15th North American Caribou Workshop
Whitehorse, Canada
12-16 May, 2014

Conservation status of caribou in the western mountains of Canada: Protections under the Species At Risk Act, 2002-2014

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Abstract: In April 2014, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reviewed the status of caribou in the western mountains of Canada, in keeping with the ten-year reassessment mandate under the Species at Risk Act. Assessed as two 'nationally significant' populations in 2002, COSEWIC revised the conservation units for all caribou in Canada, recognising eleven extant Designatable Units (DUs), three of which -- Northern Mountain, Central Mountain, and Southern Mountain -- are found only in western Canada. The 2014 assessment concluded that the condition of many subpopulations in all three DUs had deteriorated. As a result of small and declining population sizes, the Central Mountain and Southern Mountain DUs are now recognised as endangered. Recent declines in a number of Northern Mountain DU subpopulations did not meet thresholds for endangered or threatened, and were assessed as of special concern. Since the passage of the federal Species at Risk Act in 2002, considerable areas of habitat have been managed or conserved for caribou, although disturbance from cumulative human development activities has increased during the same period. Government agencies and local First Nations are attempting to arrest the steep decline of some subpopulations by using predator control, maternal penning, population augmentation, and captive breeding. Based on declines, future developments and current recovery effects, we offer the following recommendations: 1) where recovery actions are necessary, commit to simultaneously reducing human intrusion into caribou ranges, restoring habitat over the long term, and conducting short-term predator control, 2) carefully consider COSEWIC's new DU structure for management and recovery actions, especially regarding translocations, 3) carry out regular surveys to monitor the condition of Northern Mountain caribou subpopulations and immediately implement preventative measures where necessary, and 4) undertake a proactive, planned approach coordinated across jurisdictions to conserve landscape processes important to caribou conservation.

Key words: Central Mountain; COSEWIC; Designatable Units; Northern Mountain; *Rangifer tarandus*; Southern Mountain; Species At Risk Act.

Rangifer, 35, Special Issue No. 23, 2015: 49-80
DOI 10.7557/2.35.2.3647

Introduction

When Canada's Species At Risk Act (SARA) came into force in 2003, the legal list (SARA, 2002) comprised 233 wildlife species (as defined under the Act) in Schedule 1. Among these were Woodland Caribou (*Rangifer tarandus caribou*) residing in the western mountains of Canada, which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) considered as two "nationally significant" Southern Mountain and Northern Mountain populations (COSEWIC, 2002). Ranging from southern British Columbia and Alberta to Yukon and the Northwest Territories, caribou historically had a relatively widespread distribution and occurred in large (>1,000 individuals) subpopulations (Spalding, 2000). By 2000, about 30% of their early 1900s range was no longer occupied (Figure 1; Spalding, 2000; Dzus, 2001). In 2002, COSEWIC assessed the Southern Mountain population as threatened and the Northern Mountain population as of special concern (COSEWIC, 2002) and they were listed on the SARA registry the next year (Government of Canada, 2014). Subpopulations comprising the Southern Mountain population were generally small in size, increasingly isolated from one another, and subject to threats, with the majority in decline (COSEWIC, 2002). Although numbers of Northern Mountain caribou appeared to be stable, forestry, roads, gas, and other developments were beginning to affect some subpopulations through habitat modification and increasing human access (COSEWIC, 2002).

Various recovery planning and actions directed at these populations since listing under SARA have been undertaken by provinces and territories. For example, both Alberta and British Columbia have released strategic recovery documents that suggest a variety of different actions aimed at recovering subpopulations in southern and central portions of the provinces (e.g., MCTAC, 2002; Alberta Woodland Caribou Recovery Team, 2005; ASRD & ACA, 2010; Parks Canada, 2011a; Mountain Caribou Recovery Implementation Plan Progress Board, 2012). In the past decade, management plans or recommendations have also been developed for individual subpopulations or subpopulation groups (e.g., Chisana Caribou Herd Working Group, 2012; BC Ministry of Environment, 2013). Under SARA, a Management Plan for caribou in the Northern Mountain population (Environment Canada, 2012), and a Recovery Strategy for the Southern Mountain population (Environment Canada, 2014) were both released. Targeted measures, including habitat and population management and protection, have also been implemented under the authority of various provincial legislation and policies (COSEWIC, 2014a).

First created in 1977, COSEWIC was formally established under SARA (SARA, 2002, s. 14), with the functions of conducting assessments, reassessments, and classifications of species at risk "on the basis of the best available information on the biological status of a species, including scientific knowledge, community knowledge and aboriginal traditional knowledge" (SARA, 2002, s. 15). For each species, relevant information is assembled in a status report, which is subjected to an extensive expert review process (COSEWIC, 2011b). Each species is assessed according to criteria based on the IUCN Red List system to measure the likelihood of species going extinct under prevailing circumstances (Mace *et al.,* 2008). Under SARA, the government of Canada considers COSEWIC's designations within designated timeframes when establishing the legal list of wildlife species at risk (COSEWIC, 2014b).

In April 2014, COSEWIC reviewed the conservation status of caribou in the western mountains of Canada (COSEWIC, 2014a), in keeping with the 10-year reassessment mandate under SARA (SARA, 2002, s. 24). This reassessment benefited from an acceleration

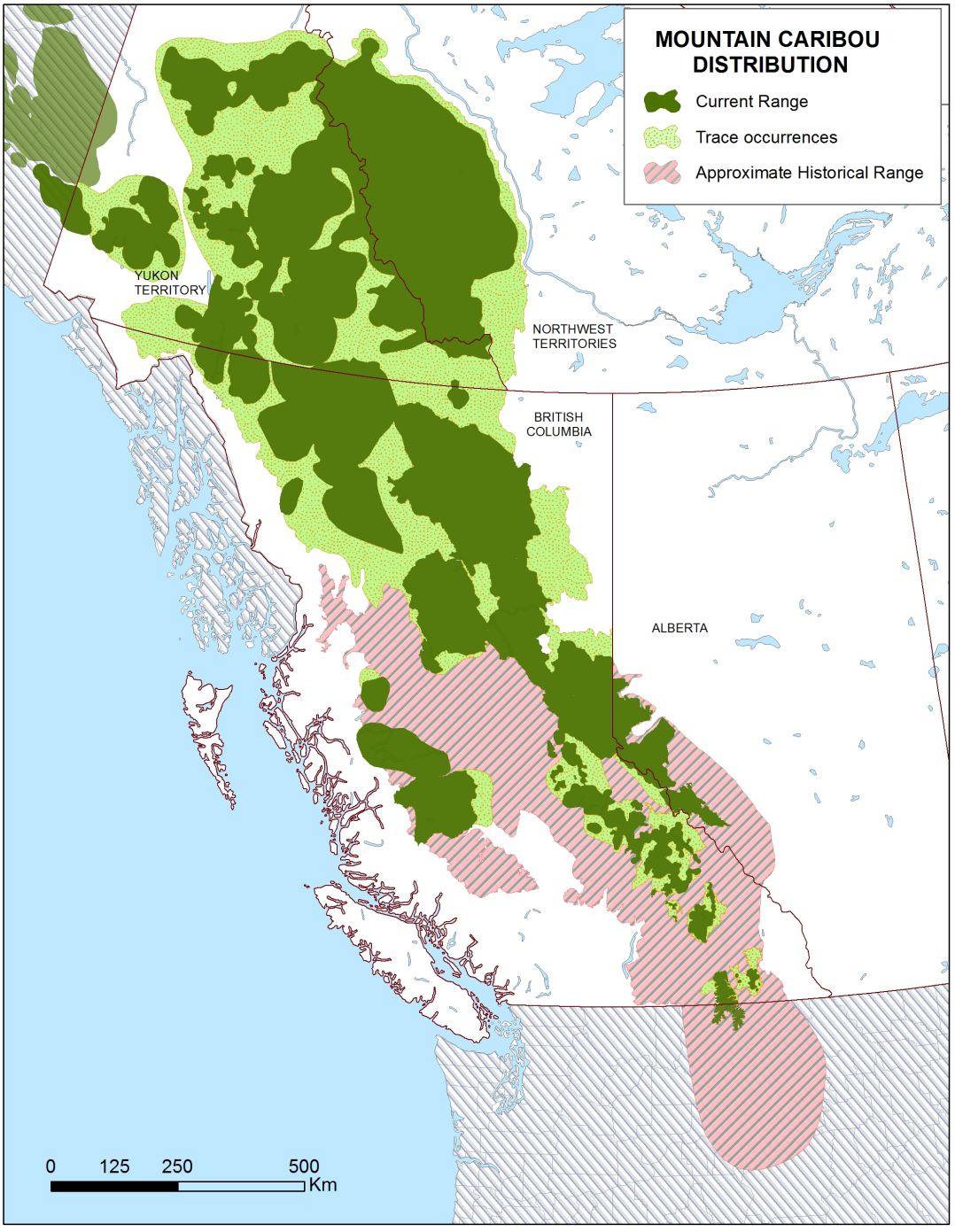

Figure 1. Approximate historic and current ranges of caribou in the mountain DUs of western Canada (from COSEWIC 2014a). Map created by Bonnie Fournier (Environment and Natural Resources, Government of the Northwest Territories, 2013).

of research and monitoring over the past decade that yielded new information on population trends and further insights into threats. Moreover, it took advantage of the recognition of new conservation units for *Rangifer* found across Canada, a special project undertaken by COSEWIC to define discrete and evolutionarily unique "Designatable Units" (COSEWIC, 2011a) for caribou throughout the country. This work used available information to derive conservation units of the species to orient future COSEWIC status assessments and reassessments, thereby addressing widely accepted deficiencies in the current taxonomy (see the 'Classification of Caribou' below). Aboriginal knowledge was also collected and summarized from First Nations and Métis sources by the COSEWIC Aboriginal Traditional Knowledge (ATK) Subcommittee (COSEWIC, 2014a).

