

## Seasonal movements of White-tailed Deer (*Odocoileus virginianus*) in the Rocky Mountains of British Columbia

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### Abstract

Nineteen adult female White-tailed Deer (*Odocoileus virginianus*), fitted with very high frequency or global positioning system collars in the Rocky Mountains of southeast British Columbia, exhibited straight-line seasonal movements ranging from <4 km to 109 km. Movement was almost entirely along the floor of both low- and high-elevation valleys, although there was some use of mid-elevation mountainsides during early winter. Spatial locations of deer spanned 891–2234 m above sea level. Seasonal movements of these deer from a single winter range extended to two provinces, three national parks, one provincial park, non-park provincial Crown land, and private land. Deer populations with similar movement patterns may be most effectively managed by considering their extensive movements and coordinating approaches across jurisdictions.

Key words: Kootenay National Park; *Odocoileus virginianus*; seasonal movement; summer range; White-tailed Deer; winter range

### Introduction

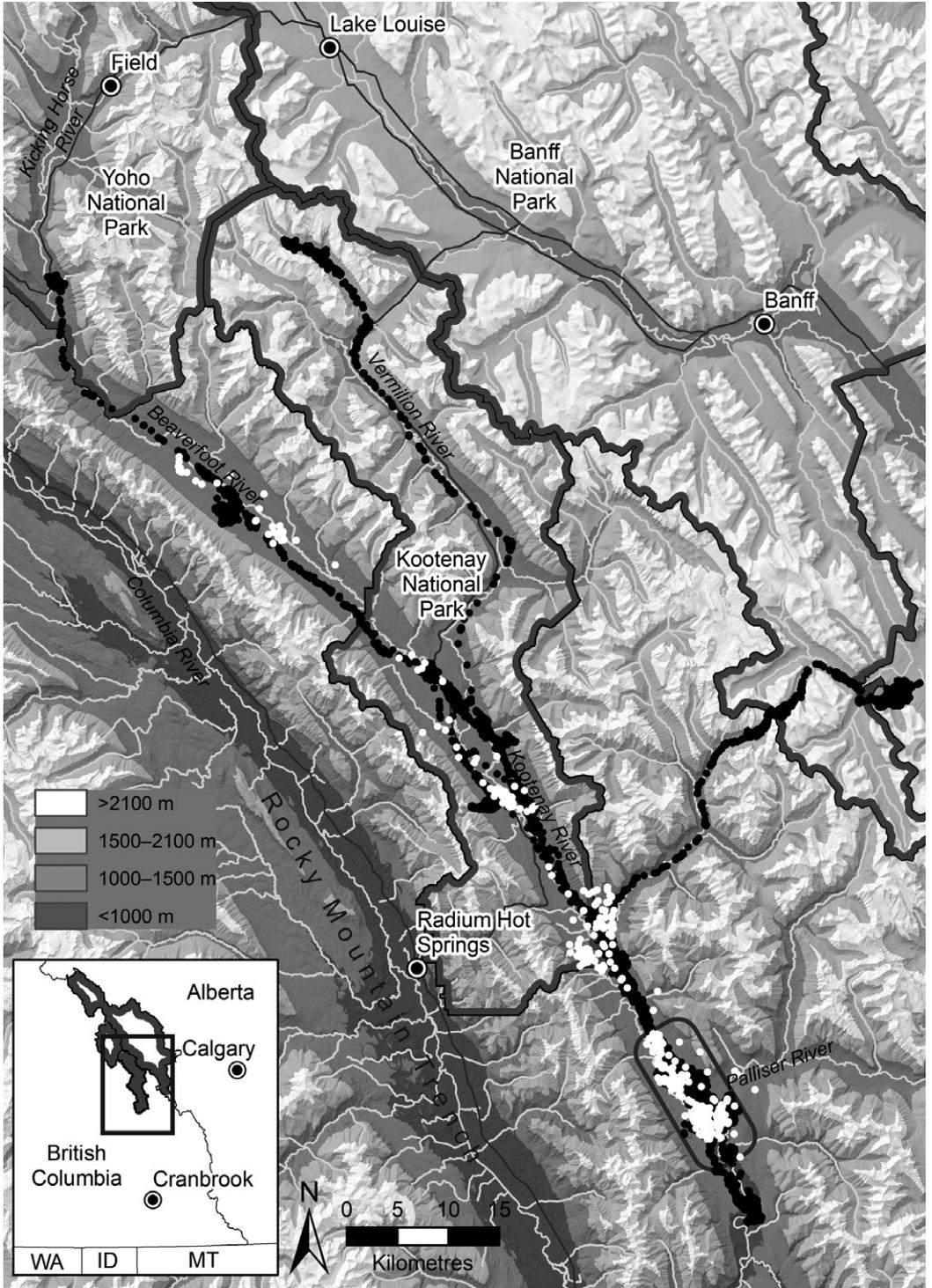
White-tailed Deer (*Odocoileus virginianus*) inhabit a range of ecosystems across North and South America. Some individuals and populations exhibit migration (round-trip movements between distinct seasonal ranges, *sensu* Berger 2004) of tens of kilometres, with greater movements typical in northern or mountainous locations (Baumeister 1992; Demarais *et al.* 2000; Robinson *et al.* 2002; Nelson *et al.* 2004; Brinkman *et al.* 2005; Stewart *et al.* 2011). In some study areas, individuals may be sedentary, facultative migrators, or obligate migrators (Sabine *et al.* 2002; Brinkman *et al.* 2005; Fieberg *et al.* 2008; Grovenburg *et al.* 2011). Deer on low-quality winter range may be more likely to migrate as a result of density-dependent competition (Henderson *et al.* 2018). During spring and summer, an advancing line of greening vegetation offers ungulates in the Rocky Mountains the opportunity to follow high-quality habitat up slope (Merkle *et al.* 2016; Middleton *et al.* 2018).

