Long-distance Movement of the Granby Ram Through Colorado and Wyoming

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ABSTRACT On 7 July 2009, Colorado Division of Parks and Wildlife staff captured and placed a Global Positioning System collar with satellite upload capability on a 5-year-old bighorn sheep (*Ovis canadensis*) ram near Granby, Colorado. This lone ram, known as the Granby ram, had been observed in the area 19 km from the nearest bighorn herd for the previous 7 months. Our goal was to monitor his movements, determine if he was likely to contact any domestic sheep, and to prevent him from contacting other bighorns if necessary. The ram remained within 10 km of the capture site for 3 months. Then, from 19 October 2009 to 11 January 2010, he traveled approximately 650 km through Colorado and Wyoming, passing through the home ranges of 5 bighorn herds. On 11 January 2010, due to concerns over pathogens the ram may have been carrying, the Wyoming Game and Fish Department killed him to prevent him from contacting Wyoming's bighorn herds. In this article, we describe the movements of the Granby ram in relation to modeled habitat and bighorn herd home ranges and characterize the attributes of his locations during his movement from Granby, Colorado to the Laramie Mountains of Wyoming.

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Long-distance movements of bighorn sheep (*Ovis canadensis*) outside of their home ranges have been reported in previous studies. O'Brien (2014) reported bighorns travelling 50 km from their core home ranges in Idaho, with 10% of the rams traveling at least 21 km outside of their core home ranges. Festa-Bianchet (1986) reported ram movements of 48 km in Alberta, Canada. DeCesare and Pletscher (2006) reported movements of 19– 33 km by 4 of 5 radio-collared males in Montana. In Colorado, an ear-tagged ram from the Dome Rock herd appeared in Waterton Canyon 50 km away and stayed for several years. In the early 1990s, a ram that had been ear-tagged as a lamb in Georgetown was harvested by a hunter in the Kenosha Mountains 35 km away. Another ear-tagged ram moved from Waterton Canyon to Green Mountain 25 km away and remained in the area for months (J. George, personal communication). In addition to these rams, there are numerous examples of bighorn sheep being observed far outside bighorn herd home ranges apparently on long-distance movements.

On 7 July 2009, Colorado Division of Parks and Wildlife (CPW) staff placed a Global Positioning System (GPS) radio collar on one such bighorn ram, which has come to be known as the Granby ram. This 5-year-old ram had

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been observed alone near Granby, Colorado, approximately 19 km from the nearest bighorn herd for the previous 7 months. Our goal was to monitor his movements, determine if he was likely to contact any domestic sheep, and prevent him from contacting other bighorns if necessary. From 19 October 2009 to 11 January 2010, he traveled approximately 650 km through Colorado and Wyoming. Here, we describe his movements in relation to modeled habitat and bighorn herd home ranges and characterize the attributes of his locations during his movement from Granby, Colorado, to the Laramie Mountains of Wyoming.

STUDY AREA

The capture location was in north central Colorado along the Fraser River between the towns of Granby and Tabernash in Grand County. This area is approximately 90 km northwest of Denver and is an island of habitat suitable for bighorn sheep. The locations used by the Granby ram while in this area ranged from 2,480 m to 2,840 m in elevation and were dominated by lodgepole pine (*Pinus contorta*). The nearest area of significant bighorn habitat is 11 km to the west. The nearest bighorn herds are the St. Vrain herd with a population in 2010 of approximately 50 bighorn 19 km to the northeast, and the Georgetown herd with a population in 2010 of approximately 300 bighorn 20 km to the south.

The removal location was in the Laramie Mountains of Wyoming in Converse County. This location is within the range of the Laramie Peak herd, which is 150 km north of Laramie, Wyoming. The area is predominately big sagebrush (*Artemisia tridentate*) shrubland. The Granby ram's locations ranged in elevation from 1,990 m to 2,400 m.