The recent reassessment of caribou in the western mountains of Canada provided an opportunity to evaluate how subpopulations comprising these newly recognised Designatable Units have fared since the implementation of SARA just over a decade ago. Our objectives here are to review: 1) the Designatable Unit structure for western mountain caribou in Canada, 2) the 2014 COSEWIC assessments of these units, including population numbers and trends that served as their basis, and 3) the recovery and management actions planned and implemented to date. We conclude with a forward-looking perspective on the conservation outlook for these populations.

Taxonomy and conservation units of western mountain caribou

Prevailing taxonomy (Banfield, 1961) recognizes four native extant and one extinct caribou subspecies in North America, based primarily on skull measurements and pelage, but also antler shape and hoof shape. It is widely considered to be outdated and insufficient for capturing the variability of caribou across their range in Canada (Geist, 2007; Gunn, 2009; Couturier *et al.,* 2009; COSEWIC, 2011a), but is still the most commonly used taxonomy because some aspects do appear to have validity and no alternative has been identified in a systematic manner (COSEWIC, 2011a). Previous COSEWIC evaluations used Banfield's (1961) subspecies as the basis for assessment. Caribou in western mountain regions of North America were included in woodland subspecies, but the nationally significant populations (Northern Mountain and Southern Mountain) were further divided into two western mountain caribou ecotypes based on COSEWIC's National Ecological Areas with the same names (COSEWIC, 2002).

The widely-recognized shortcomings of caribou taxonomy have triggered a reliance on ecotypes, based on behaviour and ecology, for conservation and management purposes. In a broad sense, woodland caribou in North America are informally recognised as 'mountain' or 'boreal' with the designation distinguishing between those subpopulations that exhibit seasonal or annual use of mountainous terrain vs. lowland boreal habitats (Festa-Bianchet *et al.,* 2011). In western Canada, this nomenclature largely coincides with the COSEWIC Southern, Central, and Northern Mountain DUs (mountain caribou) considered here, and the Boreal DU (boreal caribou). Caribou subpopulations in BC are classified by the Province into three formally-designated ecotypes according to behaviour and habitat use, with mountain subpopulations belonging to 'Northern' or 'Mountain', and the remainder as 'Boreal' (Government of British Columbia, 2014). The BC Northern ecotype corresponds with the Northern and Central Mountain DUs and the Mountain with the Southern Mountain DU (Stevenson & Hatler, 1985; Heard & Vagt, 1998). Similarly, 'mountain' caribou in Alberta are distinguished from their 'boreal' counterparts by feeding primarily on terrestrial lichens

and spend at least part of their annual cycle in the mountains (ASRD & ACA, 2010).

COSEWIC Designatable Units

SARA recognizes that entities below the species level require conservation, and provides COSEWIC with the mandate to assess them (SARA, 2002, s. 15). Accordingly, COSEWIC's DU concept (formalized in 2009) acknowledges that there are spatially, ecologically, or genetically discrete and evolutionarily significant units that are irreplaceable components of biodiversity (COSEWIC, 2011c). Discreteness may refer to distinctiveness in genetic characteristics or inherited traits, habitat discontinuity, or ecological isolation. Significance is also included in the definition of DU as a reflection of the opinion that isolation alone is insufficient for designation. Evolutionary significance may apply when there is: 1) deep phylogenetic divergence (e.g., glacial races), 2) evidence that the population persists in a unique ecological setting that has likely given rise to local adaptations, especially those related to fitness, or 3) where there is only one natural surviving occurrence in a particular ecological setting.

In previous COSEWIC assessments (COSEWIC, 2002; 2004) prior to the passage of SARA and use of Designatable Units, caribou in Canada were organized into eight "Nationally Significant Populations", not including the barren-ground subpopulations, which have not been assessed (Festa-Bianchet *et al.,* 2011; COSEWIC, 2011a). In preparation for national-scale assessments and reassessments of this wildlife species initiated in 2012, COSEWIC undertook a 2-year exercise to evaluate DUs for caribou in Canada using the new DU guidelines (COSEWIC, 2011a). The process considered established taxonomy, phylogenetics, genetics, morphology, life history, ecology, and behaviour of the species, as well as biogeographical information such as range disjunction and the eco-geography in which the species is found. Using COSEWIC DU criteria for discreteness and significance (COSEWIC, 2011c), western mountain caribou were separated into three units: Northern Mountain caribou of Yukon, Northwest Territories and northern and central British Columbia (DU7), Central Mountain caribou of east-central British Columbia and west-central Alberta (DU8), and Southern Mountain caribou of southeastern British Columbia (DU9) (COSEWIC, 2011a).

Individual subpopulations that comprise each of the three DUs are generally discrete from one another, including those recognized as members of other DUs (see COSEWIC, 2011a). The Southern Mountain DU and Central Mountain DUs are discrete from other neighbouring DUs in that phylogenetically, these caribou have both northern (Beringian-Eurasian) and southern (North American) lineages (Dueck, 1998; McDevitt *et al.,* 2009, Yannic *et al.,* 2014). Caribou sampled in the Northern Mountain DU all come from the Beringian-Eurasian lineage (Dueck, 1998; Zittlau 2004).

The new Southern Mountain DU, restricted to southeastern British Columbia and northern Idaho (Figure 2), is now comprised of 15 extant subpopulations, all of which belonged to the previous Southern Mountain population. Caribou from this DU have a distinct behaviour related to their use of habitats found in steep mountains with deep snowfall (accumulated snowpack of 2-5 m). These extreme snow conditions have led to a foraging strategy that is unique among cervids, that is, the exclusive reliance on arboreal lichens for 3-4 months of the year (Rominger *et al.,* 1991; Terry *et al.,* 2000). Caribou of the Southern Mountain DU differ from Central and Northern Mountain DU caribou based on inherited traits for behavioural strategies and habitat selection that have resulted from the steep terrain and deep snow (COSEWIC, 2011a). Hence, this group of caribou differs markedly from all other cari-

