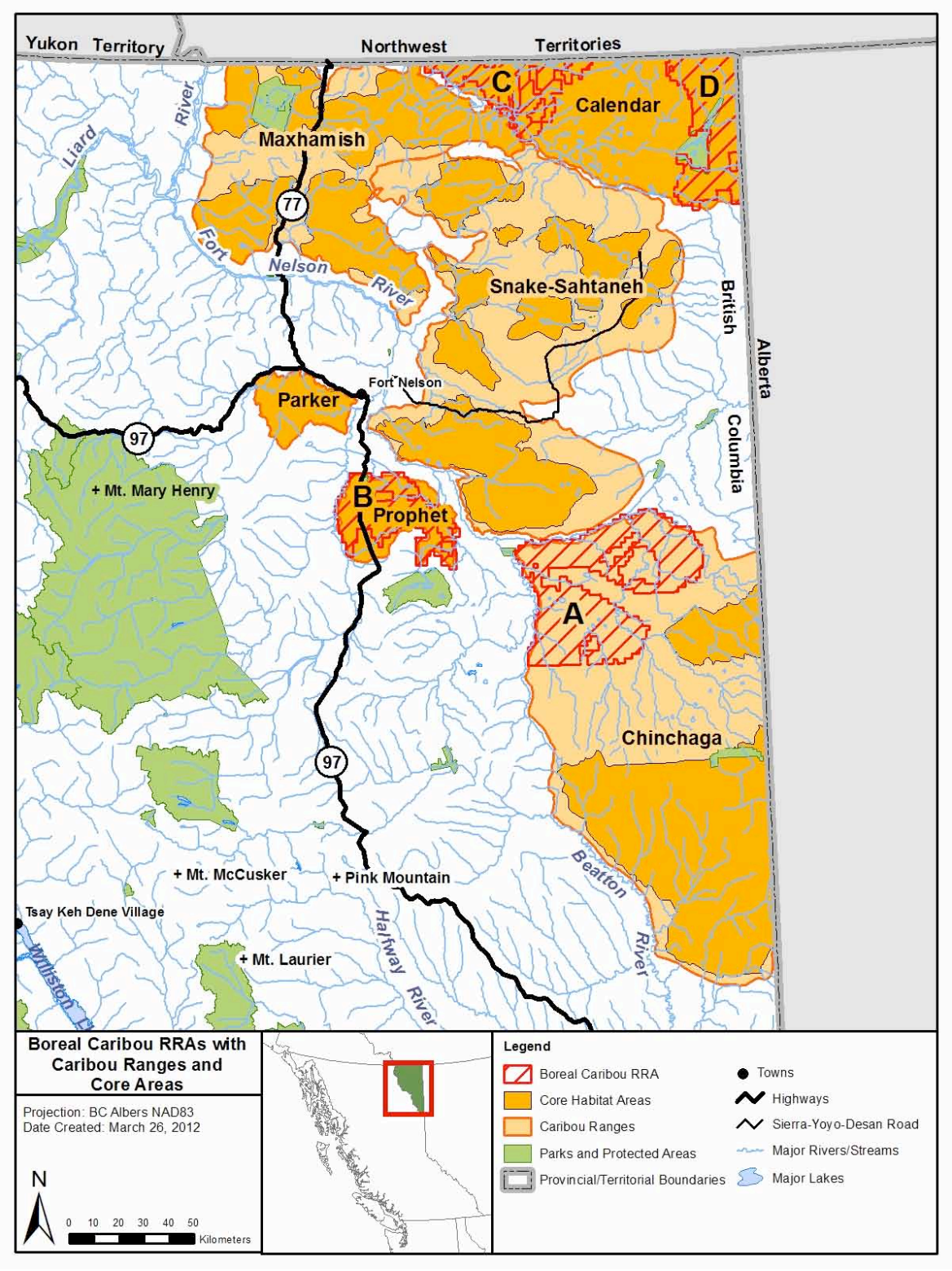

Figure 3. Location of Resource Review Areas in Boreal Caribou ranges and core habitats.

the Chinchaga RRA covers 16% of the range but does not include any core habitat (Table 2). All RRAs combined cover 13% of the total area in Boreal Caribou ranges.

The RRAs do not include any Wildlife Habitat Areas (Figure 4), but the two Calendar RRAs contain 41% of the Ungulate Winter Range in that range, and the Prophet RRA contains 75% of the Ungulate Winter Range in that range (Figure 4, Table 2). The Chinchaga RRA does not overlap with any Ungulate Winter Ranges. Boreal Caribou in northeastern BC select areas with slopes of less than 0.6° (Culling et al. 2006). Slopes of less than 0.6° comprise 75% of the total area in all RRAs combined (Figure 5, Table 2).

Most of the radio-collared caribou locations in the Prophet Range fall within the RRA (Figure 6, Table 2). However, recent telemetry data show that caribou radio-collared in the Prophet Range are also using areas that are outside of any currently identified Boreal Caribou ranges, but within the defined area of distribution (Craig DeMars, unpubl. data). RRA "D" in the Calendar Range contains 17% of the radio-collared caribou locations in that range, but the other RRA in the Calendar Range and the RRA in the Chinchaga Range contain almost no radio-collared caribou locations. The lack of locations in RRAs in the Calendar and Chinchaga ranges may reflect a lack of caribou radio-collared in those areas rather than a lack of use by caribou.

The industrial disturbance zone (area within 250 m of industrial features) covers about 60% of each RRA except RRA "D" in the Calendar Range, where it covers about 70% of the RRA (Figure 7, Table 2). The level of industrial disturbance within RRAs is slightly lower than that found in the entire range, except in RRA "D" in the Calendar Range, where the level of disturbance is similar to that of the range (Table 2; Thiessen 2009, Wilson et al. 2010). Mean patch size of undisturbed range is about 100 ha in the RRAs except in RRA "D" where mean patch size is 51 ha. The smaller mean patch size in RRA "D" may be a result of the higher level of disturbance and also possibly the orientation of the linear features. Linear features in RRA "C" in the Calendar Range are mostly oriented in a north-south and east-west grid pattern, whereas linear features in RRA "D" are oriented both north-south/east-west, and southwest-northeast/northwest-southeast. There are few undisturbed patches larger than 1000 ha in any of the RRAs in Boreal Caribou ranges (Table 2).

Table 2. Habitat, range, caribou use and disturbance characteristics of Resource Review Areas in Boreal Caribou ranges.

	Range	**Chinchaga**	**Prophet**	**Calendar**		**Total (All 6 Ranges)**
	RRA	**A**	**B**	**C**	**D**	**All 4 RRAs**
	Total range area (ha)	1 389 750	119 303	497 293	497 293	3 991 038
	Total core habitat area (ha)	597 636	119 303	497 293	497 293	2 281 524
	RRA area (ha)	240 323	98 588	87 998	123 567	550 476
Habitat Representation	% of core habitat in range within RRA	0	73	17	24	13
	% of range within RRA	16	73	17	24	13
	% of range's identified Wildlife Habitat Areas in RRA[1]	0	N/A	N/A	N/A	0
	% of range's identified Ungulate Winter Range in RRA	0	75	17	24	13
	% of RRA made up of Ungulate Winter Range	0	70	92	93	48
	% of RRA made up of high value habitat (extremely low gradient slopes 0-0.6°)	75	54	76	87	74
Caribou Use	% of range's radio-collared caribou locations in RRA	<0.01	83	2	18	5
Level of Disturbance	% of RRA within 250 meters of industrial disturbance (ha)	58	63	58	72	62
	% of RRA Ungulate Winter Range in undisturbed zone	N/A	28	38	27	30
	Mean undisturbed patch size (>0.5 ha)[2]	101	108	96	51	87
	Patch size range	0.5 – 16 849	0.5 – 8 731	0.5 – 3 545	0.5 – 1 491	0.5 – 16 849
	Number of patches	985	339	387	681	2392
	Number of patches >1000 ha	5	2	3	2	12

[1] There are no Wildlife Habitat Areas in the Prophet and Calendar ranges; none of the Wildlife Habitat Areas in the Chinchaga or other ranges overlap with RRAs.
[2] Patches < 0.5 ha were excluded to account for polygons slivers resulting from slight differences in boundaries in different map layers

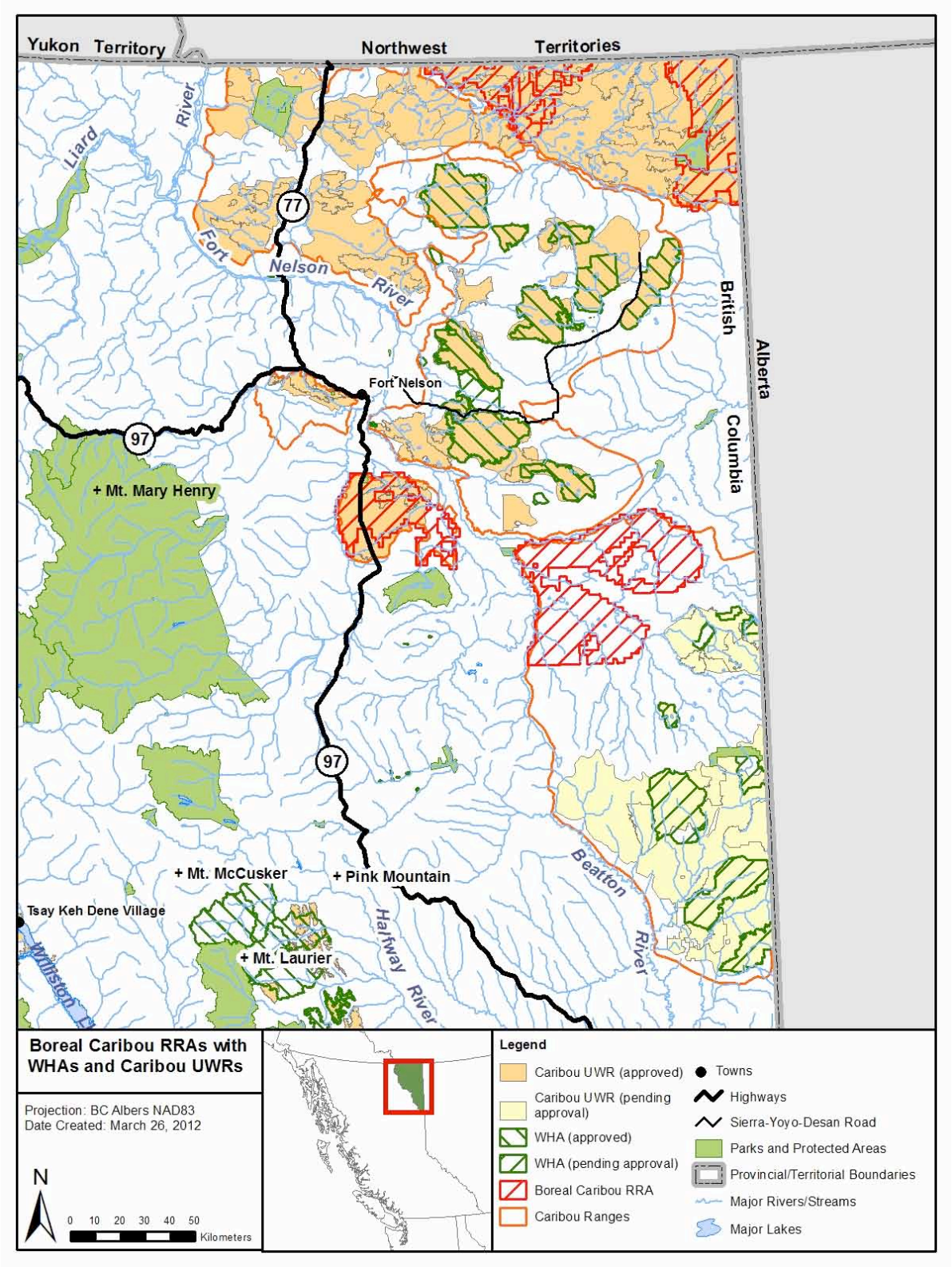

Figure 4. Boreal Caribou Resource Review Areas, Ungulate Winter Ranges and Wildlife Habitat Areas.