METHODS

On 7 July 2009, CPW staff captured the 5-year-old Granby ram via chemical immobilization. CPW staff fitted him with a Northstar Globalstar D-cell collar. This was a GPS collar with satellite upload capabilities that was programmed to record 6 locations each day at 0500 hours, 0800 hours, 1100 hours, 1400 hours, 1700 hours, and 2000 hours mountain standard time and to upload the 2000 hour location each day. They collected disease samples at the time of capture. We then monitored his movements via satellite uploads as he moved through Colorado and Wyoming. CPW staff informed the Wyoming Game and Fish Department (WGF) when he crossed into Wyoming. On 11 January 2010, he was lethally removed by the WGF to prevent him from contacting local bighorn and possibly transmitting pathogens he may have been carrying. The WGF performed a necropsy on the ram. We downloaded the stored data points from the collar.

The Payette National Forest developed a number of models to assess the viability of bighorn populations on the Forest as part of the Payette National Forest Land and Resource Management Plan (US Department of Agriculture, Forest Service 2010). One of these models was the Summer Source Habitat Model, which uses topography and vegetation to identify suitable bighorn habitat. CPW refined the US Forest Service (USFS) Summer Source Habitat Model for use in Colorado based on radio telemetry data from Colorado, as follows: 1) the minimum slope of escape terrain was reduced from 31° to 27°; 2) allowable canopy cover was increased from 30% to 70%; 3) low-intensity developed land was included; 4) mesic-wet spruce fir forest was removed; 5) pinyon pine (*Pinus edulis*)-juniper (*Juniperus* spp.) and Gambel oak (*Quercus gambelii*) with ≤ 40% was included; and 6) all alpine was included (Eichhoff et al. 2012). Wyoming has not yet refined the USFS Summer Source Habitat Model based on telemetry data from Wyoming. To evaluate the Granby ram's habitat use, we intersected his telemetry locations with slope and aspect