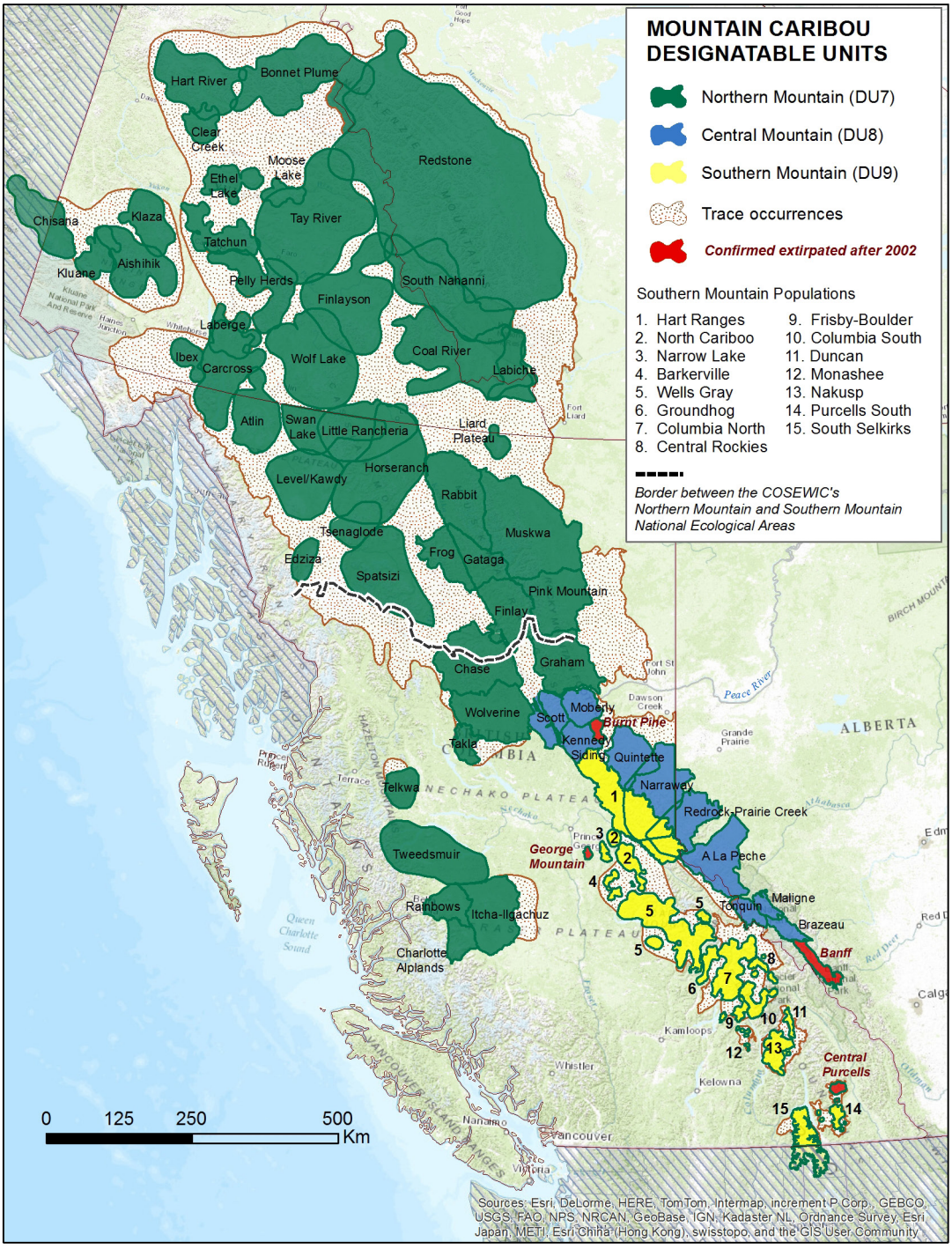

Figure 2. Caribou subpopulations in the Northern Mountain DU, Central Mountain DU, and Southern Mountain DU. The border between COSEWIC's Northern and Southern Mountain National Ecological Areas depicts the COSEWIC (2002) Northern and Southern Mountain Population boundaries (from COSEWIC 2014a). Map created by Bonnie Fournier (Environment and Natural Resources, Government of the Northwest Territories, 2014).

bou, as they have persisted in an ecological setting unique to the species that has given rise to local adaptations.

The Central Mountain DU includes ten extant subpopulations of caribou in east-central British Columbia and west-central Alberta located in and near to the northern Rocky Mountains. There are 45 Northern Mountain DU subpopulations ranging from west-central and northern British Columbia to the northern mountains of Yukon and southern Northwest Territories (Figure 2; Environment Canada, 2014). Subpopulations in the southern part of the Northern Mountain DU have relatively discrete ranges, while range overlap is more pronounced farther north. Animals from these two DUs share similar winter feeding behaviours and seasonal movement patterns, but they differ phylogenetically and are isolated by the Peace River (see COSEWIC, 2014a). Evidence from McDevitt *et al.*(2009) was suggestive of a 'hybrid swarm' of two caribou lineages within the ice free corridor that appeared along the eastern front of the Rockies producing a unique, mixed gene pool at the end of the Wisconsin glaciations ca. 14 000 years ago (Central Mountain DU). Although some evidence indicates genetic relatedness between Northern Mountain DU subpopulations in west-central British Columbia and those in the Central Mountain DU, the majority of sampled subpopulations of Northern Mountain DU caribou differ genetically (Serrouya *et al.,* 2012). All caribou in nine sampled subpopulations the Northern Mountain DU belong to the northern clade (Dueck, 1998; Zittlau, 2004; Weckworth *et al.,* 2012), but only two of 25 subpopulations in northern British Columbia have been sampled, leaving a large gap in phylogenetic information. Further work needs to be conducted to assess phylogenetics and genetic population structure of the Northern Mountain DU in particular.

There are two major differences between this new DU structure and that of the previous assessment (COSEWIC 2002). One change resulted from the reclassification of terrestrial lichen feeding/shallow snow caribou that were previously part of the Southern Mountain population. The new Southern Mountain DU is restricted to central and southeastern BC (Figure 2) and includes only the deep snow/arboreal lichen feeding ecotype. In contrast, all shallow snow/terrestrial lichen feeding caribou were reassigned to either the Central Mountain or Northern Mountain DUs. The second major difference is that the new Northern Mountain DU includes nine subpopulations in central British Columbia from the former Southern Mountain population of Woodland Caribou (COSEWIC 2002), which is currently listed under SARA as threatened and the subject of a recently-released federal recovery strategy (Environment Canada, 2014).

Population abundance and trends

Survey - methods and data availability

The IUCN/COSEWIC criteria most relevant for this assessment (for A and C; Mace *et al.,* 2008; COSEWIC, 2011b) rely on population estimates and trends over time. The 2002 and 2014 status assessments (COSEWIC, 2004; 2014a) and supporting literature explain the methods, including survey frequency, used to estimate the minimum or estimated number of caribou in each subpopulation as well as trends in absolute or relative abundance. In summary, population estimates are challenging to obtain for these animals as they reside in remote areas, occupy large ranges at low densities, and vegetation overstory across forested habitats makes observation difficult. Estimates for some subpopulations may be based on information derived from expert opinion or on sightings of caribou during surveys conducted for other species (e.g., Thiessen, 2009). For subpopulations where late-winter distribution occurs in high-elevation alpine/subalpine habitat (mostly

in the Southern and Central Mountain DUs), relatively unbiased minimum counts are reported (e.g., Seip & Jones, 2014). In other cases, however, population estimates are imprecise or do not include a measure of sampling or process variance (Tables 1-3; COSEWIC, 2014a). As with all COSEWIC assessments of wildlife species with appropriate data (COSEWIC, 2011b), the number of mature individuals, either estimated or counted, was used as an approximate estimate of population size or percentage change in population size over two or three generations -- the IUCN timeframes over which declines are measured (Mace *et al.,* 2008). It is important to note that the quantitative criteria used in the COSEWIC status assessments (COSEWIC, 2011b) are dependent on thresholds in total number or percentage change in mature individuals. From this particular perspective, precision and uncertainty becomes most important to consider when estimates approach a set threshold for designations (endangered, threatened, and of special concern).

Survey frequency has varied among the subpopulations for all DUs (Tables 1-3). In the Southern Mountain DU, the earliest available surveys date back to the late 1980s for some subpopulations or portions of those subpopulations (e.g., Barkerville, Wells Gray [south], Groundhog, Quesnel Highlands portion of the Wells Gray [north] subpopulation) (Seip, 1990; Hatter, 2006; McLellan *et al.,* 2006; Freeman, 2012). During the 1990s, at least two surveys were conducted for most subpopulations (Hatter, 2006) and surveys were carried out in most years for Barkerville, Wells Gray (north), Central Purcells, South Purcells, and South Selkirk (Wakkinen, 2003; Kinley, 2007; Freeman, 2012). Since 2002, most subpopulations in the Southern Mountain DU have been surveyed approximately every 2 years.

In the Central Mountain DU, surveys for most British Columbia subpopulations have been conducted only since the mid-2000s (Seip & Jones, 2014). The Jasper National Park subpopulations (Tonquin, Maligne, Brazeau) are surveyed annually during the fall. In addition, population trend, mortality rates of radio-collared caribou and late-winter calf recruitment rates have been tracked for all subpopulations other than Scott (BC) (ASRD & ACA 2010; Seip & Jones, 2014; Alberta Environment and Sustainable Resource Development, unpublished data). By comparison, surveys are incomplete or infrequent for the majority of the subpopulations of the Northern Mountain DU. Twenty-nine of the 45 estimates are older than 5 years, or were based solely on expert opinion, and may not reflect the current population size. Several other population estimates are based on caribou counted during surveys for other species. For 18 of the 45 subpopulations, only one estimate is available and some early surveys did not always include all of the range and so are not comparable to more recent estimates. Only nine of 45 subpopulations have been surveyed more than three times in the past 27 years.

Population trends

Tables 1-3 summarize available subpopulation size and trend data for the Southern Mountain, Central Mountain, and Northern Mountain DUs over the approximate three-generation (27 year) span used for the 2014 COSEWIC assessment (COSEWIC 2014a). Where more than one survey estimate within three generations was available for a subpopulation, we calculated a measure of population change. Few subpopulations had surveys as early as 1987. For those that did not, we used the most recent survey estimate and the highest earliest survey estimate to represent three-generation change, and did not extrapolate further. For subpopulations with one or no survey estimates, when available, population change was inferred from mortality rates of radio-collared caribou and late winter calf recruitment (e.g., Hervieux *et*

al., 2013). For subpopulations characterised by few and/or unreliable survey estimates, or where the most recent survey took place five or more years ago, trends could not be determined. We calculated the estimated population trend for each DU since the last COSEWIC assessment by comparing total number of mature individuals in 2014 to those reported by COSEWIC (2002), taking into account changes in DU boundaries.

Southern Mountain caribou DU

The 2014 estimate for the Southern Mountain DU population was 1,354 mature individuals (Table 1). The three-generation decline rate for the overall population was at least 46%. Only two subpopulations had more than 250 mature individuals, nine numbered fewer than 50, six of these fewer than 15. Some former larger subpopulations had split into several due to lack of dispersal within ranges (Wittmer *et al.,* 2005). Two additional subpopulations were recently extirpated: the George Mountain subpopulation in 2003 and the Central Purcells subpopulation in 2005 (Table 1).