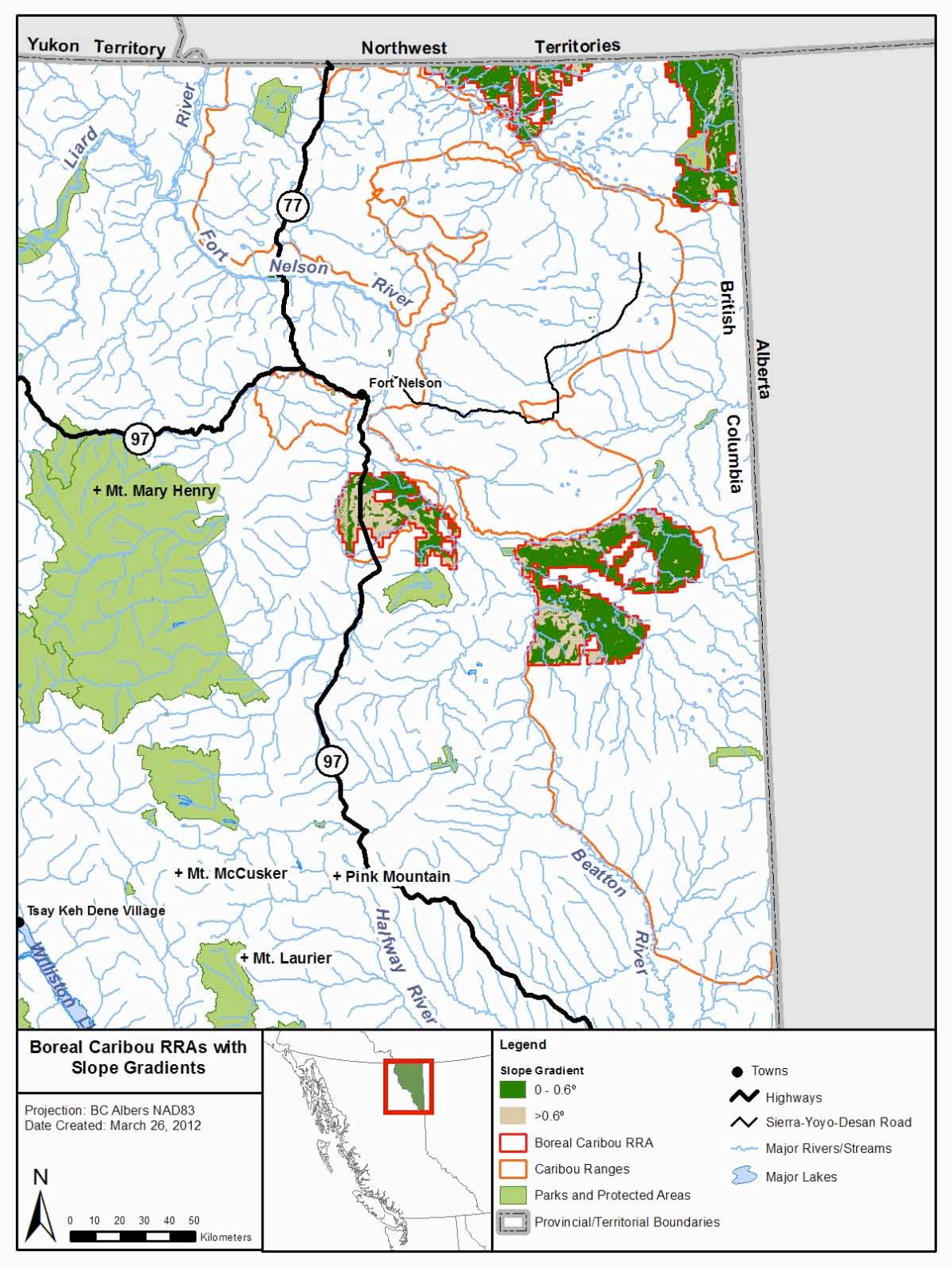

Figure 5. Slope class distribution in Boreal Caribou Resource Review Areas.

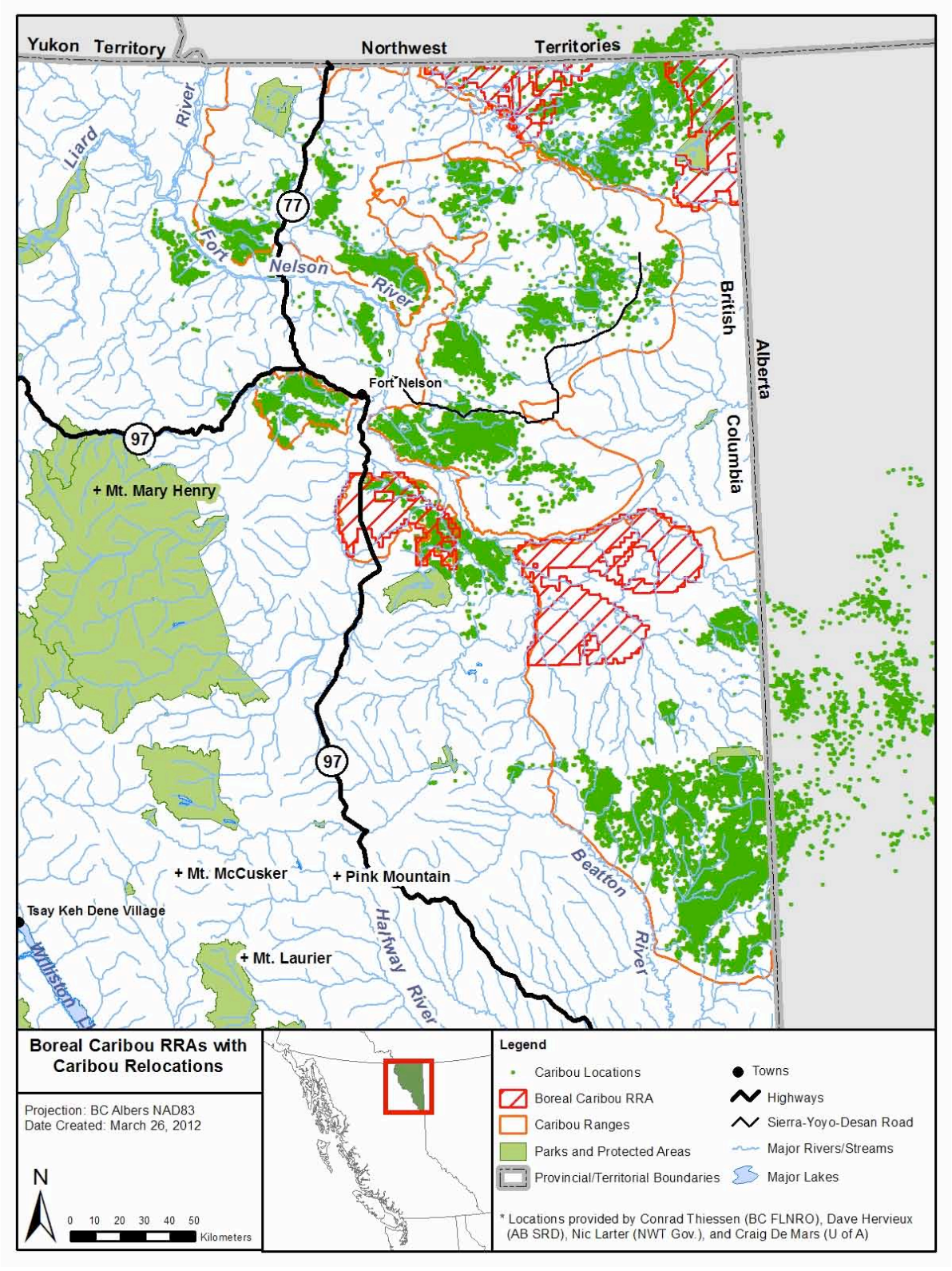

Figure 6. Radio-collared Boreal Caribou locations in Resource Review Areas.

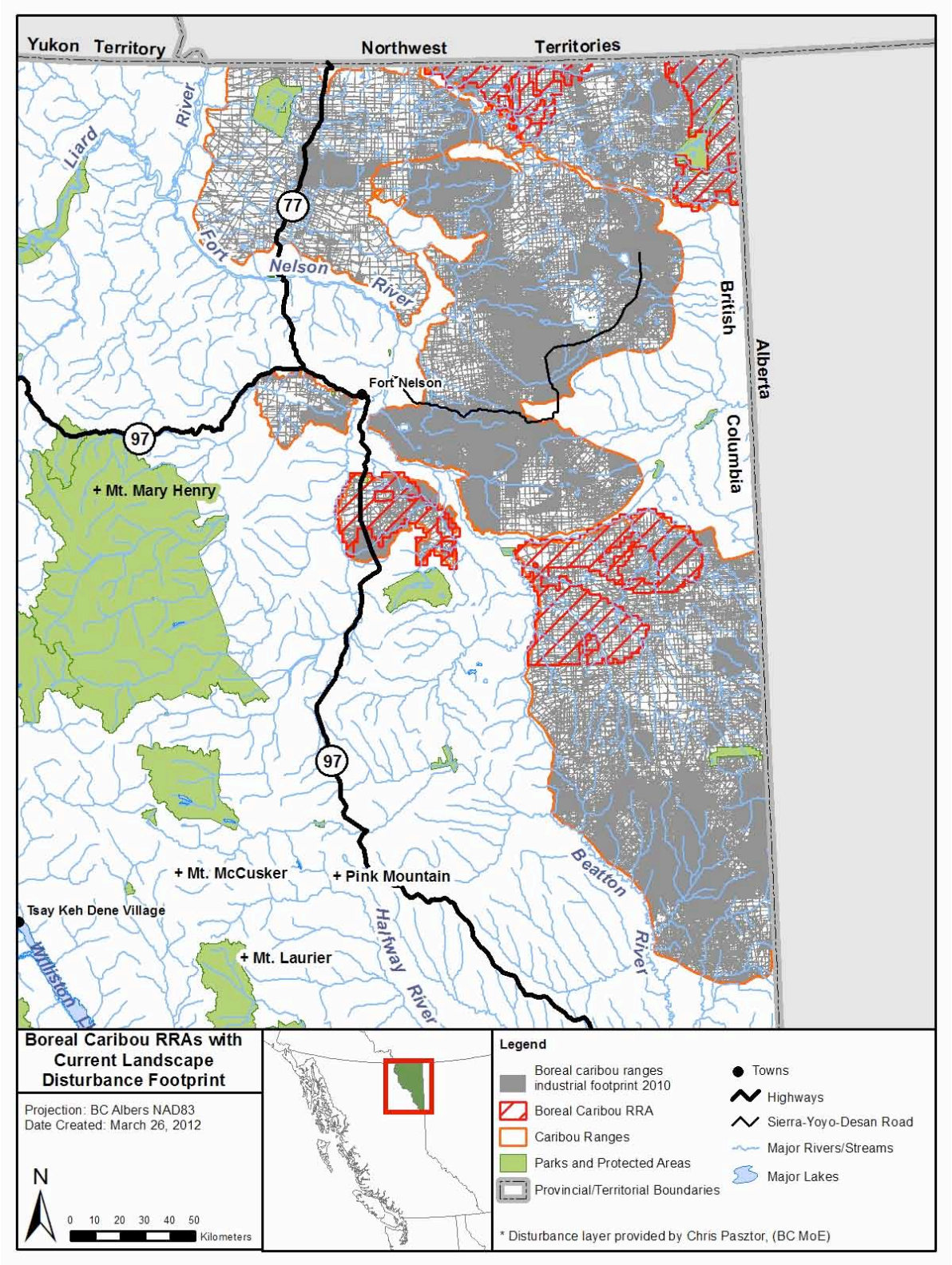

Figure 7. Industrial disturbance with 250 m buffers in Boreal Caribou Resource Review Areas.

1.3 Burnt Pine Caribou

1.3.1 Burnt Pine Caribou Plans

Two plans have recently been prepared that include objectives for the Burnt Pine Caribou Herd. Both plans provide a recovery population target of 50 caribou for the Burnt Pine Caribou Herd (Figures 8, 9). The RRA in the Burnt Pine Caribou Herd area contributes to the population objective through habitat protection.

1.3.2 Burnt Pine Caribou Resource Review Area

The Burnt Pine RRA is located in the western portion of the Burnt Pine Caribou Herd Range and contains 47% of the Wildlife Habitat Areas and 36% of the Ungulate Winter Range that currently exist in the range (Figure 10, Table 3). The RRA also contains 42% of the winter core area and 37% of the summer core area in the range (Figures 11, 12; Table 3).