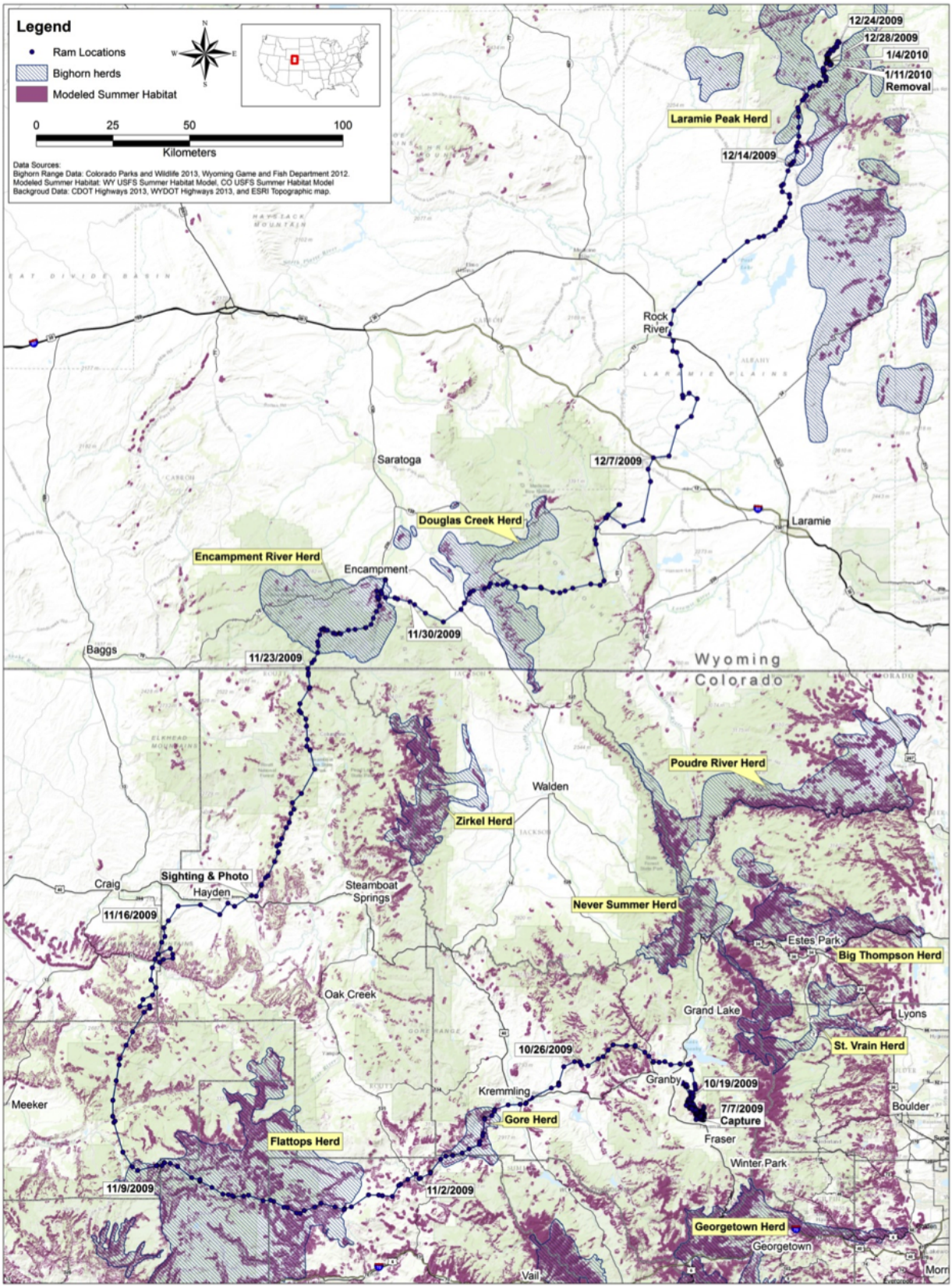

Figure 1. Locations of the Granby ram in relation to bighorn sheep herds and modeled bighorn habitat as he moved through Colorado and Wyoming, USA, 7 July 2009 to 11 Jan 2010.

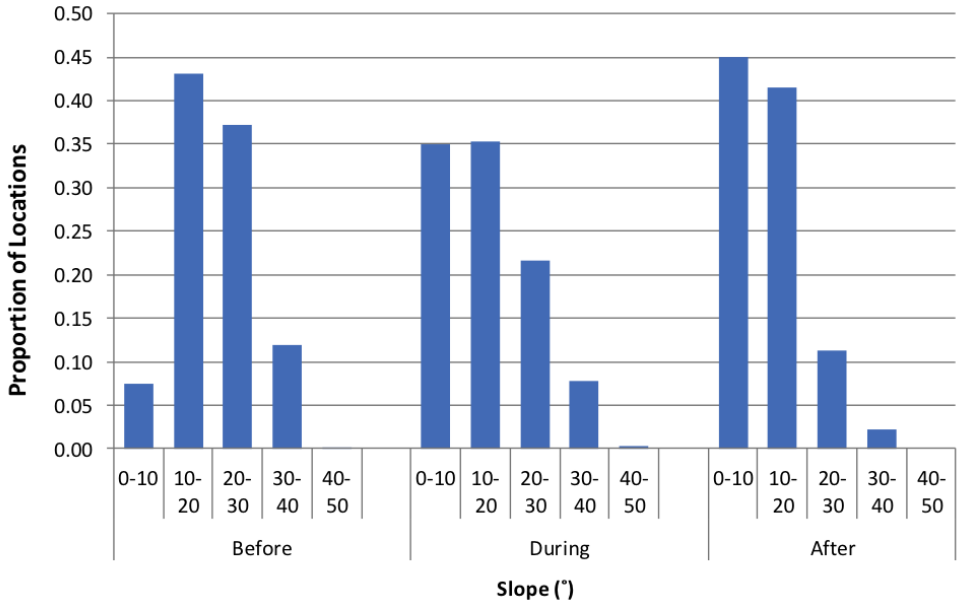

Figure 2. Slope of the locations of the Granby ram before (7 July 2009 to 18 Oct 2009; n = 577), during (19 Oct 2009 to 28 Dec 2009; n = 391) and after (29 Dec 2009 to 11 Jan 2010; n = 88) his movement from Granby, Colorado, to the Laramie Mountains, Wyoming.

derived from a 30-m DEM, LANDFIRE vegetation and canopy cover, and either the USFS Summer Source Habitat Model for the Wyoming locations or the Colorado Summer Source Habitat Model for the locations in Colorado.