All subpopulations in the revised Southern Mountain DU belonged to the former Southern Mountain population of Woodland Caribou (Environment Canada, 2014). The corresponding subpopulations were estimated at 1,850 mature individuals in 2002 (COSEWIC, 2002), indicating a 27% decline. The only increasing subpopulation (Barkerville) has likely benefitted from a recent wolf sterilization and removal program (Roorda & Wright, 2012), although there are <100 mature individuals. Some subpopulations have been subjected to intensive management measures since 2002 (see below).

Because IUCN criteria also take into account projected declines into the future (Mace *et al.,* 2008; COSEWIC, 2011a), recent population viability analyses were informative. Wittmer *et al.* (2010) developed a population viability analysis (PVA) for ten subpopulations of Southern Mountain DU caribou. All ten were predicted to decline to extinction within <200 years and all but two subpopulations had a cumulative probability of extinction of >20% (24-100%) within 45 years (5 generations). Increases in the amount of young forest have resulted in more rapid predicted extinction rates in all populations. Hatter (2006) conducted a PVA for all extant subpopulations in this DU and showed that time to quasi-extinction (N<20 animals) was < 50 years for 10 of 15 subpopulations. The probability of quasi-extinction in 20 years was >20% for 12 of 15 subpopulations and >50% for 13, but Hatter (2006) cautioned that confidence limits indicated a low level of certainty for predictions for five of the subpopulations with a high probability of extinction. By contrast, the largest subpopulations, North Cariboo Mountains and Hart Ranges, were identified in both studies as having a very low probability of extinction in this time period. However, since 2006, both subpopulations have declined, with the Hart Ranges population declining 35% (COSEWIC 2014a).

Central Mountain caribou DU

The 2014 estimate for the Central Mountain DU was 470 mature individuals (Table 2). Nine of ten extant subpopulations each contain fewer than 100 mature individuals, four among them fewer than 50. The long-term trend of the Scott subpopulation in BC, however, is unknown. In addition, the Banff subpopulation was extirpated in 2009 (Hebblewhite *et al.,* 2010), and the Burnt Pine subpopulation was confirmed functionally extirpated in 2014 (Seip & Jones, 2014). The estimated overall decline in the Central Mountain DU population was at least 64% during the last three generations. All subpopulations in the Central Mountain DU belonged to the former Southern Mountain population of Woodland Caribou (Environment Canada, 2014). The corresponding subpopulations were

estimated at 1,293 mature individuals in 2002 (COSEWIC, 2002). The decrease in numbers observed during surveys is supported by consistently high adult mortality and low calf recruitment (ASRD & ACA, 2010; Hervieux *et al.,* 2013; Seip & Jones, 2014).

Northern Mountain caribou DU

About 50,000 to 55,000 caribou occurred in the Northern Mountain DU in 2014, of which 43,187 to 47,496 were estimated to be mature individuals (Table 3). These animals accounted for about 95% of western mountain caribou in Canada. Over half (26 of 45) the subpopulations contained more than 500 mature individuals, while 13 subpopulations had fewer than 250. Nine of the 15 subpopulations that consisted of >1,000 mature individuals are located in Yukon and Northwest Territories. Combined, the Bonnet Plume and Redstone subpopulations, the two largest in the DU, comprised >15,000 animals, or 26-29% of the Northern Mountain DU (Table 3).

The four subpopulations that comprised < 50 mature individuals are located in the southern part of the DU in west-central British Columbia (Charlotte Alplands, Rainbows, Telkwa) and north-eastern British Columbia (Finlay). Trend data were limited for subpopulations in this DU, with long-term (three-generation) trend known for only 16 of 45 subpopulations (Table 3). Recent surveys indicate that all five subpopulations in west-central British Columbia (Telkwa, Tweedsmuir, Itcha-Ilgachuz, Rainbows, Charlotte Alplands) are currently declining (COSEWIC, 2014a).

The 2002 COSEWIC assessment estimated the number of mature individuals in the former Northern Mountain population as 43,950 (COSEWIC, 2002), suggesting an overall stable situation for those 36 subpopulations, albeit with considerable uncertainty because of limited survey data (Environment Canada, 2012; COSEWIC, 2014a). In contrast, the nine subpopulations at the southern part of the DU, all of which belong to the former Southern Mountain population of Woodland Caribou (Environment Canada, 2014) have experienced an overall decline of 34% since 2002, from 4,030 to 2,673 mature individuals. (Table 3; COSEWIC 2014a).

2014 COSEWIC assessments of western mountain caribou

In April 2014, the Central and Southern Mountain Caribou DUs were assessed by COSEWIC as endangered (COSEWIC, 2014a). In both cases, the IUCN Red List criteria (Mace *et al.,* 2008) for high decline rate (A) and small and declining populations (C) were invoked because these DUs have experienced pronounced population reductions within the last three generations and most subpopulations are currently small in size.

Criterion A is measured as a percentage of loss of mature individuals over time windows in the past, future, or a combination of the past and future (Mace *et al.,* 2008). The decline of 64% over the past three generations in the Central Mountain population exceeds the criterion of 50% decline for endangered, in cases where the causes of the declines have not ceased and may not be reversible (COSEWIC 2011b). Although the calculated >45% decline for the Southern Mountain population did not exceed the IUCN threshold (50%) for past declines, it qualified as endangered under this criterion based on inferred reduction of >50% within the next three generations based on PVA (Hatter, 2006; Wittmer *et al.,* 2010).

The focus of IUCN Criterion C is on populations that are numerically small and in continuing decline (Mace *et al.,* 2008; COSEWIC, 2011b). Both Central and Southern Mountain caribou are endangered under this criterion, as each population numbered fewer than 2,500 and has experienced an estimated continuing two-generation decline that exceeded the 20%

threshold (at least 62% for Central and 40% for Southern). Furthermore, in the case of Central Mountain caribou there was an apparent continuing decline in number of mature individuals, while no subpopulation was estimated to contain more than 250 individuals (COSEWIC, 2014a).

Northern Mountain Caribou did not meet quantitative thresholds for endangered or threatened when considering overall population size or decline, but were assessed as of special concern due to the deteriorating status of a number of subpopulations and increasing magnitude and scope of threats throughout the DU (COSEWIC, 2014a). All known stable or increasing subpopulations are located in the northern part of the range, whereas nine in the southern part of the range had declined by 34% since the last assessment. However, most subpopulations in this DU receive little to no monitoring attention, and many 2014 estimates were based on survey data older than 5 years. The status of northern subpopulations may be compromised in the future because of increasing threats, particularly land-use change resulting from industrial development, and extent and frequency of forest fires and insect outbreaks related to climate change (e.g., mountain pine beetle) (Environment Canada, 2012; COSEWIC 2014a). Habitat loss and increased predation levels can be expected to influence the distribution and abundance of subpopulations in a similar fashion to that which has taken place in the Central and Southern Mountain DUs (Apps & McLellan, 2006, Wittmer *et al.,* 2007; DeCesare *et al.,* 2011; Hervieux *et al.,* 2013).

Prevailing and future threats

Threats to woodland caribou in Canada, including western mountain caribou, have been well documented (Festa-Bianchet *et al.,* 2011; COSEWIC, 2014a). Recent studies have demonstrated that linear features resulting from roads, trails, geophysical exploration lines, pipelines, and utility rights-of-way can exacerbate susceptibility to predation, and therefore alter the movements, distributions, and population dynamics of caribou. These features facilitate increased predator mobility, hunting, vehicle collisions, disturbance, and directly or indirectly result in habitat reduction and fragmentation (Dyer *et al.,* 2002; Seip *et al.* 2007, van Oort *et al.,* 2010; Williamson-Ehlers, 2012; Apps *et al.,* 2013). Predation is often the primary reason for caribou declines, directly related to increased prey populations that show a numerical and distributional response to early seral forest and linear features that result from cumulative development activities (Serrouya *et al.,* 2011; Apps *et al.,* 2013; Ehlers *et al.,* 2014). Human developments associated with timber harvest, oil and natural gas extraction, wind energy, and mining have a large cumulative footprint, reducing the amount of habitat for caribou and increasing the area of early-successional forests favoured by other ungulate species and the predators of caribou (Nielsen *et al.,* 2005; Nitschke, 2008; Williamson-Ehlers, 2012). Although forest harvesting and mineral and hydrocarbon exploration and development do not generally result in substantial direct mortality of mountain caribou, habitat changes arising from these activities and associated infrastructure affect the abundance, habitat use, and movements of both predators and alternate prey (Festa-Bianchet *et al.,* 2011; Serrouya *et al.,* 2011). Recent large natural disturbances by fire and forest insects may render already limited habitat unavailable for decades, thereby reducing already fragmented ranges. For example, after over 50 years of relatively little fire activity on the Tweedsmuir-Entiako caribou range, a wildfire in 2014 affected over 130,000 ha of winter and spring migration range (R. Krause, BC Ministry of Forests, Lands and Natural Resource Operations, pers. comm.).