Based on long-term roadside surveys and incidental observations, White-tailed Deer in Kootenay National Park (KNP), British Columbia (BC), Canada, are common from spring through fall, but absent or nearly so during winter (S. Wrazej unpubl. data). Considering those observations in the context of the

strong elevation gradient in the area, seasonal elevation differences reported for nearby deer populations (Robinson *et al.* 2002; Hoekman *et al.* 2006), and an expectation of generally low-quality winter ranges for deer in snowy, mountainous areas in the northern part of their range, I speculated that deer summering in the park overwintered at lower elevations south of the park. I collared adult female White-tailed Deer south of the park and within the park, and investigated their movement patterns. Deer were monitored for variable periods and could not all be confirmed to make return movements (migrations); thus, I use the more general term “seasonal movement”. I report on seasonal movements and elevation-use patterns of these collared deer, including in relation to jurisdictional boundaries potentially affecting management regimes.

### Study Area

The Beaverfoot and upper Kootenay Rivers are part of the Columbia River watershed of southeast BC (Figure 1). Their headwaters rise in the same valley in the Rocky Mountains. From there, the Beaverfoot River flows generally north by northwest into Yoho National Park where it joins the Kicking Horse River, which eventually exits the Rocky Mountains and flows into the Columbia River in the Rocky Mountain



**FIGURE 1.** Pooled location data from 19 female White-tailed Deer (*Odocoileus virginianus*) fitted with global positioning system (black dots) or very high frequency (white dots) collars in the upper Kootenay River valley of British Columbia, 2011–2016. Winter range is oval in lower right.

Trench (hereafter "Trench"). The Kootenay River flows south by southeast, passing through and beyond KNP before exiting the Rockies into the Trench. The elevation of the valley bottom is ~1250 m at the headwaters and ~1050 m at the downstream ends of the parks. Mountains adjacent to the rivers reach a maximum elevation of 2400–3000 m.

Leading tree species vary with elevation and location, but along the valley bottoms are primarily Lodgepole Pine (*Pinus contorta* Douglas ex Loudon), Engelmann Spruce (*Picea engelmannii* Engelmann), Trembling Aspen (*Populus tremuloides* Michaux), Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco), Western Larch (*Larix occidentalis* Nuttall), and, locally, Western Red Cedar (*Thuja plicata* Donn ex D. Don). At higher elevations, leading tree species are Engelmann Spruce and Subalpine Fir (*Abies lasiocarpa* (Hooker) Nuttall). Vegetation is dominated by mixed-age, mixed-species stands of those conifers interspersed with burns, wetlands, cutblocks from past logging (outside of parks), and non-forested areas on the highest peaks. This variety includes the range of grass, shrub, and open forest cover types normally selected by deer nearby and also the greater canopy cover selected under deep snow conditions (Hoekman *et al.* 2006). There is no agriculture within the study area.

## Methods

Deer were captured in Clover traps (VerCauteren *et al.* 1999) baited with either hay and liquid and dried commercial deer attractants or hay, salt, apple, and dried molasses. One deer was immobilized by free-range darting (Dan-Inject APS, Børkop, Denmark) using a medetomidine–ketamine mixture (Caulkett *et al.* 2000). Deer captures were undertaken primarily in February 2014 on a winter range 15–20 km south of the southern boundary of KNP (Figure 1). This was at the confluence of the Kootenay and Palliser Rivers, at an elevation of 950–1100 m. Capture also occurred during November 2011, April 2012, and November–December 2015 within or beside anthropogenic forest openings in KNP, at ~1160 m elevation.