The Granby ram's locations occurred during summer, fall, and winter. We have chosen to compare all of the locations to the summer habitat model because this is the most inclusive model. Winter models are a restricted case of the summer models in which certain aspects, elevations, and areas of persistent snow are excluded. Even fewer of the Granby ram's locations would have been within the winter model.

The attributes of the locations before, during, and after the movement from Granby, Colorado, to the Laramie Mountains, Wyoming, differ and are reported separately. These differences may have been due to habitat availability in the areas used or due to the fact that the locations before the movement occurred primarily in the summer; those during the movement occurred primarily in the fall and those after the movement occurred in the winter.

RESULTS

The radio collar worn by the Granby ram recorded 1,059 locations between 7 July 2009 and 11 January 2010; an average of 5.6 locations per day (Fig. 1). The longest time between recorded locations was 15 hours. The Granby ram remained within 10 km of the capture site for 3 months after capture. Between 19 October 2009 and 28 December 2009, he traveled more than 650 km through Colorado and Wyoming. He reached the furthest extent of movement in the Laramie Mountains of Wyoming on 24 December 2009. He then traveled back along his trail for 4 days and 6 km. He remained within 1.2 km of this location until 11 January 2010 when he was lethally removed by WGF to prevent him from contacting bighorns and transmitting any pathogens he was carrying.

He passed through the ranges of 2 bighorn herds in Colorado (the Gore and Flattops herds) and 3 bighorn herds in Wyoming (the Encampment River, Douglas Creek,