In the Northern Mountain DU, human dis-

turbances and habitat loss (including functional habitat loss) have resulted from the cumulative effects of forest harvesting, mineral exploration and development and associated access, motorized and non-motorized recreational activities, changes in forest structure due to mountain pine beetle (*Dendroctonus ponderosae*) infestations and/or associated salvage logging, and impacts from climate change (Environment Canada, 2012; COSEWIC, 2014a). Direct impacts to southern subpopulations in the DU are already evident, whereas those in the northern part of the DU may be affected similarly if the multiple proposed mineral and hydrocarbon exploration and development projects, windfarms, and associated infrastructure are developed in north-central and northeastern BC (COSEWIC, 2014a). For example, in north-western BC, there are known large mineral deposits stimulating exploration activities and mine development in the Skeena region. The 344-km Northwest Transmission line was completed in 2014 to supply power to planned industrial developments and remote communities in the area (BC Hydro, 2015). The new power supply is likely to increase the feasibility of potential projects in and adjacent to caribou ranges in north-western BC.

The primary threats to caribou in the Central Mountain DU include altered predator-prey dynamics due to habitat loss and disturbances from multiple industrial activities including forest harvesting, mining of coal, and the exploration and development of oil and gas reserves. Additional factors include deaths from vehicle collisions, disturbance from motorized recreation (e.g., all-terrain vehicles, snowmobiling), facilitated access to caribou winter range for predators resulting from increased linear corridors and packed trails or ploughed roads in winter, impacts from climate change, and stochastic environmental events associated with small population sizes (DeCesare *et al.,* 2011; Hervieux *et al.,* 2013; Williamson-Ehlers *et al.,* 2012; Johnson *et al.,* 2015). Caribou in the Southern Mountain DU are subject to altered predator-prey dynamics due to habitat change resulting from forest harvesting in adjacent valley bottoms, snowmobiling, heliskiing, impacts from climate change, and Allee effects that have led to a high likelihood of extirpation due to random environmental and demographic events (Apps & McLellan, 2006; Wittmer *et al.,* 2007; 2013).

Management and recovery actions

Efforts aimed at recovering or managing declining western mountain caribou since the 1980s have focused on habitat protection, population management, and mitigation of individual development projects as the industrial footprint continues to increase across the distribution of all three DUs. In 2007, the Government of British Columbia announced a series of habitat protection measures as part of a Mountain Caribou Recovery Implementation Plan (BC Ministry of Environment, 2015). Specifically, 2.2 million ha of forested lands in the Southern Mountain DU were included in protected areas or designated as Ungulate Winter Ranges or Wildlife Habitat Areas under the provincial Forest and Range Practices Act, whereby mountain caribou habitat requirements receive special consideration when planning and implementing forest harvesting and other industrial (e.g., road building) activities (Environment Canada, 2014; BC Ministry of Environment, 2015). Approximately 1 million ha were closed to motorized vehicles (primarily to restrict snowmobiling; Seip *et al.,* 2007). Ungulate Winter Ranges and Wildlife Habitat Areas generally provide for no or modified forest harvesting and include primarily high elevation habitat in the Central and Southern Mountains, but also low elevation areas in the Northern Mountains. They also provide some restrictions on mineral exploration and guided adventure tourism activities during the calving

season. General Wildlife Measures for those areas vary with respect to the proportion of area excluded from forest harvesting, and the levels and methods of forest harvesting in modified harvest areas (COSEWIC, 2014a).

The South Peace Northern Caribou Implementation Plan (BC Ministry of Environment, 2013) provided for protection of ≥90% of identified high-elevation winter ranges across the Central Mountain and a portion of the Northern Mountain DUs. This includes the Graham, Moberly, Scott, Burnt Pine, and Narraway subpopulations in British Columbia. It also specifies protection of ≥80% of identified high-elevation winter ranges on the Quintette range, but provides no indication of how the protected portions of any of the range will be distributed geographically. In the Southern Mountain DU, caribou primarily use high-elevation ranges, and recovery efforts have focussed on protecting most of those ranges from forest harvesting. However, forest harvesting has continued outside of those ranges in adjacent valley bottoms, resulting in increased predation risk for caribou (Apps *et al.,* 2013). Similarly, for caribou in both the Central Mountain DU and the southern part of the Northern Mountain DU, continuing declines in caribou numbers is highly correlated to loss of high-quality habitat and industrial disturbances at low elevations (Johnson *et al.,* 2015).

Intensive management of caribou subpopulations including translocations, predator control, prey control, and captive breeding and rearing initiatives, have been deployed since the mid-1980s (e.g., Compton *et al.,* 1995; Young *et al.,* 2001; Zittlau, 2004; Cichowski, 2014; COSEWIC, 2014a). Initial results can appear promising but then often are not sustained. For example, the Telkwa subpopulation in west-central British Columbia increased after the transplants of 32 caribou from 1997-1999 to at least 144 total caribou in 2006 before declining to the current estimate of 19 animals (Cichowski, 2014). From 1984 to 1991, 52 caribou from the Itcha-Ilgachuz subpopulation were transplanted to the unoccupied Charlotte Alplands range (Young *et al.,* 2001). That subpopulation appeared to remain stable until about 1999, but then declined (Youds *et al.,* 2011). The only transplant of western mountain caribou over the past decade occurred in March 2012, when 19 caribou were brought from the Level-Kawdy subpopulation in the Northern Mountain DU to the Purcells South and Purcells Central ranges in the Southern Mountain DU. Seventeen died within 13 months due to predation by wolves or cougars (n=8), accidents (n=3), malnutrition (n=1), or unknown causes (n=5); the fate of the remaining two is unknown due to GPS-collar malfunction (L. de Groot, BC Ministry of Forests, Lands and Natural Resource Operations, pers. comm.).

Although wolf reduction and/or sterilization programs often enjoy initial success, as measured by enhanced caribou survival or recruitment (e.g., Farnell & McDonald, 1988; Bergerud & Elliott, 1998; Hegel & Russell, 2010), the relatively rare opportunities for longer-term monitoring have demonstrated that such interventions, once ended, do not always have sustained long-term benefits for prey species affected by apparent competition (Wittmer *et al.*, 2013). Over the past decade, predator control efforts have continued, albeit constrained by social acceptability (Serrouya *et al.*, 2011). As part of the Mountain Caribou Recovery Implementation Plan in the Southern Mountain DU, trapping and hunting seasons for wolves and cougars were adjusted in 2007 to encourage removal of those predators near caribou habitat (Mountain Caribou Recovery Implementation Plan Progress Board, 2012). Until 2014, the only wolf removal or sterilization program In the Southern Mountain DU was on the Barkerville and Wells Gray (north) subpopulation ranges, where wolves were removed and sterilized leading to densi-

ties of 3.2-3.4 wolves/1000 km^2 across about 60% of the study area; the Barkerville caribou subpopulation increased and the Wells Gray (north) subpopulation remained stable, but calf recruitment remained variable (Roorda & Wright, 2012).

In the Central Mountain DU, a 7-year wolf control effort targeting the Little Smokey range, a boreal caribou subpopulation (Hervieux *et al.,* 2014), likely affected the A La Peche Central Mountain caribou subpopulation as well because it shares the same winter range. In January, 2015, the BC Ministry of Forests, Lands and Natural Resource Operations announced two targeted wolf removal efforts "to save caribou herds under threat from wolf predation" in the South Selkirk subpopulation range (Southern Mountain DU) and the Quintette, Moberly, Scott and Kennedy-Siding) ranges (Central Mountain DU) (BC MFLNRO, 2015). A provincial management plan for grey wolf released by the Government of BC in April 2014 (BC MFLNRO, 2014:17), states that wolf control "to reduce predation risk on endangered caribou" has been a "provincial priority" since 2001. Bag limits for wolf hunting have been removed in specified management units in an effort to reduce predation on caribou.

Two moose population reductions have recently been conducted in the Southern Mountain DU. Liberalized hunting resulted in a 71% reduction in moose numbers and about a 50% reduction in wolf numbers on three ranges in the southern portion of the Southern Mountain DU; the Columbia North population experienced a modest increase while the two small populations (Columbia South, Frisby-Boulder) decreased regardless (Serrouya *et al.,* 2011). In the northern portion of the Southern Mountain DU (Parsnip portion of the Hart Ranges), moose numbers declined, possibly as a result of increased hunting, but over six years, neither wolf nor caribou numbers responded measurably (Steenweg, 2011; D. Heard, British Columbia Ministry of Forests, Lands and Natural Resource Operations, pers. comm.).

