Note

There and Back Again: One Caribou's (*Rangifer tarandus*) Migratory Behaviour Hints at Genetic Exchange between Designatable Units

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Spatial overlap periodically occurs between Boreal Caribou designatable unit (DU) 6 and Northern Mountain Caribou DU7, although overlaps are thought to occur primarily in winter when the likelihood of genetic exchange is low. In May 2013, a Caribou migrated from the Parker Boreal Caribou range (DU6) to calve in the alpine area of the Muskwa Northern Mountain Caribou range (DU7). This individual calved in the Parker range in 2014, but in 2015, she repeated her 2013 migration, travelling into the Muskwa range to calve within 700 m of her 2013 calving location. This individual's behaviour points to possible genetic exchange between the two DUs.

Key Words: Caribou; *Rangifer tarandus*; Boreal Caribou; Northern Mountain Caribou; designatable unit; genetic exchange; calving behaviour

For species that are geographically widespread, conservation strategies frequently rely on classifying and prioritizing populations as evolutionary significant units, defined as populations with unique evolutionary histories and adaptive distinctiveness (Crandall *et al.* 2000). In Canada, this approach has been applied to Caribou (*Rangifer tarandus*) with populations classified into 12 "designatable units" (DUs; COSEWIC 2011). The development of Caribou DUs incorporated multiple lines of evidence, including phylogenetics; genetic diversity and structure; morphology; movements, behaviour, and life history; and distribution. It was based on Committee on the Status of Endangered Wildlife in Canada (COSEWIC) guidelines, first approved in 2009 (COSEWIC 2015), where DUs must satisfy a variety of criteria that show both discreteness and evolutionary significance.

Boreal Caribou, classified as DU6, have a widespread distribution in Canada (COSEWIC 2011). Behaviourally, Boreal Caribou also have a unique spatial strategy when calving, with females dispersing widely to calve in isolation (Bergerud and Page 1987; Ferguson and Elkie 2004). However, these pre-calving movements occur primarily within a herd's annual range and are considerably shorter than the long-distance migrations of other DUs, such as Barren-ground Caribou (DU3). Many individuals show relatively high fidelity to calving areas, a behaviour similar to females in other DUs (Schaefer *et al*. 2001; Wittmer *et al*. 2006).

In British Columbia, Boreal Caribou (DU6) are restricted to the northeast corner of the province, where their distribution is adjacent to Northern Mountain Caribou (DU7; COSEWIC 2011). Northern Mountain Caribou are phylogenetically divergent from Boreal Caribou (COSEWIC 2011; Serrouya *et al*. 2012; Weckworth *et al.* 2012), are morphologically distinct (Kuzyk *et al.* 1999), and follow elevational migration at calving (Gustine *et al.* 2006). Overlaps between DU6 and DU7 are believed to be restricted to the winter months suggesting that little genetic exchange occurs between the two units (COSEWIC 2011; Serrouya *et al.* 2012; Weckworth *et al.* 2012). Here, however, we report plasticity in calving behaviour of one Caribou considered to be a member of the boreal population, pointing to possible genetic exchange between DU6 and DU7.

Our focal area encompasses the Parker Boreal Caribou range (58°45'N, 123°5'W) and the Muskwa Northern Mountain Caribou range (58°4'N, 124°25'W) in northeastern British Columbia, Canada. The Parker range is located within the Taiga Plains ecoprovince (Demarchi 2011) and is a mosaic of low-lying peatlands, deciduous and mixedwood uplands, and riparian areas (DeLong *et al.* 1991). Peatlands are dominated by Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh) and Tamarack (*Larix laricina* (Du Roi) K. Koch), whereas uplands are characterized by White Spruce (*Picea glauca* (Moench) Voss), Lodgepole Pine (*Pinus contorta* Douglas ex Loudon), Trembling Aspen (*Populus tremuloides* Michaux), and Paper Birch (*Betula papyrifera* Marshall).