Burnt Pine radio-collared caribou use the RRA more during winter than summer (Figure 13, Table 3). Burnt Pine caribou generally winter at higher elevations in the Mt. Stephenson (64% of winter locations) and Mt. Le Hudette (22% of winter locations) areas and summer in Pine-Le Moray Park (Jones 2007). Just over half of the winter locations on Mt Stephenson were in the RRA. Burnt Pine caribou used the Howling Wolf Ridge area during winter in only one year since the study began in 2002 (D. Seip, pers. comm.). The Kennedy-Siding caribou herd also uses the RRA in both winter and summer (Figure 13; Jones 2007). During early winter, Kennedy-Siding caribou are found in low elevation pine forests and move to higher elevations in mid-late winter (Jones 2007) so potential overlap with Burnt Pine caribou on Mt. Stephenson generally occurs in mid to late winter. We summarize range use patterns here based on the total number of radio-collared caribou locations and do not discriminate between the methods by which the locations of radio-collared caribou were collected (i.e., VHF aerial telemetry or Global Positioning Systems [GPS]). Because many of the radio-collars used during the early part of the study were VHF collars, the relative contribution of those caribou to use patterns may be overshadowed by locations from GPS collars. Therefore, it may be more appropriate to assess distribution by “caribou year” rather than caribou location, which is beyond the scope of this project. Our summary is only intended to

Recovery and Augmentation Plan for Woodland Caribou (*Rangifer tarandus caribou*) in the Central Rocky Mountains of British Columbia (Seip et al. 2010)

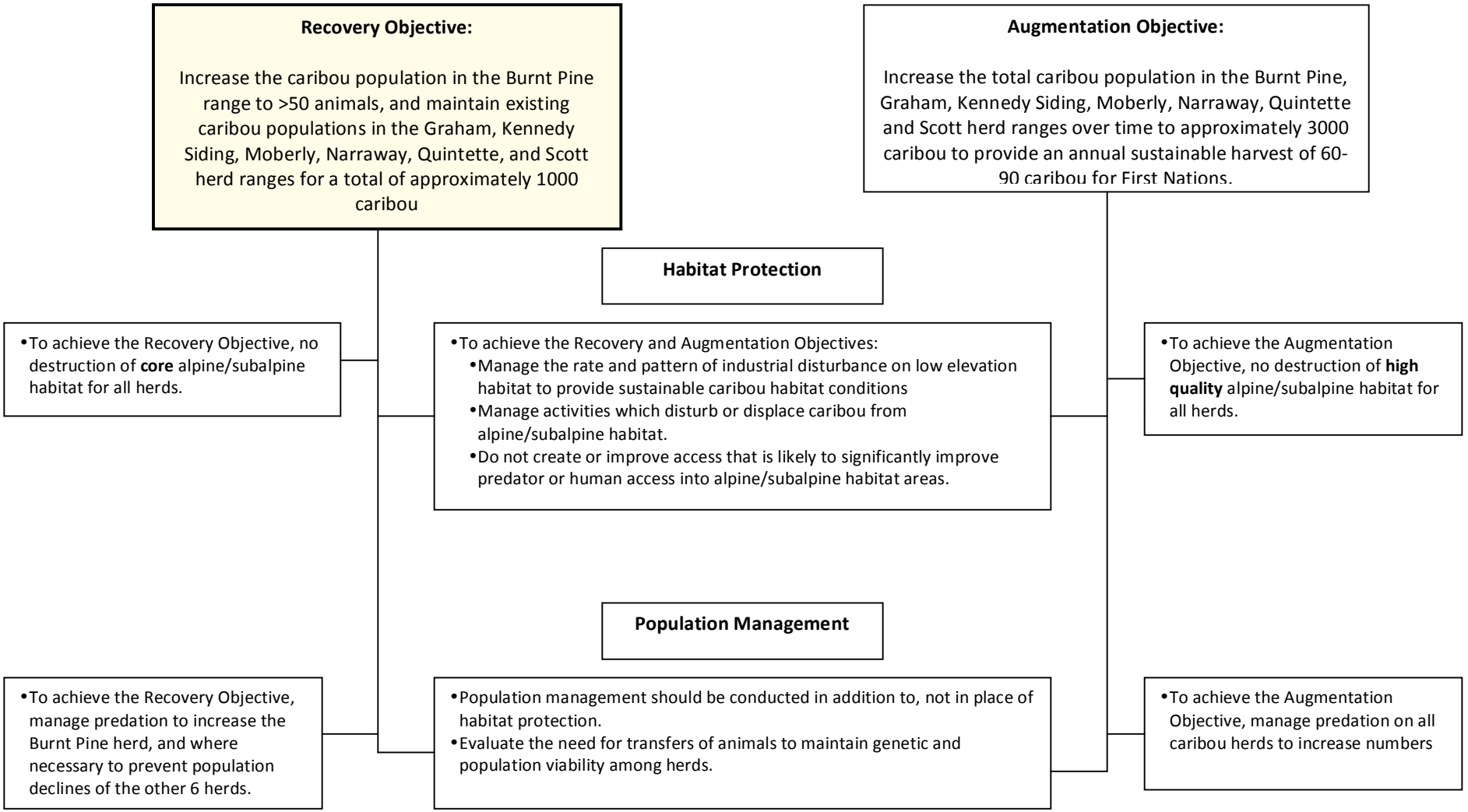

Figure 8. Objectives and strategies for the Burnt Pine Caribou Herd in the Recovery and Augmentation Plan for Woodland Caribou in the Central Rocky Mountains of British Columbia.

Burnt Pine Caribou Augmentation Plan (Ministry of Forests, Lands and Natural Resource Operations 2011)

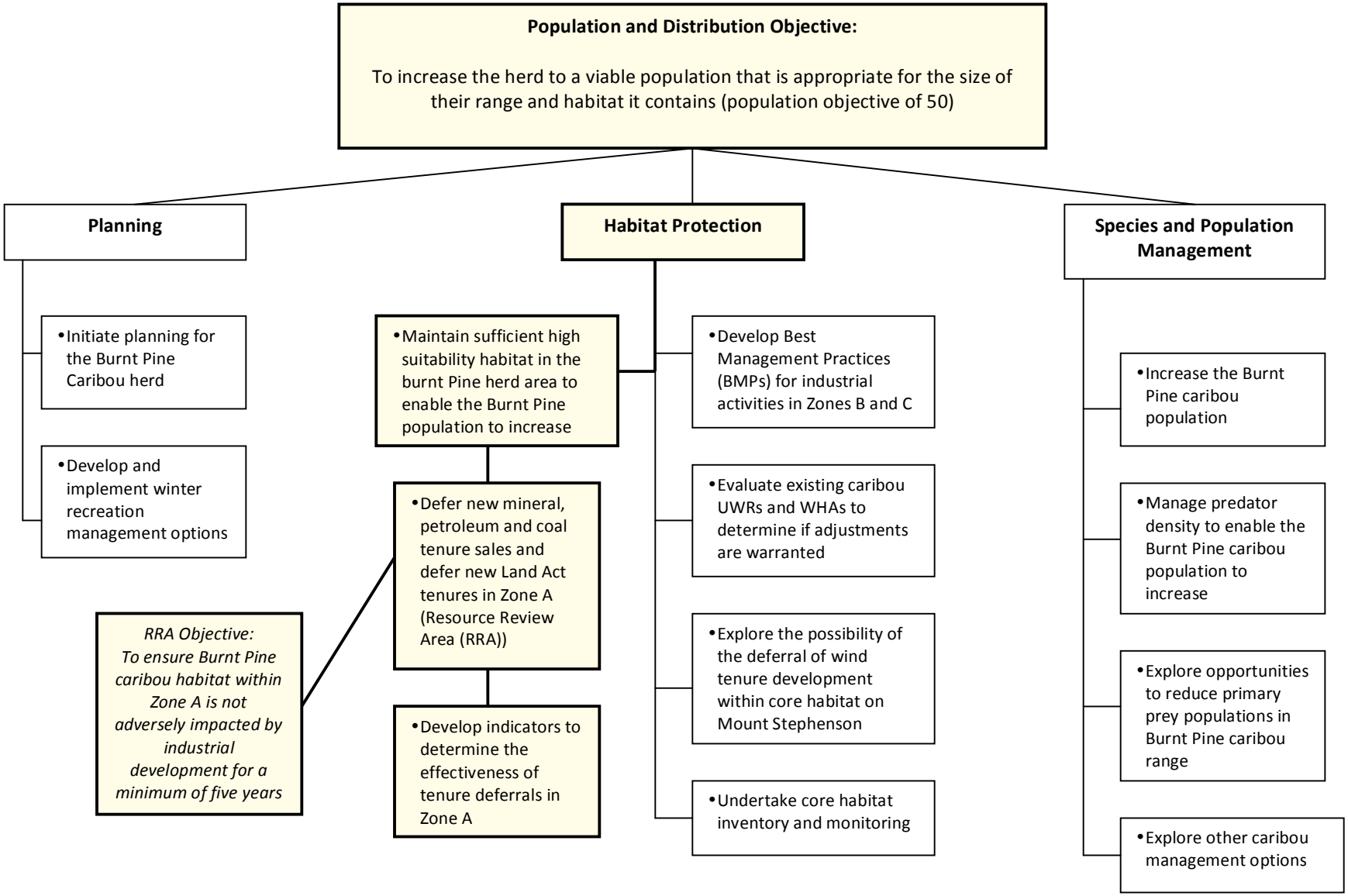

Figure 9. Role of the Resource Review Area in the Burnt Pine Caribou Augmentation Plan.

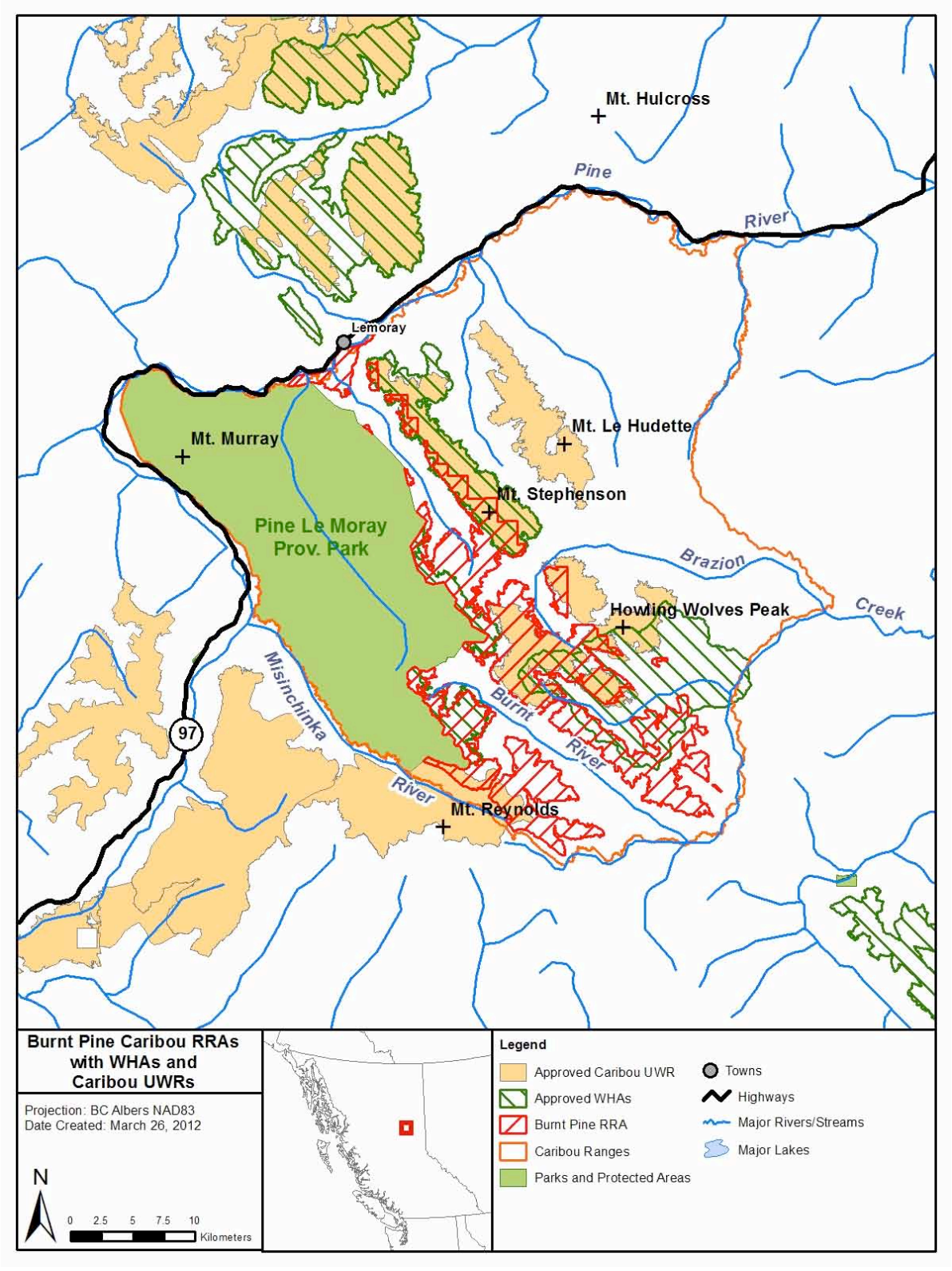

Figure 10. Burnt Pine Caribou Resource Review Area, Ungulate Winter Ranges and Wildlife Habitat Areas.

characterize patterns of use in relation to the RRA based on readily available data.