Captive breeding has the strong endorsement from the Mountain Caribou Recovery Implementation Plan Progress Board as a means to quickly increase mountain caribou numbers in some key core areas, and there is continued interest by the BC government to augment imperiled populations (C. Ritchie, BC Ministry of Forests, Lands and Natural Resource Operations, pers. comm.). A captive-rearing program was conducted for the Chisana subpopulation in Yukon in the Northern Mountain DU during 2003-2006 (Chisana Caribou Recovery Team, 2010). In that program, between 20 and 50 adult female caribou were captured annually in March and held in large enclosures (pens) until mid-June to increase early calf survival. During the 4-year period, calf survival until mid-June (time of release) averaged 93% for captive-reared calves vs. 33% for calves born in the wild (Chisana Caribou Recovery Team, 2010). Survival of calves after release until mid-October was greater for calves born in the pen (70%) than for calves born in the wild (52%). These results suggested that captive rearing could be an effective tool for small populations that are limited by poor calf recruitment (Chisana Caribou Recovery Team, 2010). Captive-rearing projects are currently being conducted (2014) for the Moberly subpopulation in the Central Mountain DU (10 females captured), and for the Columbia North subpopulation (10 females captured) in the Southern Mountain DU (S. McNay, Wildlife Infometrics Inc., pers. comm.; R. Serrouya, Columbia Mountains Caribou Project, British Columbia, pers. comm.). In 2011, a partnership between Parks Canada, the British Columbia Government, and the Calgary Zoo was created to implement a captive-breeding program that would take breeding stock from British Columbia, and augment or reintroduce animals in the four national parks and in BC

(Parks Canada, 2011b). No further details have been publicly released since then but in late 2014, Calgary Zoo made a decision not to proceed (Ellis, 2014).

The latest Alberta status report (ASRD & ACA, 2010) described various provincial recovery planning efforts for both mountain and boreal ecotypes since 1986. Not until 2005 was a recovery plan (Alberta Woodland Caribou Recovery Team, 2005) approved by the Alberta government, although this was "qualified" in that the recommendation for a moratorium on the allocation of new resource extraction rights until range-specific management plans were in place was not accepted by the government of Alberta (ASRD & ACA, 2010). No habitat has been protected on Alberta provincial lands in the Central Mountain DU for the purposes of caribou protection over the past decade; ongoing industrial development activities are managed through an inconsistently-applied patchwork of caribou-related operating guidelines focused on minimizing the size and duration of individual projects (ASRD & ACA, 2010). Oil leases continue to be sold within Alberta Central Mountain Caribou ranges, as recently as March 2015 (Weber, 2015). Parks Canada has also produced a strategy (Parks Canada, 2011a) to guide conservation efforts, which are primarily focused on measures such as seasonal closures of winter habitat, and management of elk populations, vehicle traffic control measures, and recreation in the four national parks located in the Southern and Central Mountain DUs. Predator-prey relationships in these latter protected areas are heavily influenced by land use practices or human settlements characterized by the surrounding landscapes.

Scientific assessments of Canadian wildlife by COSEWIC represent only the first stage in SARA listing and recovery processes. Assessment is followed by the separate steps of listing decisions and then recovery planning and actions (Mooers *et al.,* 2010). The SARA Recovery Strategy for the Southern Mountain "nationally significant population" assessed by COSEWIC (2002) was finalised at about the same time as the most recent COSEWIC status review (COSEWIC, 2014a). Although COSEWIC (2014a) brought forward changes to both the DU structure and status of many subpopulations (as presented above) that are well-aligned with provincially-recognized ecotypes (Government of British Columbia, 2014), experience demonstrates that it may take some time before legal listing under SARA occurs and these modifications are reflected in the SARA Registry and subject to relevant regulations. The recently completed SARA recovery strategy (Environment Canada, 2014) did, however, seek to clarify this confusing mismatch by acknowledging COSEWIC's new DU structure. That strategy document also partially identified critical habitat specific to the subpopulations of the previously-defined (COSEWIC, 2002) Southern Mountain population.

Conclusions and recommendations

2014 marked the third time COSEWIC has reviewed the status of caribou in the western mountains of Canada (in addition to 1984 and 2002). These status evaluations have documented profound range loss, pronounced and ongoing population declines, unsustainable predation rates, and continuing loss in area and connectivity of functional habitat, resulting in small and isolated subpopulations in southern and central British Columbia and Alberta. At the same time, there are mounting concerns for the welfare of subpopulations in northern British Columbia, Yukon and western Northwest Territories, which face escalating industrial development, even in currently remote regions (Hegel & Russell, 2013; COSEWIC, 2014a). Increased understanding of the distribution, ecology, and genetic variation of these western subpopulations has allowed COSEWIC to apply the Designatable Unit concept to this most

recent assessment (COSEWIC, 2011a). This exercise resulted in significant modifications to the boundaries of previously recognized Northern and Southern Mountain "nationally significant populations" (COSEWIC, 2002). COSEWIC also introduced a third unit (Central Mountain), representing subpopulations on the eastern flanks of the Rocky Mountains that were previously considered Southern Mountain caribou (Environment Canada, 2014). Although it may be some time before they are legally recognized, these boundary changes have brought federal recovery units into better alignment with those recognized by provinces and territories, particularly BC.

In spite of considerable management attention to declining populations, available high-quality monitoring data provide a clear indication that recovery actions since the passage of SARA have been generally unsuccessful for caribou in the western mountains of Canada. In some areas, such as the Southern Mountain DU, large areas of important range have been protected from forest harvesting, but herds are still declining, with many reaching very low numbers. Recent actions focused on proximate causes of decline (e.g., predator control or moose reduction) may have helped to stabilise some subpopulations (e.g., Columbia North and Barkerville), but these efforts have not been accompanied by habitat recovery at the scale necessary to enable overall population recovery (Johnson *et al.,* 2015). Alberta, in particular, has relied on mitigation measures to ameliorate site-level impacts of new and past resource development projects. Containment of the human footprint across the range of these mountain caribou DUs, however, is not usually regarded as an option, in light of the economic significance of resource development to provincial economies.

Based on declines, future developments and current recovery effects, we offer the following recommendations:

1) *Commit to reducing human intrusion into caribou ranges, restoring habitat over the long term, and conducting short-term predator control for small and/or declining subpopulations.*
All three components must be conducted simultaneously for successful recovery of western mountain caribou. Implementation of the current recovery and management plans and perhaps more drastic actions will undoubtedly result in trade-offs between the persistence of subpopulations of caribou, economic activity, and societal expectations for conservation. If restraint of the human footprint is not considered, then the prospects for preventing extirpation of declining subpopulation through reliance on mitigation of individual development projects will be increasingly limited.

2) *For management and recovery actions, especially with respect to planned movements of animals to supplement subpopulations, consider carefully COSEWIC's new DU structure for caribou, which explicitly recognizes the evolutionary significance of discrete conservation units of the species in Canada.*
Translocation efforts have involved, on occasion, a transfer of animals from one DU to another, and are being increasingly adopted or considered. Increasingly a component of strategies aimed at maintaining or recovering small subpopulations of caribou in all three DUs (DeCesare *et al.,* 2011; Environment Canada, 2014), have either met with failure, as measured by death, lack of reproduction by introduced individuals, or the results are difficult to disentangle from the effects of other recovery measures applied simultaneously. Translocation projects can also serve to increase threats to caribou subpopulations through 1) the introduction of novel genetic material that could cause outbreeding depression and reduce local adaptations, 2) removal of individuals from source subpopulations that may in some cir-

cumstances exacerbate extinction risk related to small source population sizes, 3) unanticipated disease transfer between environments that characterize caribou ecotypes, or 4) low survival of individuals transplanted from one DU into another if the basis for DU designation is local adaptations to the ecological setting. The ecological and behavioural characteristics that differentiate the three mountain caribou DUs (COSEWIC, 2011a), make the prospects for rescue unlikely through translocation from one DU to another, particularly to the Southern Mountain DU. Experience suggests that the success of most translocations will be compromised if the causes of the original decline are not addressed (St-Laurent & Dussault, 2012).

3) *Carry out regular surveys to monitor the condition of Northern Mountain caribou subpopulations and immediately implement preventative measures on ranges that show signs of population declines or acceleration of threats.*
Although the designation of special concern for the Northern Mountain population confers few obligations under SARA, the current conservation status of the subpopulations in this DU illustrates well the importance of the third stated purpose of the Act "to manage species of special concern to prevent them from becoming endangered or threatened" (SARA, 2002). In light of the worrisome signs already exhibited by southern subpopulations in this DU, intensifying natural resource development and increasing natural disturbance in the region make it necessary to be vigilant and ready to respond.

4) *Undertake a proactive, planned approach coordinated across jurisdictions to address the spatial extent and resource valuation essential to conserving landscape processes.*
Caribou conservation depends on the maintenance of landscape-scale processes expressed across extremely broad areas and a proactive approach to limiting or mitigating land-use changes and cumulative impacts that have demonstrable negative impacts on caribou. Given the limited scope of SARA, recovery and management of western mountain caribou subpopulations will necessitate coordination within and between jurisdictions at appropriate scales, including the effective protection of critical habitat. The prevailing practice of piecemeal project-by-project decision making does not consider how development should proceed at a regional scale and collectively engenders a reactive approach.