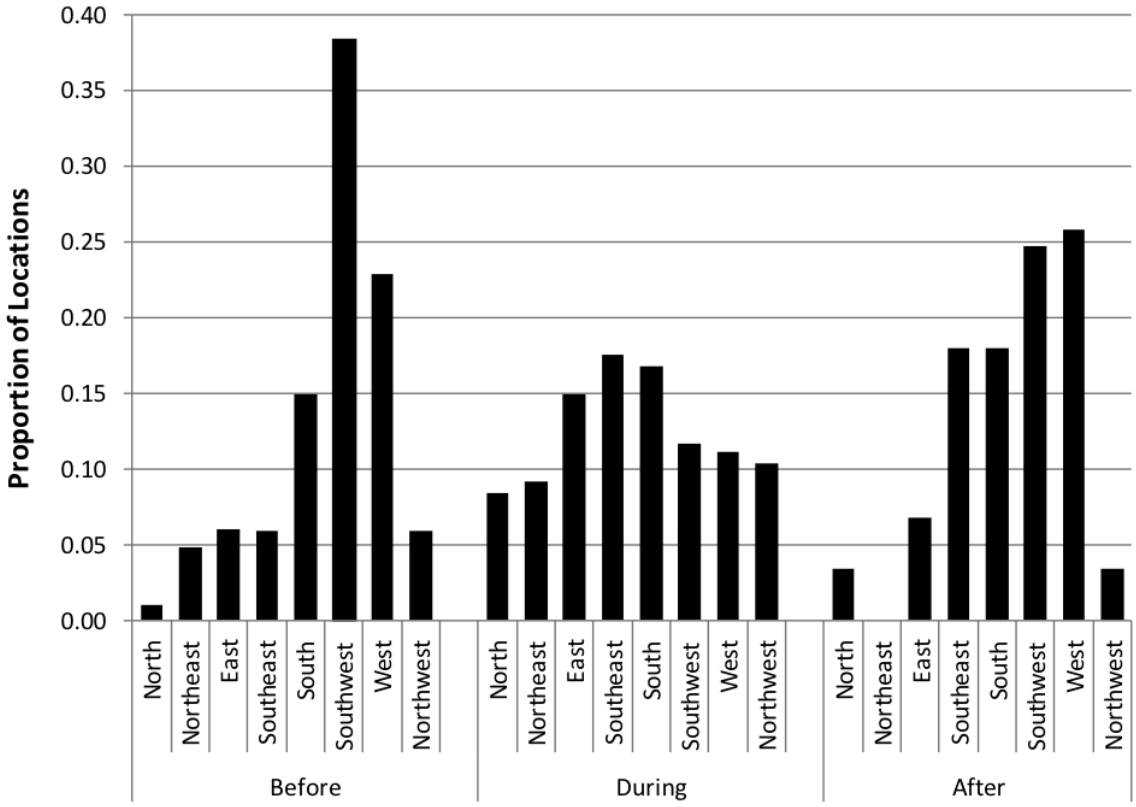

Figure 3. Aspects of Granby ram locations before (7 July 2009 to 18 Oct 2009; n = 577), during (19 Oct 2009 to 28 Dec 2009; n = 391) and after (29 Dec 2009 to 11 Jan 2010; n = 88) his movement from Granby, Colorado, to the Laramie Mountains, Wyoming.

and Laramie Peak herds). He also passed through numerous sheep grazing allotments in Colorado and Wyoming. He was observed and reported only 2 times during his travels. One of these reports initially claimed that he was travelling with other sheep but that proved to be unsubstantiated. One of the observers took a photograph of him near Hayden, Colorado.

Sixty-five percent of the locations in Colorado were within the Colorado Summer Source Habitat Model (Eichhoff et al. 2012). Four percent of the locations in Wyoming were within the USFS Summer Source Habitat Model (US Department of Agriculture, Forest Service 2010).

Ninety percent of all locations were on slopes of 0-30˚, with the highest proportion of locations on slopes of 10-20˚ (Fig. 2). The proportion of locations on slopes of 30-50˚ was higher before the movement than during or after.

Fifty-four percent of all locations had southerly aspects. During the movement, the locations were more evenly dispersed among all aspects, whereas southerly aspects were more prominent before and after the movement (Fig. 3).

Locations prior to the movement were predominately tree-dominated, whereas those following the movement were predominately shrub-dominated. During the movement, tree-dominated and shrub-dominated locations were similarly represented (Fig. 4). Of the tree-dominated locations, the 40-50% tree-cover class was the most common prior to the movement, whereas during the movement, the 50-60% tree-cover class was the most common. After the movement, only 2 locations