The industrial disturbance zone (area within 250 m of industrial features) covers about 11% of the Burnt Pine RRA (Figure 14, Table 3). Mean patch size is 504 ha (range 1.6 – 3292 ha) and 7 patches are larger than 1000 ha (Table 3).

Table 3. Habitat, range, caribou use and disturbance characteristics of the Burnt Pine Caribou Herd Resource Review Area.

	Total Range Area (ha)	171 090
	RRA area (ha)	23 231
Habitat Representation	% of range within RRA	13
	% Wildlife Habitat Area in RRA	40
	% Ungulate Winter Range in RRA	36
	% of winter core area in RRA	42
	% of summer core area in RRA	37
	% of RRA made up of Wildlife Habitat Area	37
	% of RRA made up of Ungulate Winter Range	30
	% of RRA made up of winter core area	46
	% of RRA made up of summer core area	70
Caribou Use	% Burnt Pine collared caribou winter locations in RRA	43
	% Burnt Pine collared caribou summer locations in RRA	26
Level of Disturbance	% of RRA within 250 meters of industrial disturbance	11
	% of RRA Wildlife Habitat Area in undisturbed zone	90
	% of RRA Ungulate Winter Range in undisturbed zone	90
	mean undisturbed patch size (>0.5 ha)	504
	number of patches	41
	number of patches >1000 ha	7

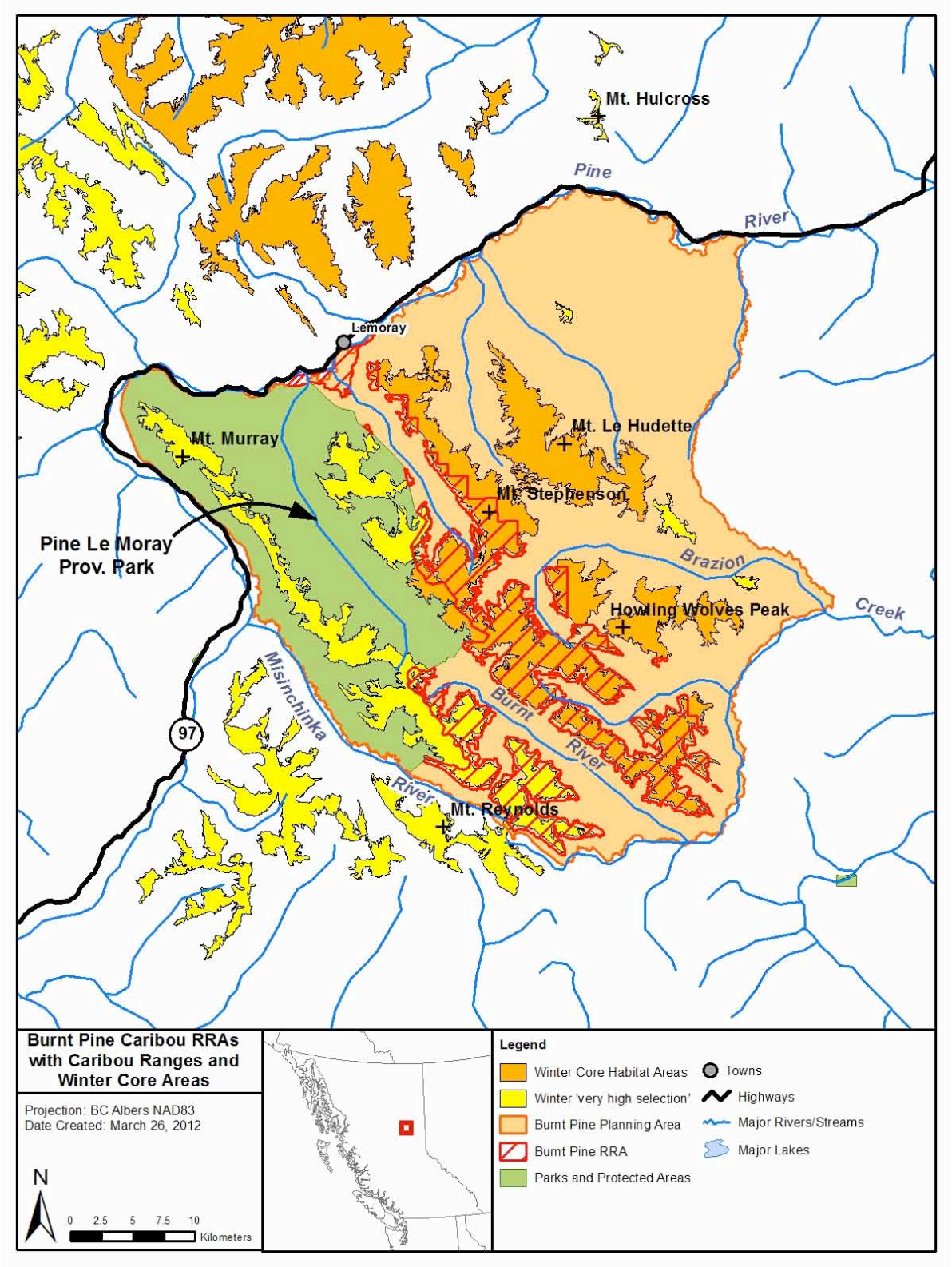

Figure 11. Burnt Pine Caribou Herd Resource Review Area, winter core areas and winter high selectivity habitat.

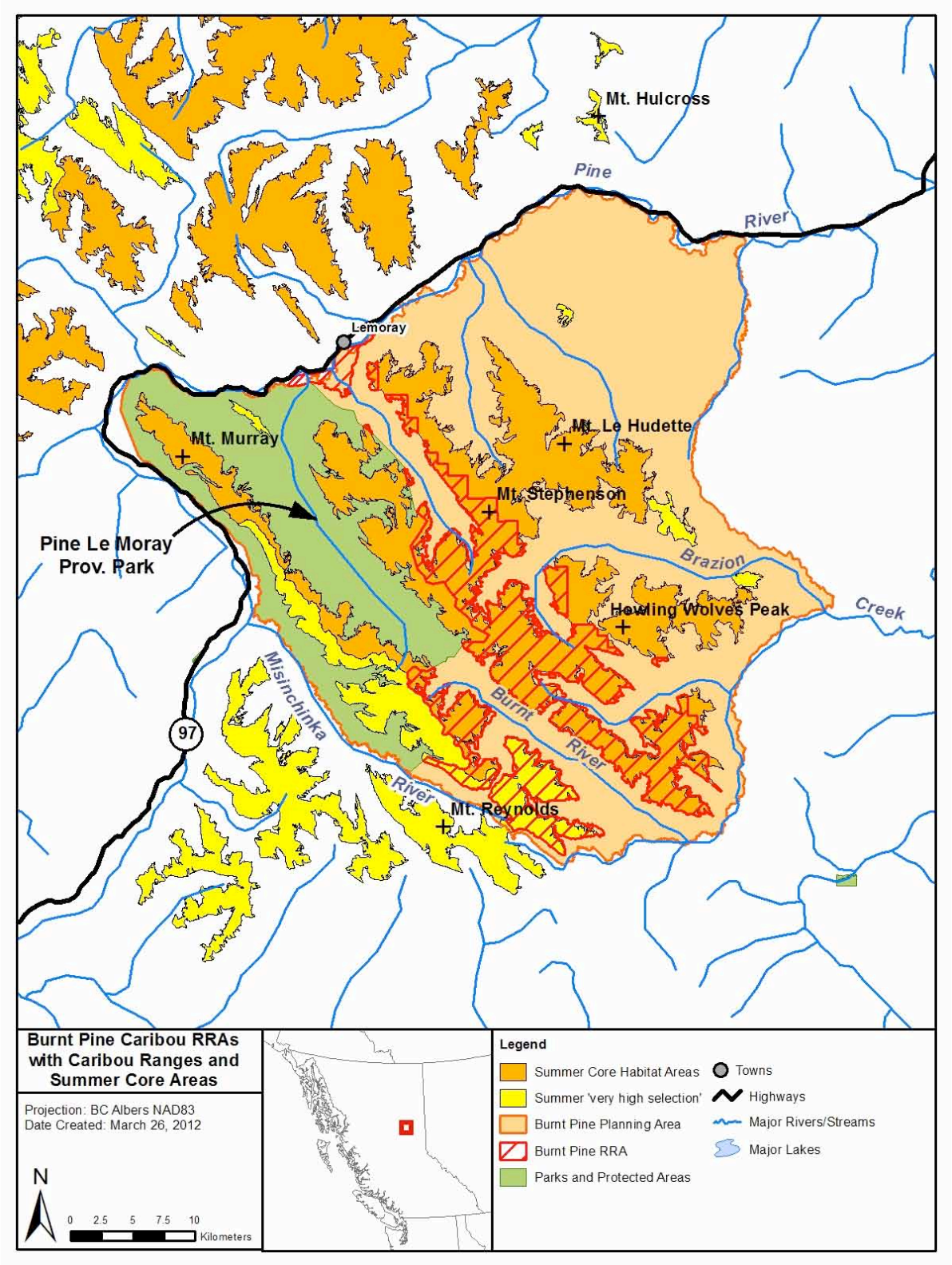

Figure 12. Burnt Pine Caribou Herd Resource Review Area, summer core areas and summer high selectivity habitat.

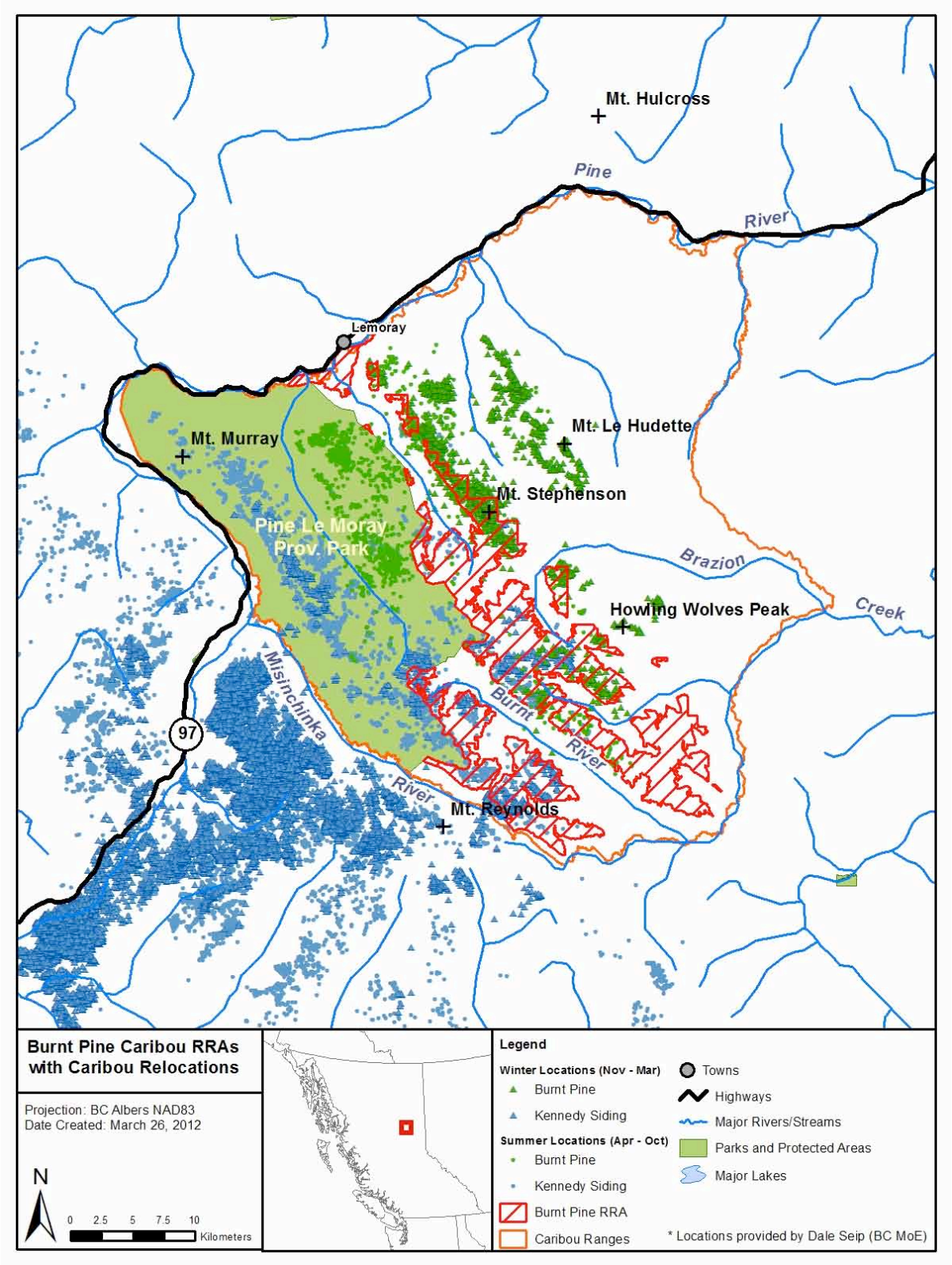

Figure 13. Radio-collared caribou locations in the Burnt Pine Resource Review Area.