The Muskwa range (Figure 1) is located in the Northern Boreal Mountain ecoprovince, and has a rugged mountainous landscape. Alpine areas typically lack vegetation or are characterized by low shrubs, herbs, bryophytes, and lichens, whereas the subalpine zone is typified by White Spruce and Subalpine Fir (*Abies*

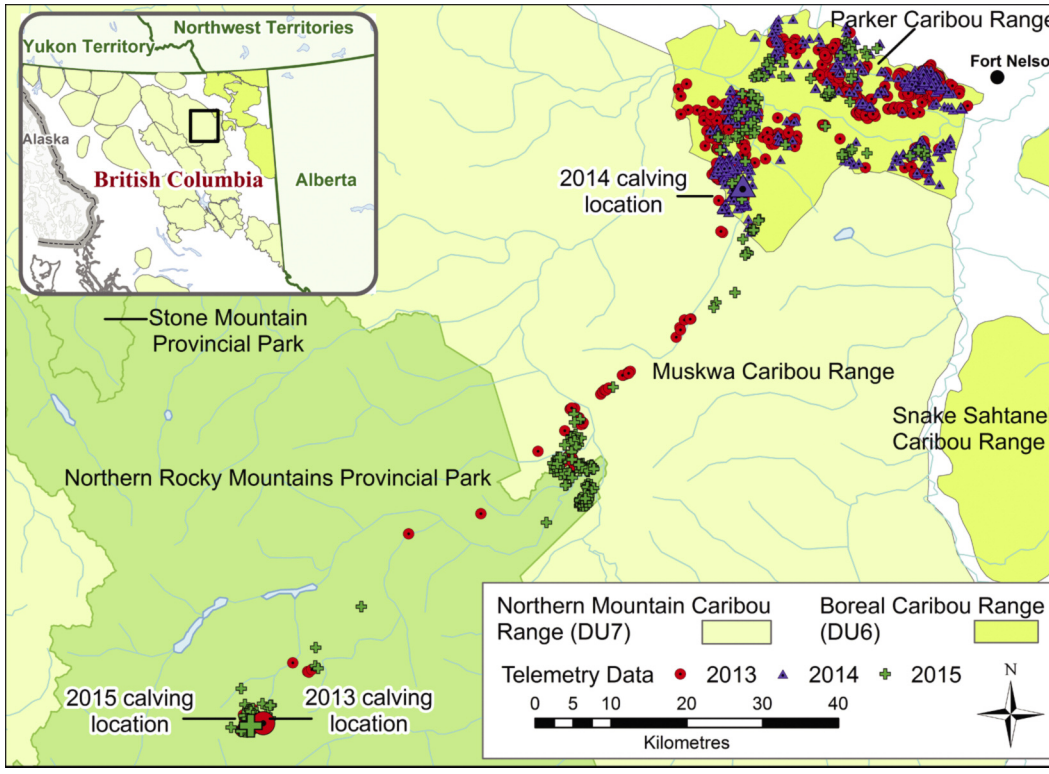

FIGURE 1. Movement of Caribou 14 in northeast British Columbia, 2013–2015. In 2013 (circles) and 2015 (crosses), this female migrated from the Parker Boreal Caribou range to calve in a high alpine area within the Muskwa Northern Mountain Caribou range; in 2014 (triangles), she remained in the Parker range. Designatable unit boundaries according to COSEWIC (2011).

lasiocarpa (Hooker) Nuttall) at lower elevations and tall Scrub Birch (*Betula glandulosa* Michaux) and willow (*Salix* spp.) shrubs at upper elevations (DeLong *et al.* 1991).

As part of a monitoring program initiated collaboratively between government and industry (BC MOE 2015), Global Positioning System (GPS) radio-collars (model 2110E; Advanced Telemetry Systems, Isanti, Minnesota, USA) were deployed on 30 female Caribou across British Columbia's Boreal Caribou range during the winter of 2012–2013. Collars were programmed for a fix rate of every 4 h during the calving season and every 8 h otherwise. In February 2015, Caribou with failing collars were recaptured and fitted with new ones (model GPS Plus Vertex Survey-1, Globalstar; GmbH Vectronics Aerospace, Keswick, Ontario, Canada) programmed for a fix rate of every 13 h. On capture, blood samples were extracted from all females to estimate pregnancy status via blood-serum progesterone testing (in pregnancy, progesterone $\geq$ 2.0 ng/mL; Prairie Diagnostic Services, Saskatoon, Saskatchewan, Canada). All Caribou were captured by net-gunning from a helicopter and were physically restrained during handling. All capture and handling procedures complied with approved government animal care protocols (Resources Inventory Committee 1998; British Columbia Wildlife Act permit FJ12-83091).