Acknowledgements
Thanks to Troy Hegel and members of the organizing committee of the 14th North American Caribou Workshop (Whitehorse, May 2014) for providing the impetus for this special issue of Rangifer. Funding for the preparation of the COSEWIC status report (COSEWIC, 2014a) was provided by Environment Canada. We wish to acknowledge the other members of the COSEWIC Terrestrial Mammals Subcommittee, Dan Benoit and the ATK Subcommittee, and numerous other reviewers who provided insightful comments and improvements to the many drafts of the status report. Thanks to members of the full committee of COSEWIC who conducted the assessment at the Spring 2014 COSEWIC Species Assessment Meeting in Halifax. Bonnie Fournier (Environment and Natural Resources, Government of the Northwest Territories) produced the maps, and Jenny Wu of the COSEWIC Secretariat provided invaluable assistance during the two-year process. We are grateful to the following individuals who helped secure population and trend information in the status report: J. Adamczewski, N. Baccante, N. Dodd, L. de Groot, A. Goddard, D. Heard, T. Hegel, D. Hervieux, N. Larter, S. McNay, L. Neufeld, R. Pither, C. Ritchie, J. Scheck, D. Seip, R. Serrouya, J. Surgenor, C. Thiessen, G. Watts, and M. Williams. G.

Kuzyk, T. Hegel, and an anonymous reviewer provided insightful comments that improved the manuscript.

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Table 1. Subpopulation and trend estimates for 15 caribou subpopulations in the Southern Mountain Designatable Unit.

Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2001	# full surveys 2002-2014	Survey Estimates[2]							Population Estimates	
				Initial Estimate[3]			2014 Estimate			Long-term % change[4]	2014 Estimate	
				Year	Total	Mature	Year	Total	Mature		Total	Mature
South Selkirks (BC)	SM	9	11	1995[5]	63	53	2014	22	20	-62	22	20
Purcells South (BC)	SM	4	8	1995	69	63	2014	23	22	-65	23	22
Purcells Central (BC)	SM	6	5	1994	22	19	2005	0	0	-100	0	0
Nakusp (BC)	SM	3	9	1996	211	192	2014[6]	64	54	-72	64	54
Duncan (BC)	SM	3	8	1999	31	23[7]	2012	2	2	-91	2	2
Central Rockies (BC)	SM	2	4	1995	30	28	2008	3	2	-93	3	2
Monashee (BC)	SM	1	5	1994	12	8	2011	4	4	-50	4	4
Frisby Boulder (BC)	SM	3	6	1994	43	39	2013	13	12	-69	13	12
Columbia South (BC)	SM	3	8	1994	114	100	2013	7	6	-94	7	6
Columbia North (BC)	SM	3	6	1997	280	247	2013	183	157	-36	183	157
Groundhog (BC)	SM	5	8	1990	109	89	2013	13	11	-88	13	11
Wells Gray (BC)	SM	0	3	1995	631	522	2013	343	298	-43	392	341
Barkerville (BC)	SM	14	6	1988	46	39	2012	88	76	95	90	78
North Cariboo Mountains (BC)	SM	2	4	1999	299	280	2011	222	202	-28	222	202
Narrow Lake (BC)	SM	2	11	1999	81	73	2014	47	45	-38	47	45
George Mountain (BC)	SM	2	7	1993[8]	24	22	2004	0	0	-100	0	0
Hart Ranges (BC)	SM	0	4	2006	716	590	2013	439	381	-35	459	398
Total					**2781**	**2387**		**1473**	**1292**	**-46**	**1544**	**1354**

Footnotes to Table 1.

[1] Nationally significant population (see full explanation in manuscript text).
[2] Censuses of DU9 caribou are conducted using standardized methods and searching predetermined survey areas. Various techniques have been used to estimate number of caribou in the survey area (survey area estimate) and for the whole population (population estimate). For surveys where no radio-collared caribou are present, the survey estimate is usually equivalent to the population estimate. For surveys where radio-collared caribou are available, caribou are sometimes found outside the survey area; these are incorporated into the population estimate but not the survey estimate. In this table, the most recent population estimate is presented for assessing the current population size of caribou in DU9, but % change is based on survey estimates. For surveys where a survey estimate was not provided, the estimate was calculated by applying a standardized sightability correction factor of 0.83 used for DU9 caribou surveys based on Seip (1990) and Young & Roorda (1999) to total caribou seen plus tracks.
[3] This survey/estimate is the oldest reliable survey conducted with the highest count of animals during the last 3 generations (27 years).
[4] Long-term % change is based on the difference between the initial and 2014 survey estimates.
[5] This survey was considered incomplete but it had the highest number of caribou counted in that time period.
[6] This survey includes the Duncan subpopulation but it was not possible to differentiate between the two subpopulations during the survey so all caribou counted are included in the Nakusp subpopulation.
[7] No composition data were available for this year so the number of mature individuals was calculated based on the proportion of adults in all surveys for the subpopulation that included composition data.
[8] No composition data were available for this year; the only year composition was available was 2002 so the number of mature individuals was calculated based on the average proportion of adults in all surveys for the nearby Narrow Lake subpopulation, which included composition data.

Table 2. Subpopulation and trend estimates for 13 caribou subpopulations in the Central Mountain Designatable Unit.

Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2001	# full surveys 2002-2014	Survey Estimates							Population Estimates	
				Initial Estimate[2]			2014 Estimate			Long-term % change[3]	2014 Estimate	
				Year	Total	Mature	Year	Total	Mature		Total	Mature
Scott[4] (BC)	SM	0	0	2007	48	37	2014/2007	43	35	Unk	43	35
Moberly (BC)	SM	3	4	1995	189	163	2014	22	18	-89	22	18
Kennedy Siding (BC)	SM	0	7	2007	120	103	2014	30	29	-72	30[5]	29
Burnt Pine (BC)	SM	4	5	1996	20	18[6]	2014[7]	1	1	-94	1	1
Quintette (BC)	SM	0	3	2008	173	147	2014	106[8]	87	-41	106[8]	87
Narraway[9] (BC/AB)	SM	0	0	2008	180	164	2014/2012	86	78	-52	86	78
Redrock/Prairie Creek[10] (AB/BC)	SM	0	0	1999	478	401	2012	127	106	-74	127	106
A La Peche[11] (AB)	SM	0	0	1999	123	106	2012	88	75	-29	88	75
Jasper (AB)[12]	SM	6	12	1989	188[13]	145	2013	51	41	-72	51	41
Banff (AB)	SM	0[14]	6	1986	29	26	2009	0	0	-100	0	0
Total					**1548**	**1310**		**554**	**470**	**-64**	**554**	**470**

[1] Nationally significant population (see full explanation in manuscript text).
[2] This survey/estimate is the oldest reliable survey conducted with the highest count of animals during the last 3 generations (27 years).
[3] Long-term % change is based on the difference between the initial and 2014 survey estimates.
[4] No survey has been conducted for the west side of the Scott range; the estimate for the western portion of the range was based on anecdotal information and expert opinion and has not been updated since 2007, so the same estimate was used for the current estimate for the purpose of assessing overall population trend. The number of mature individuals for the west side of the Scott range was derived by applying the proportion of adults during the two surveys in the east side of the Scott range to the west side estimate. The east side of the Scott range was surveyed in 2007 and 2014.
[5] Based on observation on the low-elevation winter range during the fall, the minimum population is 22 with an estimated population ranging from 25-35 (with a mid-point of 30 from Seip & Jones (2014)). The number of adults was estimated by applying the proportion of adults seen (21/22) to the total population estimate of 30.
[6] No composition data were available for this year so the number of mature individuals was calculated based on the average proportion of adults in all surveys for the nearest subpopulation that included composition data.

Footnotes to Table 2 continued.

[7] Although 1 bull caribou was seen during the March 2014 survey, Seip & Jones (2014) concluded that the population was functionally extirpated.

[8] Extrapolated from a partial survey. Total population estimated at 98-113 (midpoint=106) (Seip & Jones 2014). The number of adults was estimated by applying the % of adults (82%) in the partial survey to the total estimate.

[9] Estimate based on minimum count for Bearhole/Redwillow portion (Seip & Jones 2014) and for the remaining portion, based on 2009 population estimate of 100 caribou and mature estimate of 90 caribou (ASRD&ACA 2010) and then extrapolated back to 2008 using annual lambdas from ASRD&ACA (2010) and extrapolated to 2012 using annual lambdas from Alberta Ministry of Environment and Sustainable Resource Development (unpublished data; 2010: λ=0.983; 2011: λ=0.904; 2012: λ=0.811). Cumulative λ (2008-2012) = 0.55.

[10] Population estimates based on 2009 population estimate of 212 caribou and mature estimate of 178 caribou (ASRD&ACA 2010) and then extrapolated back to 1999 using annual lambdas from ASRD&ACA (2010) and extrapolated to 2012 using annual lambdas from Alberta Ministry of Environment and Sustainable Resource Development (unpublished data; 2010: λ=0.866; 2011: λ=0.921; 2012: λ=0.749). Cumulative λ (1999-2012) = 0.27.