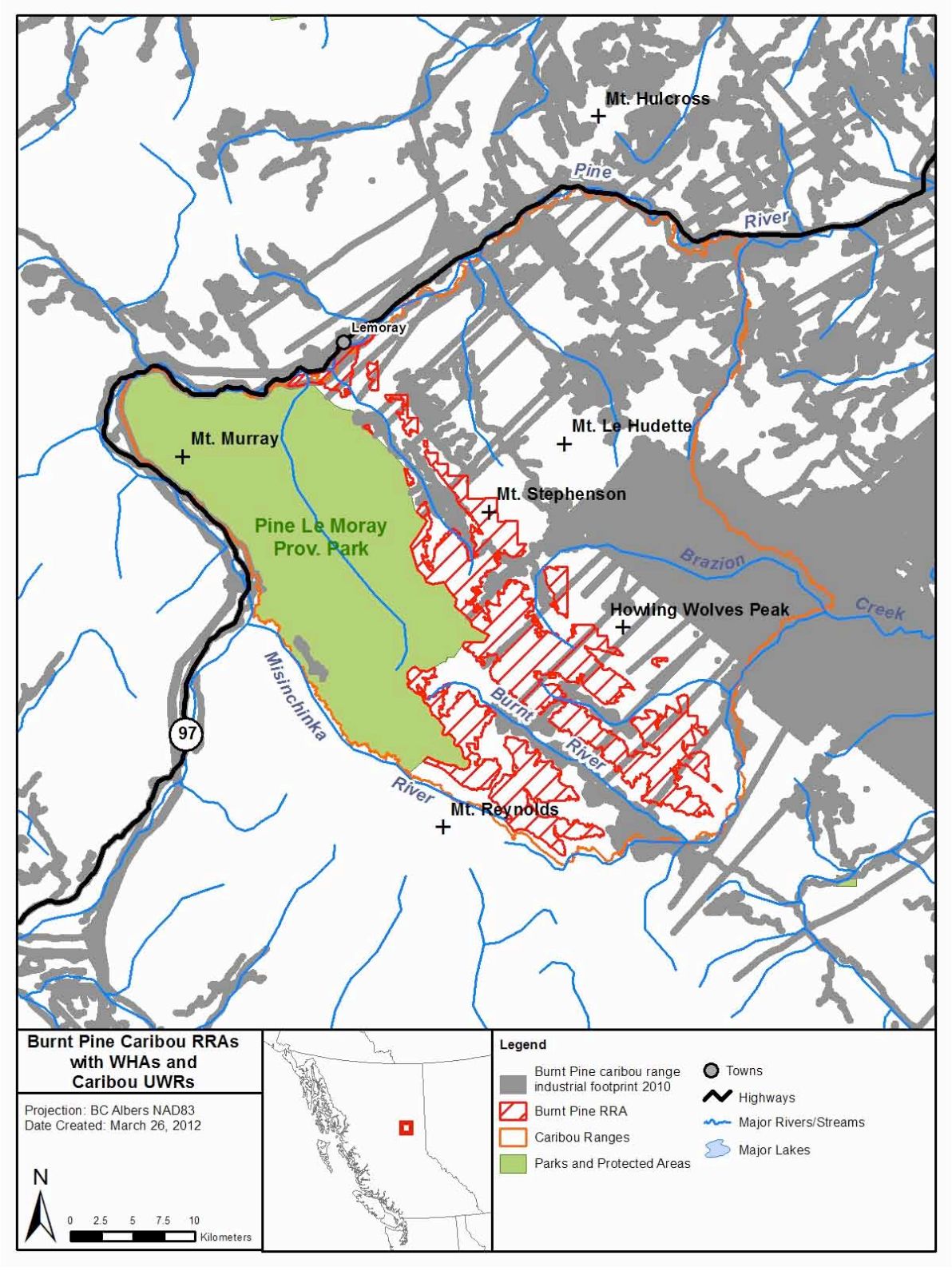

Figure 14. Industrial disturbance with 250 m buffers in the Burnt Pine Caribou Herd Resource Review Area.

2 Literature Review – Performance Measures/Indicators, Targets and Metrics

2.1 Performance Measures/Indicators and Targets

We reviewed caribou recovery or management plans from other areas to identify performance measures/indicators used to monitor effectiveness of those plans. Many plans did not contain indicators/performance measures or did not explicitly state them as such.

Table 4 summarizes performance measures/indicators and targets that were explicitly or implicitly stated in recent caribou plans.

Most indicators/performance measures focused on:

- population parameters:
  - population size;
  - population change;
  - calf recruitment;
  - adult survival;
- range occupancy/population distribution;
- habitat/range:
  - disturbance levels;
  - connectivity;
  - intactness; and,
- predator and other prey populations.

We then reviewed the literature for metrics and methods for monitoring indicators/performance measures found in existing plans (see Section 2.2).

Table 4. Examples of performance indicators and targets from other caribou management plans.

Plan	Indicator type	Indicator[1]	Target
Recovery Strategy for Three Woodland Caribou Herds (*Rangifer tarandus caribou*; Boreal population) in Labrador (Schmelzer et al. 2004)	Population	Ratio of annual recruitment versus total mortality	• ≥1
		Annual adult survival (>1 year)	• ≥0.85 over a 5-year period
		Late winter recruitment	• >15% calves in population
		Parturition rates in early June	• ≥0.85 for adult females >2 years old
		Population size	• stable or showing an increasing trend
The Forest-Dwelling Caribou (*Rangifer tarandus*) Recovery Plan in Quebec – 2005-2012 (Forest-Dwelling Caribou Recovery Team 2008)	Population	Population	• At least 12,000caribou in winter (about 2 caribou/100 km^2)
		Calf recruitment	• >30 calves/100 females or 15% calves
Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*) (Forest-Dwelling, Boreal Population) in Ontario (Ontario Woodland Caribou Recovery Team 2008)	Range	Provincial Range Occupancy	• currently occupied range defined as the present zone of continuous distribution and current use patterns of known local populations
	Population Health	Intrinsic rate of increase	• negative r values do not persist for given populations and are offset by positive values • negative r values occur only in a small proportion of local populations sampled • neutral or positive r values are observed for a large proportion of local populations at the edge of current caribou range
	Connectivity	Animal Movement	• evidence of animal movement among local populations

Plan	Indicator type	Indicator[1]	Target
West Central Alberta Caribou Landscape Plan (West Central Alberta Caribou Landscape Planning Team 2008)	Population	Population size	• South Jasper (150); Little Smoky (150); A La Peche (150); Redrock-Prairie Creek (350); Narraway (100?)
	Wolf management	Wolf density	• 2-6 wolves/1000 km^2
	Alternate prey	Moose density	• <100/1000 km^2 without white-tailed deer
			• <50/1000 km^2 with white-tailed deer
		White-tailed deer density	• to be determined based on inventory or expert opinion
A Proposed Monitoring and Adaptive Management Strategy for Mountain Caribou Recovery Implementation (Wilson and Nyberg 2009)	Population	Population size/trend	• lambda>1, averaged over 3 years or herd at the target population size
		Proportion of calves	• >15% calves, averaged over 3 years
		Adult survival	• >88%, averaged over 3 years
	Distribution	Spatial distribution of mountain caribou detections	• 75% of high suitability winter habitat occupied, based on 1-km buffered detections over 3 years
	Predator Management	Wolf density in and near caribou habitat	• <1.5-6.5 wolves/1000 km^2 depending on planning unit risk
	Recreation	Evidence of displacement of caribou	• no evidence of displacement based on aerial survey or telemetry information
	Prey management	Summer moose density in and near caribou habitat	• <50-300/1000 km^2 depending on planning unit risk
	Habitat management	Km of road-building in caribou habitat/yr	• net decrease in total length of roads in caribou habitat over time (deactivation exceeds new construction, 5-year horizon)

[1] Indicators were not always explicitly stated and therefore were adapted from the text; only indicators with stated targets are included

2.2 Metrics Used to Measure Caribou Population and Range Condition

Indicators for caribou population and range condition generally fell into 4 categories:

- population;
- range occupancy/distribution;
- habitat/range; and,
- predators and alternate prey.

2.2.1 Population Measures

The most common metrics found for evaluating population condition included:

- population size;
- population growth rate;
- calf recruitment; and,
- adult survival/mortality.

Although population size is a desirable population metric to use, it is often the most difficult to obtain. For caribou that live in open areas during at least part of the year, aerial surveys of those open areas provide minimum population sizes based on the number of caribou observed. A sample of marked animals (e.g. radio-collared caribou) can be used in conjunction with total counts to estimate the total population based on the proportion of marked caribou seen during the survey (Wittmer et al. 2005a). However, if the number of marked caribou is low, confidence limits around the estimate are usually wide, making it difficult to assess change in population size between successive surveys.

Caribou in the Burnt Pine Caribou Herd are found primarily at high elevations in alpine and alpine parkland habitat during winter (Jones 2007, 2008). Because a large proportion of the population is visible at high elevations in late winter, minimum population counts are possible, and a number of minimum count surveys have been conducted in late winter for that herd (Seip and Jones 2011). However, these are only minimum counts and the portion of the population that is not visible is not enumerated. Also, the western portion of the winter range is shared with the Kennedy-Siding herd (Jones 2008, Seip and Jones 2011), so a radio-collared caribou sample is needed to discern which population the groups of caribou in the shared area belong to.

Boreal Caribou are notoriously difficult to enumerate (Alberta Sustainable Resource Development and Alberta Conservation Association 2010, Ministry of Environment 2010). One alternative to total population counts for widely distributed species is the stratified random block method, which estimates densities in portions of the survey area, which are then applied to the total survey area to provide a population estimate (Gasaway et al. 1986). Stuart-Smith et al. (1997) conducted a stratified block survey on Boreal Caribou in northeastern Alberta and found that sightability was 40%. A Stratified Random Block count for caribou was conducted in the Maxhamish Range in BC in March 2006 (Rowe 2006) and densities from that survey were applied to all Boreal Caribou ranges to estimate population sizes (Ministry of Environment 2010). Rowe (2006) noted that sightability issues limited the effectiveness of conventional stratified inventory within the Maxhamish Range and that calf recruitment and adult mortality monitoring is likely a more cost-effective method of assessing population status.

Two techniques recently used for potentially improving estimates of population size for Boreal Caribou include: forward looking infrared technology to detect caribou during transect surveys (Carr et al. 2012); and mark-recapture sampling of caribou pellets using DNA analysis (Hettinga 2010, Wasser et al. 2011, Carr et al. 2012). Carr et al. (2012) tested the two techniques and concluded that both provided similar population estimates and that confidence intervals using those two methods were tighter than confidence intervals for a population estimate based on random transect counts. Costs of both techniques were similar but the forward looking infrared technology required specialized equipment and trained observers (Carr et al. 2012). Mark-recapture sampling using fecal DNA worked well when samples were collected during at least 3 sampling session, and potentially could be integrated into already existing monitoring (Hettinga 2010, Carr et al. 2012).

A widely used method for assessing population condition for woodland caribou is calculating rates of population change using calf recruitment and adult survival rates (Hatter and Bergerud 1991, Stuart-Smith et al. 1997, Rettie and Messier 1998, McLoughlin et al. 2003, Wittmer et al. 2005a, Alberta Sustainable Resource Development and Alberta Conservation Association 2010, Latham et al. 2011a, Nagy 2011, DeCesare et al. 2012). Adult survival rates are based on survival of a sample of radio-collared caribou, and calf recruitment is generally based on the proportion of radio-collared female caribou with calves in late winter (calves/100 cows) or the proportion of calves counted during late winter composition surveys. Because adult females can be difficult to distinguish from adult males in late winter in treed habitats, calf

recruitment is sometimes reported as calves/100 adults or % calves rather than calves/100 cows.

Late winter calf recruitment is also used as an indicator of population change if adult mortality rates are not available. A population is considered stable when calves make up 15% of the late winter population (Bergerud 1996) or when late winter calf recruitment is 28.9 calves/100 cows (Environment Canada 2008).