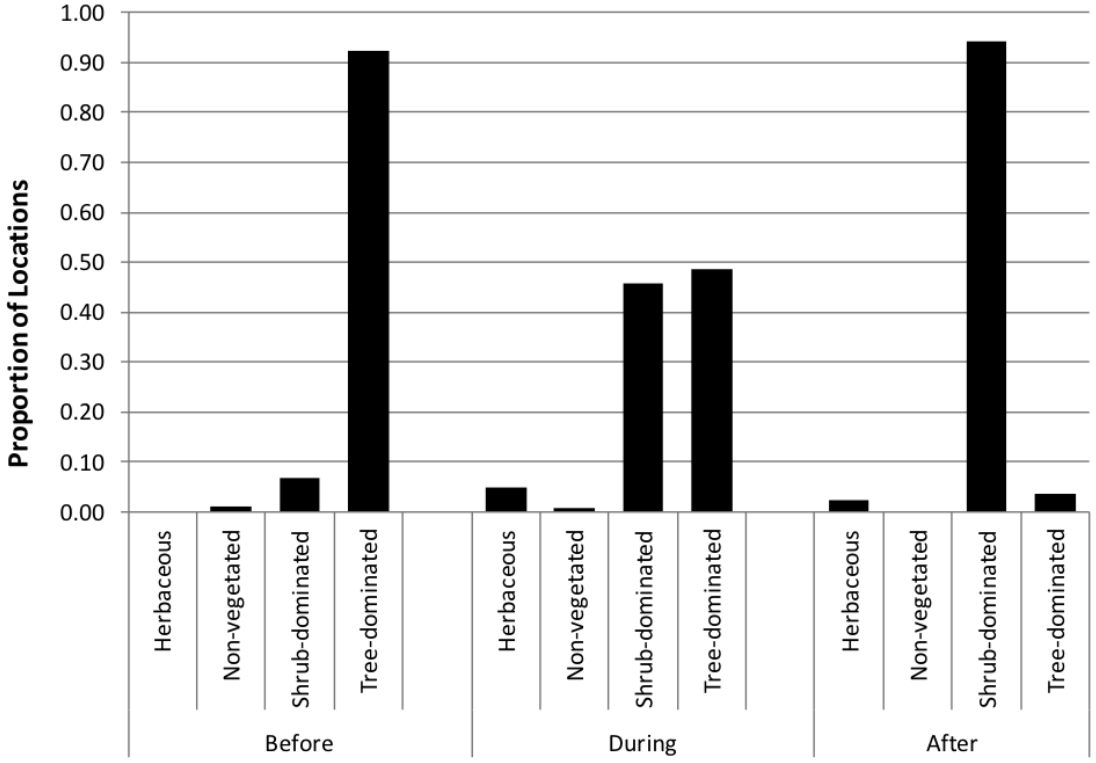

Figure 4. Vegetation cover classes of the locations of the Granby ram before (7 July 2009 to 18 Oct 2009; n = 577), during (19 Oct 2009 to 28 Dec 2009; n = 391) and after (29 Dec 2009 to 11 Jan 2010; n = 88) his movement from Granby, Colorado, to the Laramie Mountains, Wyoming.