Females <11 months old and all males were released. All other females were fitted with collars, either global positioning system (GPS; G2110D, Advanced Telemetry Systems, Isanti, Minnesota, USA) or very high frequency (VHF; LMRT-2, Lotek Wireless, Newmarket, Ontario, Canada). One female originally fitted with a VHF collar was later recaptured and fitted with a GPS collar. GPS collars attempted fixes hourly, were programmed to detach about 10 months after collaring, and were downloaded on retrieval. VHF-collared deer were relocated on an approximately two-week schedule

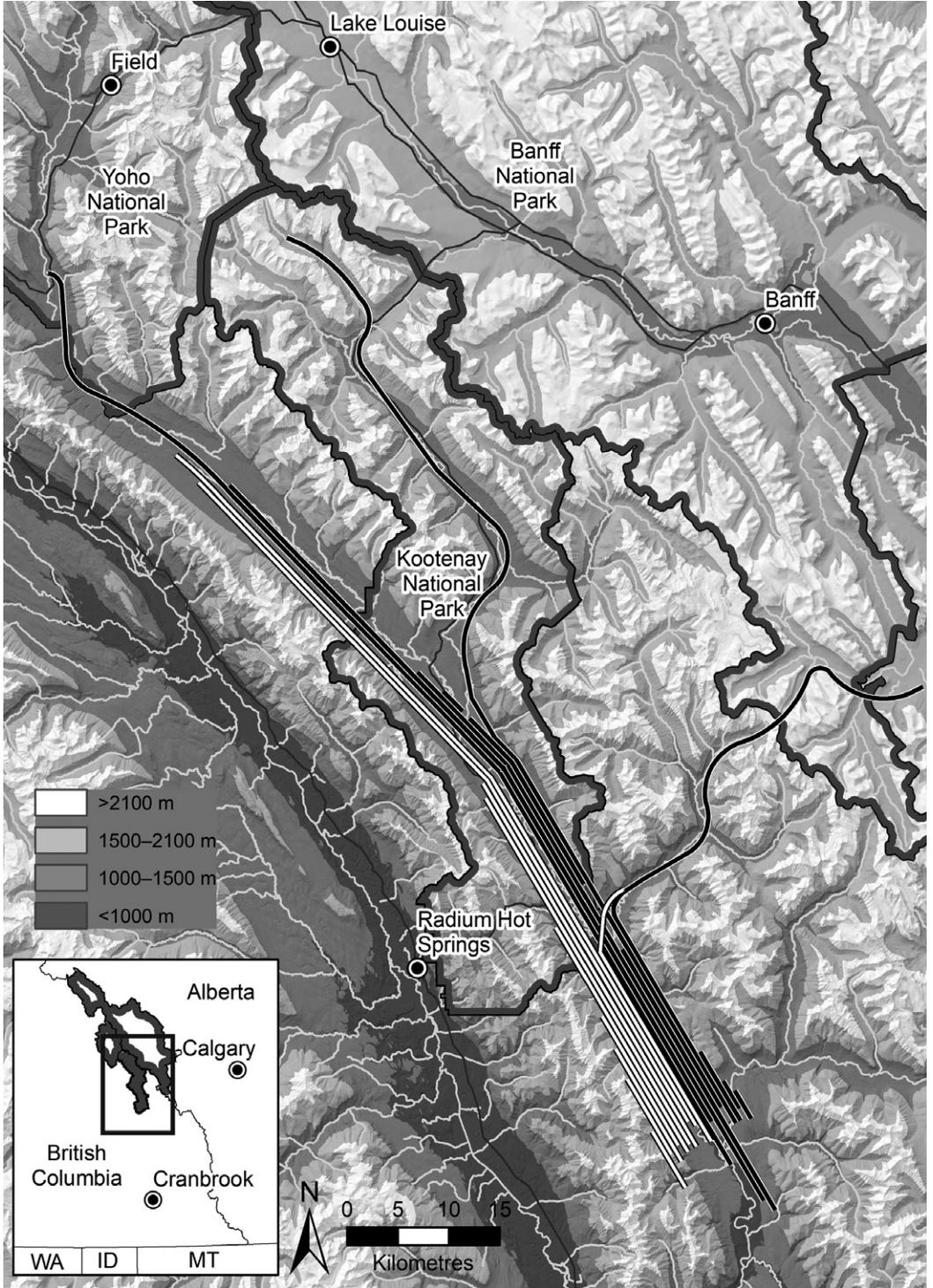
through ground monitoring. Aerial monitoring was undertaken twice in late winter of the first year, when only one deer was collared and snow depth prevented ground access, and once for all deer in another year as they left the winter range when not all deer could be located from the ground.