While Wittmer et al. (2005b) found that population trends were significantly correlated with adult female survival, DeCesare et al. (2012) found that adult female survival and recruitment rate were nearly equivalent drivers of population growth and recommended monitoring both adult survival and recruitment rates.

2.2.2 Range Occupancy/Distribution

Range occupancy describes the distribution of caribou within their range. As caribou population size decreases, they occupy less of their range (Bergerud 1996, Schaefer 2003). Alternatively, caribou may focus their use in a portion of their range in response to disturbance in another part of their range (Smith et al. 2000, Courtois et al. 2007, Arsenault and Manseau 2011). Although it may be difficult to determine why the population is occupying less range, both cases indicate less than optimal conditions for caribou.

Distribution can be assessed by aerial surveys (e.g., Nellemann and Cameron 1996, Weir et al. 2007, Bowman et al. 2010), or radio-collared caribou (e.g., Rettie and Messier 1998, Wittmer et al. 2005b, Culling et al. 2006).

2.2.3 Habitat/Range

Habitat and range configuration are important indicators for the ability of a caribou range to support caribou and include:

- amount of high quality habitat;
- disturbance; and,
- undisturbed patch size and connectivity.

High quality habitat

Caribou select habitat in a hierarchical manner; at the coarsest landscape scale the priority of selection is to avoid predation risk (Rettie and Messier 2000, Gustine et al. 2006). Caribou often use habitats or areas within their ranges where overlap with other prey or wolves (*Canis lupus*) is low (Seip 1992, Cumming et al. 1996, James et al. 2004, Courbin et al. 2009, Latham 2009, Bowman et al. 2010, Hebblewhite et al. 2010, Robinson et al. 2012).

Throughout the year, Boreal Caribou select treed black spruce peatlands (bogs) and avoid upland habitat, young habitat and anthropogenic disturbance (Bradshaw et al. 1995, Stuart-Smith et al. 1997, Rettie and Messier 2000, James and Stuart-Smith 2000, Culling et al. 2006, Dyke 2008, DeMars et al. 2011, Nagy 2011). In the Snake-Sahtaneh Range in northeastern BC, Boreal Caribou also select areas of extremely low gradient (0° to 0.6° slope) with the strongest selection shown for sites with less than 0.3° gradient (Culling et al. 2006). Other recent telemetry data from northeastern BC also supports this selection pattern. McLoughlin et al. (2005) suggested that caribou can avoid predation by maximizing selection of peatlands since uplands present caribou with higher than expected levels of predation risk.

In northeastern BC, habitat selection during calving is similar to overall selection, but caribou also select fens (low vegetation habitat class), and wetlands and waterbodies (Culling et al. 2006, DeMars et al. 2011). Site fidelity during calving is greater than during any other season (Faille et al. 2010, Tracz et al. 2010). Winter habitat selection is also similar to overall selection, but caribou also appear to use denser coniferous forest stands during periods of high snow accumulation (Culling et al. 2006). Habitat classes derived from Ducks Unlimited Forest Nelson Earth Cover Classification Landsat TM7 imagery (Ducks Unlimited 2003) proved useful in delineating Boreal Caribou ranges and core habitats, and describing habitat use in northeastern BC (Culling et al. 2004, 2006). Expanded Ducks Unlimited Earth Cover mapping (Ducks Unlimited 2011) has also been used in an ongoing study encompassing several ranges (DeMars et al. 2011).

High quality habitat has been captured in Boreal Caribou ranges and core habitats (Culling et al. 2004, Ministry of Environment 2010). Ranges are defined as broad areas of known historical or current use that supply the resources necessary to support local populations of Boreal Caribou, and core habitats are defined as areas of high current capability and suitability based on general habitat requirements and documented

occurrence. Range and core habitat boundaries were updated in 2010 (Ministry of Environment 2010). Wildlife Habitat Areas and Ungulate Winter Ranges are two tools available under the *Forest and Range Practices Act* and the *Oil and Gas Activities Act* and related regulations that have been used to protect known Boreal Caribou calving and wintering areas respectively. While Wildlife Habitat Areas do not adequately address the Boreal Caribou's need for "space" over the landscape, they do offer a measure of protection at the individual calving site level.

Burnt Pine caribou are found primarily in alpine and subalpine habitat throughout the year (Jones 2007, 2008). Jones (2008) identified core areas and highly selected habitat for both winter and summer. Important known winter ranges have been established as Ungulate Winter Ranges and important known calving areas have been established as Wildlife Habitat Areas under the *Forest and Range Practices Act* and the *Oil and Gas Activities Act* and related regulations.

Level of disturbance

Disturbance on caribou ranges has been linked to:

- reduced range occupancy (Rettie and Messier 1998, Smith et al. 2000, Schaefer 2003, Apps and McLellan 2006, Vors et al. 2007, Wittmer et al. 2007, Courtois et al. 2008, Arsenault and Manseau 2011);
- displacement (Chubbs et al. 1993, Schaefer and Mahoney 2007, Weir et al. 2007);
- reduced spatial separation between caribou and other prey or predators (Latham 2009, Peters 2010, Robinson et al. 2012);
- reduced adult caribou survival (Dunford 2003, Smith 2004, Courtois et al. 2007);
- reduced calf recruitment (McCarthy et al. 2011); and,
- population declines (Schaefer 2003, Vors et al. 2007, Wittmer et al. 2007).

Also, Latham et al. (2011a) suggest that increased numbers of white-tailed deer resulting in increased numbers of predators and consequently higher incidental predation on caribou may be a result of disturbance and/or climate change.

Caribou generally avoid roads and other linear features (James and Stuart-Smith 2000, Dyer et al. 2001, Oberg 2001, Dyke 2008, Fortin et al. 2008, Courbin et al. 2009, Hebblewhite et al. 2010, Leblond et al. 2011,

Nagy 2011, Polfus et al. 2011, Pinard et al. 2012), often despite the availability of preferred habitat (e.g. vegetation types) near those features (Florkiewicz et al. 2003, Cameron et al. 2005, Schindler et al. 2007). They also avoid areas disturbed by forest harvesting (Rettie and Messier 2000, Smith et al. 2000, Schaefer and Mahoney 2007, Courtois et al. 2008, Courbin et al. 2009).

Avoidance distance varies with type of disturbance, size of undisturbed patches and caribou range (Dyer et al. 2001, Florkiewicz et al. 2003, Hebblewhite et al. 2010, Nagy 2011; see summary of disturbance distances in Environment Canada 2011c – Table 49 in Appendix 7.4). In general, caribou distance themselves away from disturbances if they have the opportunity to (Chubbs et al. 1993, Cumming and Hyer 1998, Schaefer and Mahoney 2007, Weir et al. 2007, Nagy 2011). However, in areas with very high densities of disturbance, undisturbed patch sizes may be limited, diminishing the opportunities for caribou to use areas distant to disturbance (Leblond et al. 2011). On very disturbed landscapes, during calving when fidelity to ranges is higher, caribou may need to choose between reducing range fidelity (potentially resulting in lower female and calf survival due to reduced familiarity with escape cover, predation risk and food distribution) or maintaining site fidelity in a landscape where predation risk has increased due to increased disturbance (Faille et al. 2011, Tracz et al. 2011).

For Boreal Caribou, relationships have been developed between population parameters and the degree of disturbance (% disturbance or density of disturbance) within ranges. Negative relationships have been found between:

- population change (lamba) and % habitat within 250 m of industrial disturbance plus % burned in the last 50 years (Sorenson et al. 2008);
- population change (lamba) and linear feature density plus % young habitat (<30 years old, burn + cut) (Boutin and Arienti 2008); and,
- calf recruitment and % habitat within 500 m of industrial disturbance (Environment Canada 2008, 2011c).

Based on those relationships, thresholds have been suggested that indicate the level of disturbance at which caribou populations are likely to decline (Environment Canada 2011c).

Distance to disturbance from caribou locations is another measure frequently used in assessing habitat selection and displacement (Chubbs et al. 1993, James and Stuart-Smith 2000, Florkiewicz et al. 2003, Schaefer and Mahoney 2007, Latham 2009, McNay 2009, DeMars et al. 2011, Leblond et al. 2011, Nagy 2011). The area of avoidance around anthropogenic disturbances has been referred to as the “development

footprint" for industrial activities (Dyer et al. 2001) or the "zone of influence" for all human activities (Florkiewicz et al. 2003, Polfus et al. 2011).

Undisturbed patch size and connectivity

Nagy (2011) cautions against using only % disturbance or density of disturbance to track cumulative effects of industrial development and suggests that the amount and patch configuration of unburned secure habitats remaining within developed areas is a more appropriate measure. Nagy (2011) found a positive relationship between population size and size of "secure" patches (unburned areas greater than 400 m from disturbance) for Boreal Caribou populations in the Northwest Territories. Schneider et al. (2010) suggest that large undisturbed patches may need to be protected to prevent infiltration by predators from surrounding areas.

The distribution and configuration of high quality habitat across the landscape is also an important determinant of range quality for caribou. Boreal Caribou select areas where high quality habitat patches are clustered and well connected (O'Brien et al. 2006). During calving, % Barren Ground Caribou occurrence and density increased as habitat cluster size increased (Nellemann and Cameron 1996). In west-central Alberta, caribou selected winter habitat patches with high area to perimeter ratios (Saher 2005).

Some measures of patch size and configuration include:

- habitat patch size (Rettie and Messier 2000, Wittmer et al. 2007);
- area-weighted patch size (McNay 2009, Arlt and Manseau 2011);
- undisturbed area patch size and distribution (Nagy 2011); and,
- patch area to perimeter ratio (Saher 2005).

In Alberta, the concept of "intactness" has been proposed as an indicator of relatively undisturbed areas (West Central Alberta Caribou Landscape Planning Team 2008, McCutchen et al. 2009). In BC, Apps and McLellan (2006) used the Recreation Opportunity Spectrum classification system as a measure of remoteness.

Connectivity can be measured with the centroid connectivity index (CCE), which uses a combination of patch size and distance between patches (Daust et al. 2003, Mladenoff and DeZonia 2004) or by cluster size distribution where clusters of patches are connected using various buffer distances (Dave Daust, pers. comm.).

2.2.4 Other Species

In northeastern BC, the primary predators of Boreal Caribou are wolves and black bears (*Ursus americanus*; Culling et al. 2006). The interaction between industrial disturbance, numbers of other ungulate species such as moose and white-tailed deer, numbers and hunting efficiency of wolves, and wolf encounter rates with caribou is believed to be the driving force behind Boreal Caribou population declines (McLoughlin et al. 2003, Schneider et al. 2010, Boutin 2010, Festa-Bianchet et al. 2011). While predation is considered the main proximate limiting factor for Boreal Caribou populations, large-scale habitat alterations that affect habitat use and movements of predators and alternate prey ultimately affect caribou populations (Cumming and Hyer 1996, Rettie and Messier, 1998, McLoughlin et al. 2003).

Research from northeastern Alberta in the 1990's indicated that Boreal Caribou spaced themselves away from wolves and moose by using large peatlands (James et al. 2004). However, as industrial development continued, by the mid 2000's, white-tailed deer numbers, wolf numbers and incidental wolf predation on caribou increased and caribou populations started to decline (Latham et al. 2011a). Beaver (*Castor canadensis*) are also an important alternate prey for wolves in Boreal Caribou ranges during summer (Culling et al. 2006, Latham et al. 2011a).

Consequently, distribution and abundance of other species also need to be considered when assessing caribou range condition. The most important species to consider are wolves, bears, moose, white-tailed deer and beaver.

Bergerud and Elliot (1986) suggested that wolf densities exceeding 6.5 wolves/1000 km^2 would result in a decline in caribou populations. Aerial surveys for wolves are difficult in Boreal Caribou habitat (Conrad Thiessen, pers. comm.). In the Snake-Sahtaneh Range, Culling et al. (2006) used radio-telemetry to estimate a minimum wolf density of 6.3 wolves/1000 km^2. Estimating wolf numbers will require the use of radio-telemetry, with a minimum of 3 members collared in each pack. Currently, there are 10 wolves collared in 4 individual wolf packs within 3 Boreal Caribou ranges in northeastern BC, including the Maxhamish (1 pack), Prophet (1 pack) and Snake-Sahtaneh (2 packs; Craig DeMars, pers. comm.).

Bears and caribou generally prefer different habitats (Bastille-Rousseau et al. 2011, Latham et al. 2011b) and bears appear to be an opportunistic predator on caribou (Bastille-Rousseau et al. 2011). However, some

individual bears prefer to forage in peatlands and may contribute to caribou calf mortality (Latham et al. 2011b). In the Snake-Sahtaneh Boreal Caribou Range in northeastern BC, Culling et al. (2006) found that black bears were strongly associated with deciduous-dominated upland and riparian habitats, and early seral plant communities on disturbed sites (cutblocks and linear openings) during the spring calving period. They also found that individual bears made brief forays into adjacent black spruce peatlands. For bears, the most common technique for assessing populations focuses on collecting hair from bears at bait stations and using DNA to distinguish between individuals.