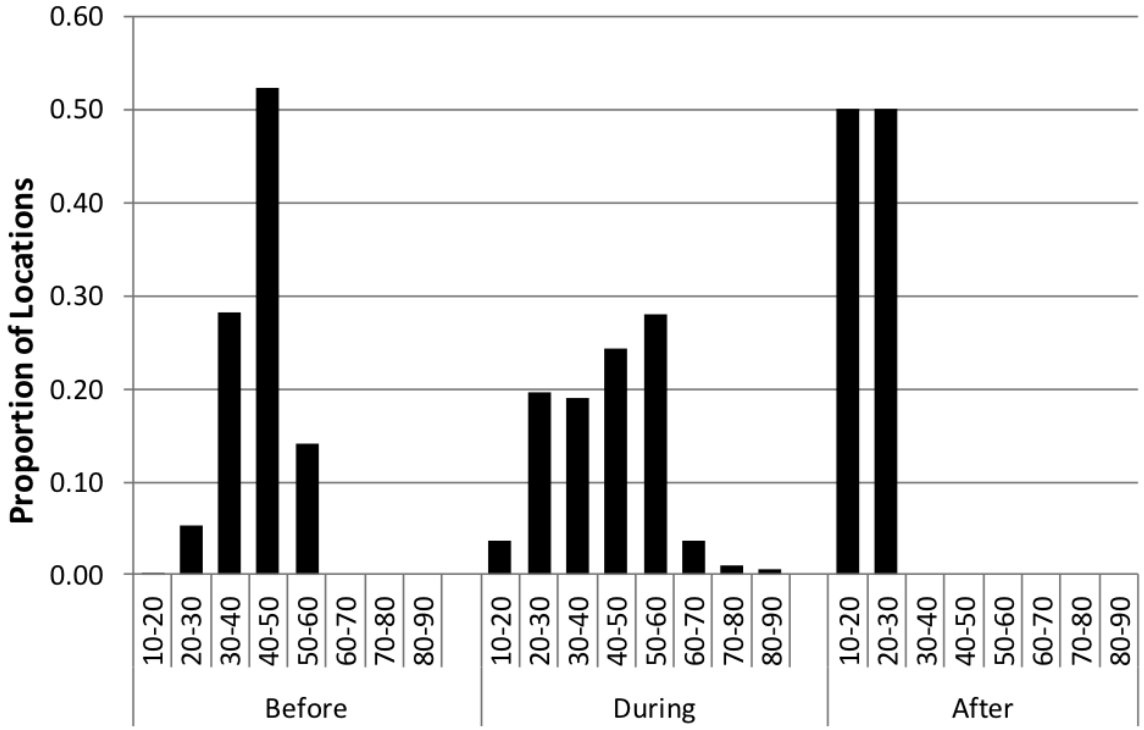

Figure 5. Percentage of tree-cover in tree-dominated locations of the Granby ram before (7 July 2009 to 18 Oct 2009; n = 533), during (19 Oct 2009 to 28 Dec 2009; n = 118) and after (19 Dec 2009 to 11 Jan 2010; n = 2) his movement from Granby, Colorado, to the Laramie Mountains, Wyoming.

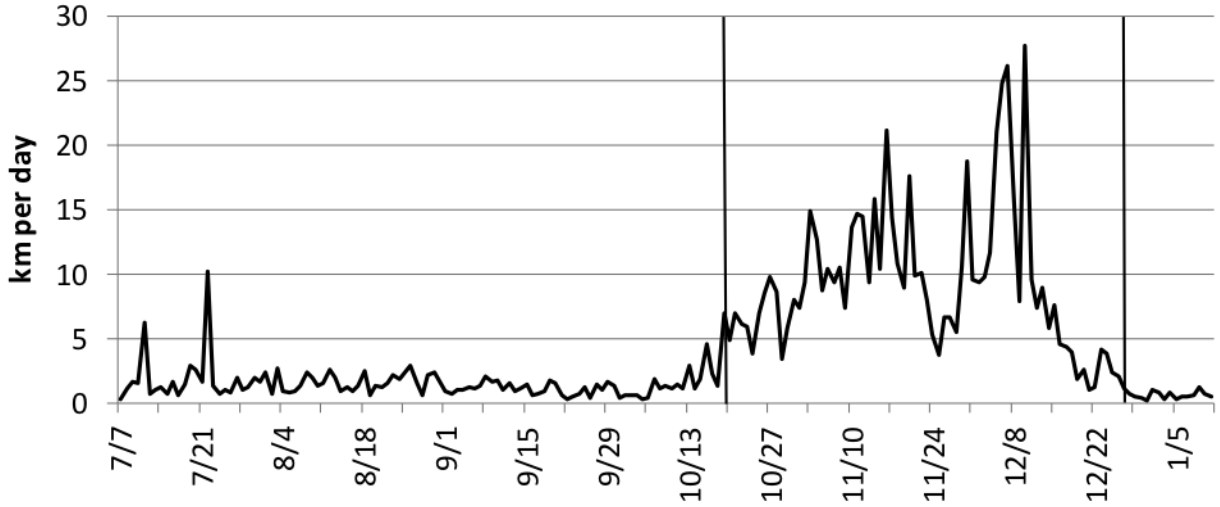

Figure 6. Speed of travel of the Granby ram before (7 July 2009 to 18 Oct 2009), during (19 Oct 2009 to 28 Dec 2009) and after (29 Dec 2009 to 11 Jan 2010) his movement from Granby, Colorado, to the Laramie Mountains, Wyoming.

were tree-dominated (10-30% tree cover) (Fig. 5).

Before, during, and after his movement from Granby, Colorado, to the Laramie Mountains of Wyoming, he traveled an average of 1.8, 11.3, and 0.7 km per day, respectively (Fig. 6). Before his movement, he only traveled more than 3 km per day on 3 occasions (10, 6, and 5 km/day). During his movement, he only moved slower than this on 8 days after he reached the Laramie Peak herd. He traveled more than 20 km/day on 5 occasions, with a maximum of 27.7 km/day. The longest distances moved per day occurred during movement across large expanses of non-habitat between the Douglas Creek and Laramie Peak herds of Wyoming. After his movement, he never moved more than 1.3 km/day.