Maximum straight-line movements were determined for each deer monitored from at least January or February to July or August or the reverse for one or more years, i.e., for those with potential to demonstrate seasonal movements. Universal Transverse Mercator coordinates were used to calculate Euclidean distances between the most distant points. Elevations reported here are only as recorded on-board GPS collars because, in the mountainous study area, relatively small horizontal errors would translate into considerable elevation errors if extracted via a geographic information system, especially for VHF collar data. All maximum and minimum elevation records were confirmed to be within clusters of sequential locations and, hence, unlikely to reflect significant GPS error. To represent movement vectors at an appropriate scale, sequential records of deer locations were manually approximated graphically. Where overlapping individuals were not distinguishable, these representations were further linearized for visual clarity.

## Results

Time from date of collaring to death, collar drop, or cessation of monitoring ranged from 299 to 1417 days for the 10 VHF-collared deer ( $\bar{x}$  = 667, SD 295) and from 166 to 320 days for the nine GPS-collared deer ( $\bar{x}$  = 286, SD 56) for which seasonal movements were calculated. Maximum straight-line movements (Figure 2) ranged from 6.1 to 82.4 km for VHF-collared deer ( $\bar{x}$  = 33.0 km, SD 27.3) and from 3.4 to 109.2 km for deer with GPS collars ( $\bar{x}$  = 48.7 km, SD 40.0). Among GPS-collared deer, maximum elevations ranged from 1199 m to 2234 m and minimum elevations from 891 m to 997 m (pooled sample: 10% < 1010 m, 10% > 1382 m). Variation in elevation use was evident during summer, with two deer occurring at maximum elevations (>1900 m) at a time when all others were below 1500 m, and during early winter when two deer used elevations above 1600 m while others were below 1300 m (Figure 3).

Seventeen deer were not recorded outside the contiguous Kootenay–Beaverfoot–Kicking Horse valley (Figures 1 and 2), but two moved into a major tributary valley or crossed the Continental Divide into Alberta. All 19 occurred for at least part of the year on provincial Crown land in BC, of which at least nine also made use of Kootenay, Yoho, or Banff national parks, one of Spray Valley Provincial Park,



**FIGURE 2.** Maximum extent of movements of 19 female White-tailed Deer (*Odocoileus virginianus*) fitted with global positioning system (black lines) or very high frequency (white lines) collars in the upper Kootenay River valley of British Columbia, 2011–2016. Movements are presented as linear vectors for visual clarity.

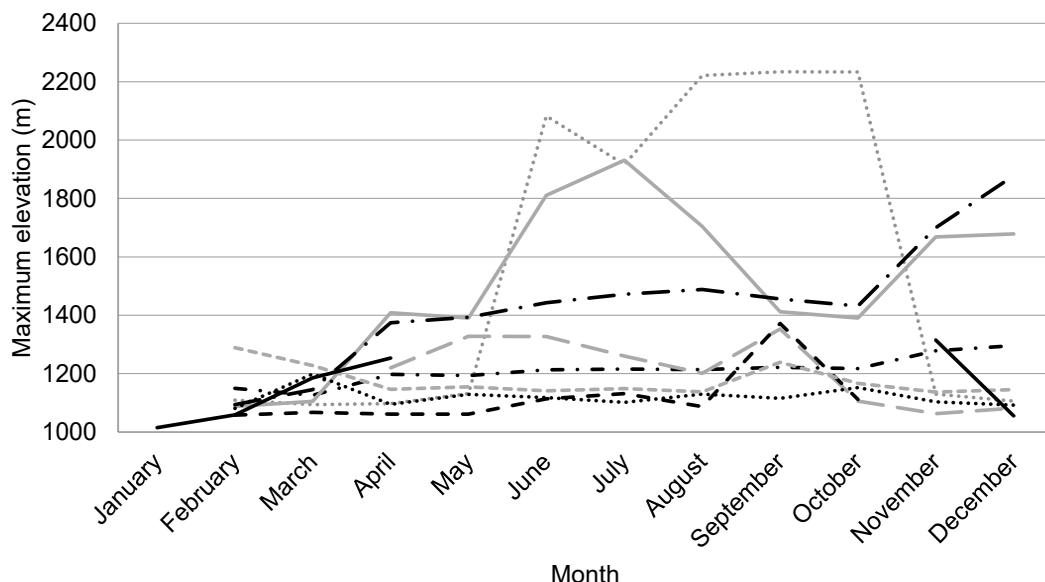


FIGURE 3. Maximum elevation per month of nine White-tailed Deer (*Odocoileus virginianus*) captured in the upper Kootenay River valley of British Columbia and fitted with global positioning system collars, 2012–2016.