A stratified random block survey technique has typically been used to estimate moose numbers (Gasaway et al. 1986). However, because stratified random block surveys are expensive to conduct, aerial transect surveys can be used to determine relative density estimates to compare densities between areas or between time periods. Aerial transect surveys were used to compare moose and white-tailed deer relative densities in northeastern Alberta between the mid-1990s (James et al. 2004) and the mid 2000s (Latham et al. 2011a). Distance sampling has recently been used to estimate moose populations and is proving to be effective and more efficient than stratified random block surveys (Hebblewhite et al. 2010, Peters 2010, Thiessen 2010). Thiessen (2010) used the distance sampling technique to estimate moose densities in the Horn River basin in northeastern BC. Transects used during the 2010 survey (Thiessen 2010) can be used for subsequent surveys to monitor changes in moose density. Although white-tailed deer numbers are currently low in Boreal Caribou ranges in northeastern BC (Conrad Thiessen, pers. comm.), incidental sightings during the moose distance sampling surveys could potentially be used to assess relative changes in white-tailed deer numbers.

Beavers are also an important prey species in summer for wolves that use Boreal Caribou ranges (Culling et al. 2006, Latham et al. 2011b). Aerial surveys for beavers were conducted in the Parker and Prophet ranges in fall 2011 (Conrad Thiessen, pers. comm.).

2.2.5 Performance Measures for Resource Review Areas

Table 5 lists performance measures recommended for assessing the effectiveness of RRAs in supporting goals and objectives in existing plans for Boreal Caribou and the Burnt Pine Caribou Herd.

Table 5. Recommended performance measures and methods for assessing effectiveness of RRAs.

Performance Measure	Method
Population rate of increase (lambda, λ)	• adult mortality rate based on radio-collared caribou • calf recruitment based on calves with radio-collared caribou cows or calves with all cows observed during late winter recruitment surveys • λ averaged over 2 years (2013/14 and 2014/15)
Adult mortality rate	• based on radio-collared caribou • averaged over 2 years (2013/14 and 2014/15)
Calf recruitment rate	• based on calves with radio-collared caribou cows or calves with all cows observed during late winter recruitment surveys • averaged over 3 years (2012/13, 2013/14 and 2014/15)
% area within 500 m of industrial activities	• Boreal Caribou – use Wilson et al. (2010) disturbance layer and add new features from satellite photos in 2012/13 and 2014/15 • Burnt Pine caribou – update disturbance map from this report by adding new features from satellite photos in 2012/13 and 2014/15
% area in burns <40 years	• build maps from fire disturbance database and satellite photos in 2012/13 • update in 2014/15
Undisturbed patch size distribution	• use methods used by Nagy (2011) • assess in 2012/13 and 2014/15
Connectivity between undisturbed patches	• use centroid connectivity index or cluster size distribution
% area of undisturbed low gradient slope (Boreal Caribou)	• slope classes: 0-0.3°, 0.3-0.6° and >0.6° • calculate based on disturbance layer in 2012/13 and 2014/15
Wolf density	• winter counts using radio-collared wolves to locate packs (3 radio-collared wolves/pack) • averaged over 3 years (2012/13, 2013/14, 2014/15)
Moose density	• distance sampling • averaged over 3 years (2012/13, 2013/14, 2014/15)
White-tailed deer relative density	• incidental observations during moose distance sampling • averaged over 3 years (2012/13, 2013/14, 2014/15)

Performance measures for population condition include population rate of increase, adult mortality rate and calf recruitment rate. Although adult mortality rate and calf recruitment rate are components of the population rate of increase, they are also recommended as performance measures to identify which vital rate is most influencing rate of change. We do not recommend caribou population size as a performance measure because population estimates are difficult to determine and lack sufficient precision to detect small to moderate changes in numbers.

For habitat/range and disturbance, performance measures address both level of disturbance, and characteristics of undisturbed patches. For industrial disturbance, because there have been no studies of disturbance on Boreal Caribou ranges in northeastern BC, we recommend using a 500 m buffer around disturbance to accommodate the variation in disturbance distances in different areas (Environment Canada 2011c: Appendix 7.4). A measure of area burned is also recommended since disturbance from both industrial activities and natural disturbance have been linked to population change (Sorenson et al. 2008). Undisturbed patch size distribution can be used to assess the size and composition of areas beyond the industrial disturbance zone. Areas with larger, well-connected undisturbed patches provide caribou with more opportunities to distance themselves from disturbances and potential increased predation risk. For Boreal Caribou, we also recommend the percent of undisturbed areas consisting of very low gradient slopes (0-0.6°) as an indicator of the extent of preferred habitats (Culling et al. 2006) within undisturbed patches.

Performance measures for other species include wolf density, moose density and white-tailed deer relative density since the interaction between industrial disturbance, numbers of other ungulate species such as moose and white-tailed deer, numbers and hunting efficiency of wolves, and wolf encounter rates with caribou is believed to be the driving force behind Boreal Caribou population declines (McLoughlin et al. 2003, Schneider et al. 2010, Boutin 2010, Festa-Bianchet et al. 2011). Although black bears contribute to both caribou adult and calf mortality, we do not include black bear density as a performance measure since black bear predation rates on caribou are not necessarily related to black bear density. We did not list beaver density as a performance measure but do recommend assessing beaver densities as part of ongoing monitoring since beavers are a significant component of the summer diet of wolves in Boreal Caribou ranges (Culling et al. 2006, Latham et al. 2011b).

3 Boreal Caribou Resource Review Areas Performance Measures and Monitoring Plan

3.1 Performance Measures

Indicators/performance measures discussed in Section 2 can be used to evaluate effectiveness of RRAs in contributing to the objectives and goals of the Boreal Caribou Implementation Plan. Because the role of RRAs is to provide conditions that are more favourable for caribou persistence than conditions that exist outside RRAs, performance measures will need to evaluate conditions both within and outside RRAs.

For Boreal Caribou, effectiveness of RRAs will be assessed at 3 levels of spatial resolution:

- RRA;
- Boreal Caribou range; and,
- Boreal Caribou population and distribution.

Because a stable population is not one of the goals of the Implementation Plan, we cannot use a performance measure based on relationships previously developed between vital rates and levels of disturbance and associated thresholds for self-sustaining populations (Sorenson et al. 2008, Environment Canada 2008, 2011c). Instead, we base performance measures on the following questions used to evaluate effectiveness of RRAs at three spatial scales.

1. Do the RRAs contain appropriate conditions for caribou?
2. Are caribou in RRAs better off than caribou outside of RRAs?
3. Are caribou in ranges with RRAs better off than caribou in ranges without RRAs?

Performance measures at the RRA level focus on range conditions (habitat and disturbance) while performance measures at the range and Boreal Caribou population levels include both range conditions (disturbance, predator abundance, alternate prey abundance) and caribou population condition. A monitoring program to assess performance measures is provided in Section 3.2.

3.1.1 Resource Review Area Level

Do the RRAs contain appropriate conditions for caribou?

At the RRA level, available baseline information (see Table 2) indicates that high value Boreal Caribou habitat, defined as extremely low slope gradients (0° to 0.6° slope), is available in all four RRAs. Although the Chinchaga RRA does not contain any core habitats, designated areas (Wildlife Habitat Areas, Ungulate Winter Ranges) or caribou locations, presence of extremely low slope gradients suggests that the RRA contains suitable caribou habitat.

Performance measures at the RRA level for the next 3 years focus on no increase in the industrial disturbance zone within RRAs (Table 6). These performance measures account for the influence of activities in the areas adjacent to the RRA boundaries as well as within the RRA. Although no new oil and gas tenures are permitted within the RRAs, access to reach existing tenures embedded within the RRAs may need to be considered. In those situations, using existing disturbance features as much as possible, and avoiding fragmenting larger undisturbed patches will help meet targets.

Table 6. Performance measures for Boreal Caribou RRAs at the RRA level.

Performance Measure	Target
% RRA within 500 m of industrial activities	No increase between 2012 and 2015
% RRA in burned area <40 years	No increase between 2012 and 2015
Undisturbed patch size distribution	No increase in smaller patch sizes or decrease in larger patch sizes between 2012 and 2015
Connectivity between undisturbed patches	No decrease between 2012 and 2015
% of low gradient slope (0° to 0.6° slope) in the undisturbed zone	No decrease between 2012 and 2015

The lack of radio-collared caribou locations in the Chinchaga RRA and in portions of the Calendar RRAs likely reflects a lack of animals collared in those portions of those ranges and identifies an important knowledge gap that needs to be filled. In addition to tracking performance

measures, the proportion of locations in RRAs of each caribou collared in an RRA should be tracked to assess how much time caribou that are known to use RRAs, spend time in them.

3.1.2 Boreal Caribou Range Level

Are caribou in RRAs better off than caribou outside RRAs?

To evaluate effectiveness of RRAs at the Boreal Caribou range level, a suite of performance measures that address caribou population trends, disturbance, and other species need to be considered (Table 7). Adult caribou mortality rate and calf recruitment rate are components of the population rate of increase (λ), but are also useful to consider independently to assist in determining how each vital rate contributes to population changes.

Table 7. Performance measures for Boreal Caribou RRAs at the range level.

Performance Measure	**Target**
Caribou Population rate of increase (lambda, λ)[1]	$\lambda_{RRA} > \lambda_{Outside\ RRA}$
Caribou mortality rate[1]	$Mortality\ rate_{RRA} < Mortality\ rate_{Outside\ RRA}$
Caribou calf recruitment[1]	$Calf\ recruitment_{RRA} > Calf\ reruitment_{Outside\ RRA}$
Wolf density	$Wolf\ density_{RRA} < Wolf\ density_{Outside\ RRA}$
Moose density	$Moose\ density_{RRA} < Moose\ density_{Outside\ RRA}$
White-tailed deer relative density	White-tailed deer relative $density_{RRA}$ < White-tailed deer relative $density_{Outside\ RRA}$
% area within 500 m of industrial activities	$\%\ disturbance_{RRA} < \%\ disturbance_{Outside\ RRA}$
% area in burned area <40 years	$\%\ burned_{RRA} < \%\ burned_{Outside\ RRA}$
Undisturbed patch size distribution	% of larger undisturbed $patches_{RRA}$ > % of larger undisturbed $patches_{Outside\ RRA}$
Connectivity between undisturbed patches	$Connectivity_{RRA} > Connectivity_{Outside\ RRA}$

[1] these measures will be used if it can be determined that they are not confounded by caribou using areas outside of the intended unit (e.g. inside vs. outside RRA)

Although wolf predation is a primary proximate limiting factor for caribou populations (Seip 1992, Bergerud 1996, McLoughlin et al. 2003), wolf densities are influenced by a number of species including moose and white-tailed deer (Latham et al. 2011b). In northeastern BC, beaver is also an important component of wolf summer diet (Culling et al. 2006). Increases in beaver and white-tailed deer have both contributed to increased wolf densities in northeastern Alberta (Latham et al. 2011b). Tracking wolf and alternate prey densities will help identify mechanisms of caribou population change and will ultimately contribute to more informed management efforts. Although beaver density is not listed as a performance measure, beaver density should also be assessed since beavers contribute significantly to the wolf summer diet.

Performance measures for disturbance are based on levels of disturbance and size of undisturbed area.

Targets for performance measures for RRAs at the range scale are based on performance measure levels in RRAs compared to levels within the same range but outside the RRA. When assessing caribou population performance measures in RRAs versus areas outside of RRAs, the amount of time that RRA caribou spend outside the RRA will need to be addressed to determine if their fates are influenced by conditions outside the RRA boundaries.

In addition to adult mortality rates, causes of adult mortality should also be determined to assess the relative contribution of different mortality factors to overall caribou mortality. Also, the shape of each RRA (e.g. areas to perimeter ratio) should be assessed.

3.1.3 Boreal Caribou Population Level

Are caribou in ranges with RRAs better off than caribou in ranges without RRAs?

The suite of performance measures at the range level are also relevant at the Boreal Caribou Population level (Table 8). However, targets are based on performance measure levels in ranges with RRAs versus ranges without RRAs. Because performance measures addressing whole ranges will be influenced by the degree of disturbance in each range, each performance measure must be weighted by the amount of disturbance in the range.

Table 8. Performance measures for Boreal Caribou RRAs at the Boreal Caribou Population level.