At the time of capture, the Granby ram was in good body condition and no mycoplasma, parainfluenza, or hemolytic pasteurella strains were detected in the biological samples (CPW, unpublished data). At the time of removal, he was still in good body condition (WGF, unpublished data). The WGF were unable to determine what bacterial strains he was carrying at the time of death due to contamination of the nasal and lung passageways with ingesta resulting from gunshot wounds of the thoracic cavity (WGF, unpublished data).

DISCUSSION

Prior to being collared, the Granby ram was observed several times over a 7-month period alone and in an area not used by other bighorns. This area is between 2 herds: 1) the Georgetown herd 20 km to the south; and 2) the St. Vrain herd 19 km to the north. After being collared, he remained in the area alone for another 3 months before he initiated his movement to Wyoming. The timing of this movement is consistent with that of rutting behavior in nearby herds. It is common for rams of this age class to travel seeking mating opportunities during the rut. However, we do not know of any previously documented movements of this magnitude.

O'Brien (2014) concluded that the frequency of bighorn movements outside of their core herd home ranges and the distances traveled were underestimated in his study. This was due to non-detection of animals that moved away from frequently used areas and the intervals between detections, during which the location of the animals is unknown. This was true for studies involving collared animals

monitored by aerial and ground-based surveys. In the case of the Granby ram, it was very unlikely that we would have known about his movements had he not been wearing a radio collar with satellite upload capabilities.

In a study of the Georgetown herd, the most probable herd of origin for the Granby ram, from 2006-2011, 9 to 18 rams were collared each year (Huwer 2015). The very high frequency (VHF) collars were located via ground and aerial telemetry an average of 1.5 times per month (range = 1.0-2.4) and the 3 GPS collars recorded 6 locations per day. None of these rams were found to have moved outside of their home range. In the same study, 17 to 35 ewes were collared each year. The VHF collars were located via ground and aerial telemetry an average of 2.3 times per month (range = 0.9-3.7) and the 11 GPS collars recorded 6 to 8 locations per day. Four different ewes were found to have moved outside their home range on 1 occasion for distances of 14 km, 10 km, 10 km, and 1.6 km. Each of these returned to their home range within a few months (CPW, unpublished data).

During his movement, the Granby ram frequently used areas that were more forested, less steeply sloped, and further from escape terrain than called for by the USFS Summer Source Habitat Model. He also covered large distances through areas considered unsuitable habitat for bighorn sheep. This is consistent with O'Brien (2014) who reported that foraying bighorn were twice as likely to be seen outside of habitat and more than 15 times more likely to be found in non-habitat than animals within the core herd home range. He concluded that, "foraying animals were clearly more willing to spend time in nonpreferred habitat types, allowing them to traverse it on their way to unconnected habitat patches."

MANAGEMENT IMPLICATIONS

Disease outbreaks are considered the primary factor limiting bighorn populations. Management of disease in bighorn sheep centers on reducing the probability of contact between domestic and bighorn sheep. Bighorn sheep that make long-distance movements risk contacting domestic sheep and transmitting diseases from domestic sheep to other bighorn sheep with which they come into contact. Therefore, much work has gone into establishing expectations of barriers to movement of bighorn sheep and domestic sheep to predict the probability of contact between bighorn sheep and domestic sheep.

The movement of the Granby ram represents a rare event with a high risk of creating contact between domestic sheep and bighorn sheep. Management options to prevent the spread of disease through these types of movements is limited as is the ability to predict them. To better predict and manage the risks of bighorn sheep movements outside of their home ranges, more information is needed on their frequency and extent. This information could be gathered through the increased use of radio collars with satellite upload capability in studies involving collared animals, as well as increased efforts to document the movements of solitary bighorn sheep and those encountered outside of known bighorn sheep home ranges.

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