For each collared female, we predicted parturition based on movement patterns during the 2013–2015 calving seasons. In northeast British Columbia, peak calving occurs in mid-May (Culling *et al.* 2006; DeMars and Boutin 2014). For the 2013 and 2014 calving seasons, we predicted parturition events using a movement-based method (MBM) outlined in DeMars *et al.* (2013). This method estimates parturition status (calved/did not calve) using *a priori* thresholds of 3-day average movement rates (TDAMs; m/h). For each female, we used GPS location data and predicted that a female had calved when TDAMs dropped below 15.3 m/h. In 2015, we could not use the MBM because collar fix rates were too infrequent; therefore, we predicted parturition visually by plotting daily movement rates.

In 2013, a radio-collared female in the Parker range initiated an unusual pre-calving migration pattern. This female, estimated to be 4–6 years of age, was captured on 7 January 2013 within the Parker range and was determined to be pregnant. This individual, hereafter known as Caribou 14, remained within the Parker range

until 27 May 2013, when she embarked on a journey of approximately 100 km into the Muskwa range where she calved in the alpine area on Mount Shawcross on 1 June 2013 (Figure 1). Caribou 14 remained in the alpine and subalpine areas until 30 June 2013 when she retraced her migratory path, arriving back in the Parker range two weeks later.

The following year, Caribou 14 remained in the Parker range, where she calved on 30 May 2014 and remained for the rest of the year (Figure 1). On 21 February 2015, she was recaptured in the Parker range, fitted with a new collar, and determined to be pregnant. On 14 May 2015, she once again left the Parker range and travelled into the Muskwa range, following a similar route as in 2013. She calved on 27 May 2015 within 700 m of her 2013 calving location. She remained in the alpine area until 1 August 2015 then travelled approximately 34 km in a 24-h period to a peatland complex on the eastern side of the Muskwa range. This rapid movement suggests pursuit by a predator and potential loss of her calf (DeMars *et al*. 2013). Caribou 14 remained in this area of the Muskwa range until she was killed by a wolf pack on 21 November 2015 (DES 2015).

Of the 30 female Boreal Caribou monitored during the course of our study, Caribou 14 was the only individual to demonstrate this atypical calving behaviour. In fact, among the 156 adult female Caribou collared in British Columbia boreal ranges between 2012 and 2015 (Culling and Culling 2015), Caribou 14 was the only animal to exhibit this unusual calving strategy.

The long distance pre-calving migratory movements of Caribou 14 and fidelity to an alpine calving site are characteristics consistent with Northern Mountain Caribou (DU7). Yet, this individual also displayed characteristics of DU6 Caribou by also calving and overwintering in the Boreal Caribou range. It is currently unknown whether calving behaviours are fixed in Caribou; nonetheless, unique calving behaviour is a key criterion for differentiating ecotypes (Bergerud 1996) and is among the multiple lines of evidence differentiating DUs (COSEWIC 2011), suggesting that plasticity in calving behaviour is rare. Although previous studies have documented movement of Boreal Caribou between ranges in Quebec and Labrador (Brown *et al.* 1986), and spatial overlap of mountain and northern ecotypes of Caribou in all seasons in central British Columbia (Jones 2007), to our knowledge, ours is the first documented case of a Caribou switching between calving behaviour characteristic of Boreal Caribou (DU6) and calving behaviour associated with Northern Mountain Caribou (DU7).

If such behaviours are genetically hard-wired (Berthold and Pulido 1994; but see Serrouya *et al*. 2012, who suggested that genetic structure does not consistently correspond with ecotype), the long distance migration and parturition in the Muskwa range by Caribou 14 suggest that genetic exchange between these two DUs may be occurring. Such exchange would have to take place during the rut and, in this respect, Caribou 14 showed spatial variation during this period, being in the Parker range for the 2013 and 2014 ruts and in the Muskwa range for 2015.

The potential intermixing of Northern Mountain and Boreal Caribou has direct implications for conserving Caribou within this range, where the population is estimated to be less than 50 and in sustained decline (Environment Canada 2012; Culling and Culling 2015). Such intermixing, for example, may reduce the vulnerability of a small, isolated population to negative genetic effects, such as inbreeding depression (Ingvarsson 2001). However, we caution that our observation is restricted to a single animal and, therefore, conclusions may be limited. Nevertheless, our results suggest further investigation may be warranted to understand rates of potential movements between these two adjacent populations and would help resolve the current DU boundaries.

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