Alberta, and five of private land in BC. Of the nine using one or more national parks for part of the year, at least eight were on Crown or private land in BC during part or all of the current regular, youth, or bow-only “antlerless” hunting seasons from October through December (MFLNRORD 2018). One collared deer summered south of the winter range; all others were generally north.

### Discussion

Given the lower frequency of monitoring of VHF collars and potential effects of limited access on manual monitoring, data from VHF collars likely underrepresent deer movements and use of high elevations relative to GPS collars. The apparently shorter maximum movements of VHF-collared deer despite longer duration of monitoring may reflect that. However, for both collar types, a wide range and broadly similar distribution of maximum movements was recorded. Even with the possibility that some deer movements reported in other studies may have represented dispersals, mean and maximum seasonal movements reported here are greater than values reported from nearby studies in the mountains of BC and northwest United States (Morgan 1993; Secord 1994; Robinson *et al.* 2002; Hoekman *et al.* 2006) and in 10 earlier studies from the same region summarized by Baumeister (1992: 56) and similar to those observed by Baumeister (1992). Compared with the findings of most of those authors and Henderson *et al.* (2018), maximum movements of the deer in my study

were an order of magnitude greater.

A range of elevation-use strategies was apparent. Use of minimum elevations was similar among individuals, but maximum elevations varied considerably. Most deer activity was along the floor of the main valley in which they wintered. When deer left that valley, movements typically followed the floors of the tributary valleys in which they travelled. However, the higher elevations of those tributaries, along with some limited forays from the main valley to adjacent mountain slopes, were associated with several other patterns of elevation use. Some deer occurred at high elevations for at least part of the summer, and some moved to relatively high elevations during early winter.

Relatively long-distance movement by deer in this study area may have reflected the abundance and broad distribution of moderate- to high-elevation summer habitats and the limited elevation gradient at valley-floor positions, such that any deer gaining the advantage of following the wave of greening vegetation upslope (Mysterud 2013; Merkle *et al.* 2016, Middleton *et al.* 2018) without leaving valley floors would be obliged to move considerable distances in this landscape. The existence of a wintering population in an elevated valley proximal to the Trench is notable. The Trench is as close as 15 km to summer and winter activity (Figure 1), is accessible via several passes or downstream movement, is at lower elevations with less snow and warmer winter temperatures, includes agricultural fields and extensive riparian areas, and

is notable for an abundant large-mammal fauna and high-quality winter range (Benson 1970) including for deer. Delaying movement to winter ranges is advantageous to some ungulates (Mysterud 2013), yet White-tailed Deer are poorly adapted to snow (Stelfox and Taber 1969; Telfer and Kelsall 1984). For deer in my study, further travel through snow to reach the Trench may be prohibitive late in the season despite apparently higher-quality habitat used by other deer in the Trench. Alternatively, the shorter return distance to summer habitats and the ability to more precisely gauge the initiation of green-up may offer advantages to remaining within the mountains during winter. Additional collaring on summer ranges within this region of the Rocky Mountains would indicate whether some White-tailed Deer summering there do seasonally join other deer in the Trench.

Deer wintering in the upper Kootenay River valley occurred in Kootenay and Yoho national parks in BC, Banff National Park and Spray Valley Provincial Park in Alberta, and both private land and non-park Crown land in BC. For a species as resilient as White-tailed Deer (Halls 1978), a lack of protective management across jurisdictions is unlikely to have the severe population effects experienced by many migratory ungulates (Bolger *et al.* 2008). However, management goals for resource extraction, fire, deer hunting, predator hunting and trapping, ecological integrity, and recreation have the potential to constrain or enhance deer populations and movements. Cross-jurisdictional differences may influence the ability of any agency to achieve its wildlife or ecosystem objectives. For example, managing predators or enhancing habitat to benefit deer would have less effect if done only on a portion of the population's annual range, and maintaining a naturally functioning system may be affected by activities on other land bases, such as hunting during the "antlerless" deer season on provincial and private land. It would be prudent for resource managers to coordinate their efforts with nearby jurisdictions or at least consider the effect of extensive seasonal movements when managing White-tailed Deer in the Rocky Mountains.

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