Performance Measure	**Target**
Caribou Population rate of increase (lambda, λ) (weighted by level of disturbance in range)	$\lambda_{Calendar}$, $\lambda_{Chinchaga}$, $\lambda_{Prophet}$, **>** λ_{Parker}, $\lambda_{Maxhamish}$, $\lambda_{Snake\text{-}Sahtaneh}$
Caribou mortality rate (weighted by level of disturbance in range)	Mortality rate$_{Calendar}$, Mortality rate$_{Chinchaga}$, Mortality rate$_{Prophet}$, **<** Mortality rate$_{Parker}$, Mortality rate$_{Maxhamish}$, Mortality rate$_{Snake\text{-}Sahtaneh}$
Caribou calf recruitment (weighted by level of disturbance in range)	Calf recruitment$_{Calendar}$, Calf recruitment$_{Chinchaga}$, Calf recruitment$_{Prophet}$, **>** Calf recruitment$_{Parker}$, Calf recruitment$_{Maxhamish}$, Calf recruitment$_{Snake\text{-}Sahtaneh}$,
Wolf density (weighted by level of disturbance in range)	Wolf density$_{Calendar}$, Wolf density$_{Chinchaga}$, Wolf density$_{Prophet}$, **<** Wolf density$_{Parker}$, Wolf density$_{Maxhamish}$, Wolf density$_{Snake\text{-}Sahtaneh}$
Moose density (weighted by level of disturbance in range)	Moose density$_{Calendar}$, Moose density$_{Chinchaga}$, Moose density$_{Prophet}$, **<** Moose density$_{Parker}$, Moose density$_{Maxhamish}$, Moose density$_{Snake\text{-}Sahtaneh}$
White-tailed deer density (weighted by level of disturbance in range)	White-tailed deer density$_{Calendar}$, White-tailed deer density$_{Chinchaga}$, White-tailed deer density$_{Prophet}$, **<** White-tailed deer density$_{Parker}$, White-tailed deer density$_{Maxhamish}$, White-tailed deer density$_{Snake\text{-}Sahtaneh}$
% range within 500 m of industrial activities	% disturbed$_{Calendar}$, % disturbed$_{Chinchaga}$, % disturbed$_{Prophet}$, **<** % disturbed$_{Parker}$, % disturbed$_{Maxhamish}$, % disturbed$_{Snake\text{-}Sahtaneh}$
% range in burned area <40 years	% burned$_{Calendar}$, % burned$_{Chinchaga}$, % burned$_{Prophet}$, **<** % burned$_{Parker}$, % burned$_{Maxhamish}$, % burned$_{Snake\text{-}Sahtaneh}$
Undisturbed patch size distribution	% of larger undisturbed patches $_{Calendar}$, % of larger undisturbed patches$_{Chinchaga}$, % of larger undisturbed patches $_{Prophet}$, **<** % of larger undisturbed patches $_{Parker}$, % of larger undisturbed patches $_{Maxhamish}$, % of larger undisturbed patches $_{Snake\text{-}Sahtaneh}$
Connectivity between undisturbed patches	Connectivity $_{Calendar}$, Connectivity$_{Chinchaga}$, Connectivity$_{Prophet}$, **>** Connectivity$_{Parker}$, Connectivity $_{Maxhamish}$, Connectivity $_{Snake\text{-}Sahtaneh}$

3.2 Monitoring Program

RRAs were established in June 2010 with a 5 year window for evaluating their effectiveness. Therefore, monitoring and analysis must be completed in the next 3 years. Table 9 summarizes the monitoring program schedule from 2012 to 2015.

Table 9. Boreal Caribou RRA monitoring plan activity schedule.

Activity	April – March			April – June
	2012/13	2013/14	2014/15	2015
Baseline GIS work	Collect data			
GIS/map indicators	Collect data		Collect data	Analyze/ assess effectiveness
Caribou Radio-collars[1]	Initial captures	Supplement as needed	Supplement as needed	
Radio-collars - Habitat use /movements etc.	Collect data – winter	Collect data – all year	Collect data – all year	Analyze/ assess effectiveness
Calf recruitment	Collect data	Collect data	Collect data	Analyze/ assess effectiveness
Adult mortality		Collect data	Collect data	Analyze/ assess effectiveness
Adult mortality causes		Collect data	Collect data	Analyze
Wolf density	Collect data	Collect data	Collect data	Analyze/ assess effectiveness
Moose density; white-tailed deer relative density	Collect data	Collect data	Collect data	Analyze/ assess effectiveness
Beaver density	Collect data	Collect data	Collect data	Analyze

[1] Planning for the radio-collaring program should start as soon as possible (ordering collars, acquiring permits, etc.) to avoid delays to the 2012 capture work. Orders to radio-collar manufacturers should be placed no later than August and all required permits should be in place before mid October.

GIS-based monitoring of disturbances can begin right away, while augmenting the existing sample of radio-collared caribou can start in late fall/early winter. Caribou population rate of increase and adult mortality rate can only be assessed for 2 years (2013/14 and 2014/15) because the next opportunity to deploy radio-collars is not until late fall 2012/13. Calf recruitment rate can be assessed during all three years since calf recruitment surveys are conducted in late winter. Effectiveness of RRAs will be assessed in 2015. The assessment will include recommendations on the future status of each RRA and potential boundary adjustments.

The monitoring program includes maintaining a sample of 20 radio-collared caribou in each of the following monitoring units: RRAs (4); non-RRA portions of ranges with RRAs (2); and, ranges without RRAs (3) to support collection of calf recruitment, adult mortality and population rate of increase performance measures. A total of 9 monitoring units are recommended (Table 10). The main difference between strategies in the 9 units are the presence or absence of an RRA. The Boreal Caribou Implementation Plan also calls for restoration activities in some of the units, but the effects of restoration will not be realized until after this initial monitoring period is completed.

Table 10. Boreal Caribou monitoring units and associated plan strategies, and radio-collars required.

Range	Unit	Plan Strategies[1]		# Radio-collars		
				Current		Target
		RRA	Restore	VHF[2]	Iridium[3]	
Chinchaga	RRA	X	X			20
	Non- RRA			2		20
Maxhamish	Non-RRA			10	9	20
Calendar	RRA1	X		1		20
	RRA2					20
	Non-RRA					20
Snake-Sahtaneh	Non-RRA		X	5	4	20
Prophet	RRA	X	X		6	20
Parker	Non-RRA		X		5	20

[1] Other plan strategies are applied across all ranges and include mitigation (predator control, fire suppression) and managing the development footprint.

[2] A flight should be conducted to reassess status of VHF radio-collared caribou (alive, dead, collar malfunction).

[3] All existing Iridium collars are currently scheduled to be removed in July 2013.

In ranges without RRAs (Maxhamish, Snake-Sahtaneh, Parker), sampling effort should be focused in core habitats, which contain the highest capability Boreal Caribou habitat in those ranges.

Radio-collars should be satellite linked (Iridium) to track status of animals (alive/dead) in real time, allowing a precise determination of timing of mortality and a quick response time for assessing mortality causes, and to augment existing telemetry data to support future range and core habitat refinement. All currently deployed Iridium collars are scheduled to be removed in July 2013 (Craig DeMars, pers. comm.) and therefore will not contribute to a full year of adult mortality and calf recruitment monitoring in 2013/14. Consequently, the monitoring program will require 180 new collars to be placed on Boreal Caribou in 2012. If possible, those collars should be programmed to last until the end of March 2015 to avoid having to replace collars in 2014/15. Additional collars and capture work will be required in 2013/14 and 2014/15 to increase the radio-collared caribou sample back to 20 to compensate for mortalities and collar malfunctions. The VHF collar sample should be included in calf recruitment and adult mortality monitoring in addition to the Iridium sample.

3.3 Other Strategies

RRAs are only one component of a suite of strategies recommended in the Boreal Caribou Implementation Plan. Predator reduction is one of the other strategies proposed for implementation across all six Boreal Caribou ranges. Although reduction of predators is to be applied consistently between RRAs and areas outside of RRAs in each range, and across all six ranges, it is more likely to result in relatively inconsistent application. Therefore, to aid in assessing the effectiveness of RRAs, predator reduction efforts will need to be taken into account as a co-variant.

3.4 Future Conditions

The monitoring program recommended in this report is restricted to the three-year window still remaining before the effectiveness of RRAs has to be assessed. Because the monitoring program only measures current conditions, it does not address effectiveness of the RRAs under future conditions. As more of the landscape is disturbed by development, the

relative contribution of the RRAs to sustaining Boreal Caribou will likely increase as long as RRAs contain adequate conditions for Boreal Caribou to persist.

When assessing the effectiveness of RRAs at the end of the 5 year evaluation period, the future effectiveness of RRAs should also be considered. Information collected during the initial 5 year monitoring period should be used to predict effectiveness of RRAs in the future relative to areas outside of RRAs.

4 Burnt Pine Caribou Resource Review Area Performance Measures and Monitoring Plan

The Burnt Pine Caribou Herd Resource Review Area is located in the western half of the Burnt Pine Caribou Range. The most important wintering areas for the herd are located at high elevations in the Mt. Le Hudette and Mt. Stephenson areas, and key calving and summer ranges are located in Pine-LeMoray Park (Jones 2007, 2008, D. Seip, pers. comm., see also Section 1.2). The northern strip of the RRA includes a portion of the high elevation range on Mt. Stephenson, but although most of the rest of the RRA shows some use by Burnt Pine caribou (see Figure 13), the majority of use in the southern part of the RRA is by the Kennedy-Siding caribou herd (Jones 2007, 2008, Seip and Jones 2011).

Unlike the Boreal Caribou situation where a lack of locations in RRAs may reflect a lack of sampling rather than a lack of use, radio-collared caribou in the Burnt Pine Caribou Herd have been monitored since 2002 (Jones 2007, 2008, Seip and Jones 2011) and important high use areas have been identified.

4.1 Performance Measures

Although both management plans set a goal to increase the Burnt Pine Caribou Herd to more than 50 animals, in 2011, only 5 caribou were seen during a population survey (Seip and Jones 2011). Furthermore, during the most recent survey in March 2012, only one caribou was seen (D. Seip, pers. comm.).

Due to the apparent lack of caribou in the Burnt Pine Caribou Herd, we focused performance measures for the Burnt Pine RRA only on habitat/range condition (Table 11). We recommend assessing range conditions within the RRA and also specifically within the Mt. Stephenson portion of the RRA where the majority of use by the Burnt Pine Caribou Herd has occurred.

Table 11. Performance measures for the Burnt Pine Caribou Herd RRA.

Performance Measure	Target
% RRA within 500 m of industrial activities	No increase between 2012 and 2015
Undisturbed patch size distribution in the RRA	No increase in smaller patch sizes or decrease in larger patch sizes between 2012 and 2015
Connectivity between undisturbed patches	No decrease in connectivity
% RRA in the Mt. Stephenson area within 500 m of industrial activities	No increase between 2012 and 2015
Undisturbed patch size distribution in the Mt. Stephenson portion of the RRA	No increase in smaller patch sizes or decrease in larger patch sizes between 2012 and 2015

Although the current contribution of the RRA to the population goal for the Burnt Pine Caribou Herd may not be possible to assess at this point in time, the contribution of the RRA to the population goal for the Kennedy-Siding caribou herd are possible and should be considered. One potential mechanism for recovering caribou in the Burnt Pine area may be to provide conditions that will allow the Kennedy-Siding herd to increase and expand into the Burnt Pine Caribou Range (D. Seip, pers. comm.). Therefore, range conditions in both the Kennedy-Siding and Burnt Pine caribou ranges, and range use by both the Kennedy-Siding and Burnt Pine caribou populations should be monitored.

One portion of the Burnt Pine RRA that does not contain caribou habitat is the northwestern most block that is located at low elevation adjacent to Highway 97. That block does not appear to contribute any current value to either the Burnt Pine or Kennedy-Siding caribou ranges (D Seip, pers. comm.).

4.2 Monitoring Plan

Performance measures for range conditions identified in Table 11 should be assessed in 2012 and in 2015.

In addition, caribou that use the Mt. Stephenson area and the rest of the RRA should be monitored regardless of which herd they belong to.

Surveys of the RRA (and non-RRA portion of the Mt. Stephenson area) should be conducted monthly from December to March each year and caribou found in the RRA should be radio-collared. In early winter, Kennedy-Siding caribou use low elevation pine forests in their range (Jones 2007) so any caribou using the Mt. Stephenson area at that time are likely to be Burnt Pine caribou. As winter progresses, Kennedy-Siding caribou move to higher elevations (Jones 2007) so caribou present in the Mt. Stephenson area during late winter could be either Kennedy-Siding or Burnt Pine caribou.

4.3 Future Conditions

As recovery of the Burnt Pine Caribou Herd progresses, performance measures for population condition similar to those recommended for Boreal Caribou RRAs should be included.

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