[11] Population estimates based on 2009 population estimate of 135 caribou and mature estimate of 116 caribou (ASRD&ACA 2010) and then extrapolated back to 1999 using annual lambdas from ASRD&ACA (2010) and extrapolated to 2012 using annual lambdas from Alberta Ministry of Environment and Sustainable Resource Development (unpublished data; 2010: λ=0.836; 2011: λ=0.880; 2012: λ=0.835). Cumulative λ (1999-2012) = 0.71. The population was estimated to be 175-200 based on a count of 162 in October 1988 (Brown *et al.* 1994).

[12] There are 3 subpopulations in Jasper, but were combined to assess long-term trend.

[13] Data interpreted from Figure 1 in Hebblewhite *et al.* 2010. Data based on annual maximum counts and telemetry studies. The number of mature individuals was derived by applying the proportion of adults in caribou sightings in that year (Parks Canada unpublished data) to the total number.

[14] Although no structured surveys were conducted prior to 2004 (J. Whittington, Parks Canada, pers. comm. 2015), the 1986 estimate is based on a minimum count obtained from annual maximum counts and/or telemetry studies (Hebblewhite *et al.* 2010).

Table 3. Subpopulation and trend estimates for 45 caribou subpopulations in the Northern Mountain Designatable Unit.

				Survey Estimates							Population Estimates	
				Initial Estimate			2014 Estimate				2014 Estimate	
Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2004	# full surveys 2002-2014	Year	Total	Mature	Year	Total	Mature	Long-term % change[2]	Total	Mature
Northern Yukon/Northwest Territories												
Hart River	NM	1[3]	1	-			2006	2200	1853		2200	1853
Clear Creek	NM	1	0	-			2001	900	801		900	801
Bonnet Plume[4]	NM	0	0	-			1982	5000	4200[5]		5000	4200[5]
Redstone[6]	NM	0	0	-			2012	>10000	7300-10000[5]		>10000	7300-10000[5]
South Nahanni	NM	1	1	2001	1432	1337	2009	2105	1886	10[7]	2105	1886
Coal River	NM	1[8]	1	-			2008	450	413		450	413
La Biche	NM	1	0	-			1993	450	388		450	388
Southwest Yukon												
Chisana[9]	NM	0	9	2003	720	607	2013	701	631	4	701	631
Kluane	NM	1	2	2003[10]	235	204	2009	181	163	-20	181	163
Aishihik	NM	4	1	1981	1500	1399	2009	2044	1813	30	2044	1813
Klaza	NM	2[11]		-			2012	1180	1065		1180	1065

Table 3 continued.

				Survey Estimates							Population Estimates	
				Initial Estimate			2014 Estimate				2014 Estimate	
Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2004	# full surveys 2002-2014	Year	Total	Mature	Year	Total	Mature	Long-term % change[2]	Total	Mature
Central Yukon												
Ethel Lake	NM	1	0	-			1993	316	289		316	289
Moose Lake	NM	1	0	-			1991	300	270		300	270
Tay River	NM	1	0	-			1991	3758	2907		3758	2907
Tatchun	NM	1	0	-			2000	521	415		521	415
Pelly Herds	NM	0	1	-			2002	1000	876		1000	876
Finlayson	NM	4	1	1986	3067	2350	2007	3077	2657	13[12]	3077	2657
Wolf Lake	NM	3	0	-			1998	1491	1240	- [13]	1491	1240
Southern Lakes Yukon												
Laberge	NM	0	1	-			2003	200	176		200	176
Ibex	NM	1	2	1998	424	329	2008	850	748	127	850	748
Carcross[14]	NM	1	2	1997	403	312	2007	775	674	116	775	674
Atlin[14]	NM	1	1	1999	809	679	2007	600-1000	514-857	-2	600-1000	514-857

Table 3 continued.

				Survey Estimates							Population Estimates	
				Initial Estimate			2014 Estimate				2014 Estimate	
Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2004	# full surveys 2002-2014	Year	Total	Mature	Year	Total	Mature	Long-term % change[2]	Total	Mature
Northwest BC												
Swan Lake[14]	NM	0	1	-			2007	600-800	515-686		600-800	515-686
Little Rancheria[14]	NM	2[15]	0	-			1999				800-1600	672-1342
Horseranch[14]	NM	1	0	-			2000	800-1000	680-850		800-1000	680-850
Level Kawdy	NM	1	0	-			1998	1538	1239		1538	1239
Edziza	NM	0	1	-			2006	151	140		151	140
Tsenaglode[16]	NM	0	0	-			2008				100-400	85-340
Spatsizi	NM	1	0	-			1994	2861	2258		2861	2258
Northeast BC												
Liard Plateau[14]	NM	0	3	2005	141	122	2011	151	140	15	151	140
Rabbit	NM	2[17]	1	-			2007	1133	954		1300	1095
Muskwa	NM	1	1	2001	658	559	2007	738	611	9	1000	838
Gataga	NM	1	0	-			2000[18]	265	220		265	220
Frog	NM	1	0	-			2001[18]	237	199		237	199
Finlay	NM	1	1	1994	193	170	2002	26	19	-89	26	19
Pink Mountain	NM	1	0	-			1993	1275	1145		1275	1145

Table 3 continued.

				Survey Estimates							Population Estimates	
				Initial Estimate			2014 Estimate				2014 Estimate	
Subpopulation	2002 COSEWIC Assessment NSP[1]	# full surveys 1987-2004	# full surveys 2002-2014	Year	Total	Mature	Year	Total	Mature	Long-term % change[2]	Total	Mature
North-central BC												
Graham	SM	1	2	-			2009	708	637	-[19]	708	637
Chase	SM	1	4	-			2009	475	404	-[20]	475	404
Wolverine	SM	1	6	1996	361	324	2010	341	298	-9	341	298
Takla	SM	1	1	-			2004	122	98		122	98
West-central BC												
Telkwa	SM	10	13	1987	40	33	2013	16	12	-64	25	19
Tweedsmuir	SM	2	1	1987	471	433	2002	300	248	-47[21]	300	248
Itcha-Ilgachuz	SM	14	7	1987	933	675	2014	1350	905	34[22]	1685	1220
Rainbows	SM	7	1	1987	103	92	2008	50	43	-53	50	43
Charlotte Alplands	SM	6	0	1993	53	38	2001	23	19	-50	23	19

[1] Nationally significant population (see full explanation in manuscript text).
[2] Long-term % change is based on the difference between the initial and 2014 survey estimates.
[3] Although a survey was conducted in 1978, the population estimate was not comparable to the most recent survey because the survey area was not exactly the same.
[4] Estimate based on expert opinion.
[5] The number of mature individuals was derived by applying the average % adults from hunter observations from 1991 to 2010 (Larter 2012).
[6] This estimate is based on an opportunistic ground survey and therefore was not included as a conducted survey.
[7] % change in population size based on 1337 mature individuals in 2001 and 1465 mature individuals in 2009 for an area comparable to the 2001 survey area.
[8] Although a survey was conducted in 1997, the population estimate was not comparable to the most recent survey because the survey area was not exactly the same.
[9] Fall composition surveys have been conducted annually from 1987 to 2011, except 1989 and 2004 (Chisana Working Group 2012). Data prior to 2003 are not considered because population estimates were based on an interpolation of composition data. Since 2003, population estimates are based on formal estimates of the subpopulation's size and are not directly comparable to pre-2003 estimates.

Footnotes to Table 3 continued.

[10] The 2003 survey was a fall composition survey so it was not a formal population estimate.
[11] Although surveys were conducted in 1989 and 2000, the population estimates were not comparable to the most recent survey because the survey areas were not exactly the same.
[12] Although the change from 1986 to 2007 was a net increase of 13%, the population increased from 2350 mature individuals in 1986 to 4474 in 1990, and then decreased to 2657 by 2007 (a 41% decline from its peak in 1990 to 2007).
[13] No recent population estimate so the 3 generation % change was not calculated.
[14] The ranges of the Carcross, Atlin, Swan Lake, Little Rancheria, Horseranch and Liard Plateau subpopulations straddle the Yukon/BC border
[15] Although surveys were conducted in 1988 and 1999, the population estimate were not comparable because the survey areas were not exactly the same.
[16] The population estimate is based on expert opinion; the number of mature individuals was derived by assuming 85% adults.
[17] Although surveys were conducted in 1996 and 2000, the population estimates were not comparable to the most recent survey because the survey areas were not exactly the same.
[18] There is insufficient information available to determine whether this was a full count or a partial count so this estimate should be considered a minimum number present until a full survey can be conducted, and should not be used to assess trend when a full survey is conducted.
[19] Absolute % change not possible to assess since the total survey area varied between surveys.
[20] Although surveys were conducted in 1993, 2002, 2007 and 2008, the population estimates were not comparable to the most recent survey because the survey area/survey method were not exactly the same.
[21] The decline is supported by an average λ of 0.947 for 12 years where data were available during the period 1985/86 to 2008/09 (Cichowski & MacLean 2005, Cichowski 2010).
[22] Although the change from 1987 to 2012 was a net increase of 34%, the population increased from 675 mature individuals in 1987 to 2161 in 2003, and then decreased to 905 by 2014 (a 58% decline from its peak in 2003 to 2014).