WILDLIFE MONITORING REPORT FOR THE EAST VAIL WORKFORCE HOUSING PARCEL, TOWN OF VAIL, COLORADO

Prepared for:

The Vail Corporation
Vail Resorts Development Company

P.O. Box 959
Avon, CO 81620

AUGUST, 2018

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1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

Vail Resorts (VR) commissioned a baseline wildlife study, focusing on winter bighorn sheep (*Ovis canadensis*) use on and around the ± 23.3-acre East Vail Workforce Housing parcel, where affordable housing may be considered on the 5.4-acre western portion of the parcel. Other wildlife species in the vicinity of the subject parcel were also evaluated between October 13, 2017 and June 14, 2018. The study was designed to develop a better understanding of wildlife use on and surrounding the parcel should a development proposal move forward.

1.2 METHODS

The study used multiple field techniques tailored to site conditions. Five trail cameras strategically deployed and maintained on and around the subject parcel documented wildlife use within the camera's motion detection range, 24/7, and within visual range during daylight hours, for the entire study period. Three cameras were located within and overlooking the 5.4-acre development area, another was located overlooking the potential, on-site, habitat enhancement area in the Natural Area Preservation (NAP) portion of the parcel, and another was located overlooking the eastern edge of the high quality sheep habitat below Booth Creek cliffs, west of the subject parcel. Tracking surveys were conducted on 11 days the vicinity of the East Vail parcel between October 13, 2017 and May 14, 2018 as another approach to document wildlife presence. Tracks, other wildlife sign, and wildlife sightings were identified to species. Binocular/ spotting scope surveys for sheep, peregrine falcons, and other wildlife were conducted on two days each month from strategic vantage points along the valley bottom. Those surveys extended from Saddleridge, in the Town of Vail, east to where Gore Creek crosses under I-70. Additional opportunistic surveys were conducted after local residents emailed the author when sheep were observed on or near the subject parcel, allowing the author to be on-site shortly thereafter to document the circumstances of such use. A phone discussion and meeting were held with Colorado Parks and Wildlife (CPW) representatives covering a host of sheep- and habitat-related issues associated with the East Vail sheep herd and the East Vail Workforce Housing project.

1.3 RESULTS

This study was primarily designed to detect and characterize winter bighorn sheep use on and in the vicinity of the East Vail parcel. Winter severity affects spatial and temporal, winter, big game habitat use patterns. Compared to the last nine years, winter 2017/18 was below average for total snowfall, total snowfall days, and mean base snowfall depth, and above average for maximum base depth. The most recent milder winter than 2017/18 was 2011/12. Shallower and less persistent snow in the East Vail project area over the 2017/18 winter should have allowed sheep to use higher elevation habitats, more forested habitats, and a larger portion of their winter range than during average and harsher winters.

All trail cameras functioned properly over the entire study period. None were discovered, tampered with, or stolen. A total of 125,699 images were taken. Tracking and hiking-based observational surveys covering 16.9 miles in the vicinity of the East Vail parcel detected 24 and 16 species of birds and mammals, respectively. The wildlife detected represent a subset of all species present over the course of the year. The study covered the period when most Neotropical migrant birds were absent.

1.3.1 Bighorn Sheep

In total, 93 sheep were detected on (n=50 sheep on 3 days) and in the immediate vicinity (n=43 sheep on 2 days) of the 5.4-acre East Vail development area during winter 2017/18. This includes 75 animals detected by trail cameras and 18 animals detected by observational surveys. Virtually all foraging on and in the immediate vicinity of the parcel occurred on the smooth brome cut slope above the Frontage Road, most of which is on the CDOT ROW. The south-facing cut slopes above the Frontage Road are non-forested and steeper than the aspen forest portion of the development area, resulting in shallower depths, less persistent snow, and more favorable foraging opportunities. Use of the aspen forest composing the majority of the parcel was limited to escape routes on two occasions. A single sheep was also detected travelling through the NAP portion of the parcel in May, outside the winter period.

The distribution of 847 bighorn sheep sightings over the course of the study was mapped in relation to the East Vail parcel and CPW's sheep winter range, severe winter range, and winter concentration area polygons. No sheep sightings were made outside of CPW's winter range polygon. That 277-acre sighting distribution included the 625 sheep sightings recorded by all trail cameras during the study, all of which were within the 2017/18 visual sightings distribution of 222 sheep. Fifteen percent of CPW's 1,800-acre winter range polygon was used during winter 2017/18. That distribution represents a spatial subset of overall habitat use over the relatively mild 2017/18 winter. That may be a function of (1) CPW's polygon reflecting many winters of sheep use, including the 1990's when the herd was at peak numbers (125 sheep, USFS 1998; 80-100 sheep, B. Andree, CPW, 2017, pers. comm., Jan. 18, 2018), compared to the present population of 41 sheep, (2) sheep now using the highest quality habitat available, (3) sheep avoiding forested habitats, and (4) sheep restricted from some portions of their winter range by jackstrawed logs.

Sheep were at lower elevations within their overall winter range polygon and used southwest- and south-facing aspects that had the best snow-shedding characteristics, even though it was a mild winter. The cluster of sheep sightings and trail camera results below the Booth Creek cliffs suggests that area is the most heavily used and most important block of winter range within the overall winter range polygon. Four occasions of time lapse images of sheep foraging in the high quality habitat below the Booth Creek cliffs indicated that sheep appeared to select against foraging far into transitional aspen habitat. This "avoidance" behavior was more likely related to the quality, quantity, and availability of forage than to predator detection.

Environmental factors explain the greater sheep use of the high quality, mountain shrub-dominated winter range below the Booth Creek cliffs, compared to that on the East Vail parcel. However, all sheep winter range is important, particularly considering the amount of high quality habitats lost to human developments and aspen encroachment. The entire East Vail parcel should be considered sheep winter range. While sheep may use various parcel habitats differently over multiple years, they can access all portions of the property, and that use contributes to the functionality of the overall winter range.

With respect to minimum herd size and composition, the maximum number of sheep observed during the study at any one time was 39. Based on sex and age composition of sheep observed over the course of the study, the herd was composed of at least 10 lambs, 21 ewes, and 10 rams, totaling 41 sheep. The highest number of lambs seen at any one time was 10 on January 25 and March 14. The 2017, 10:21 lamb: ewe ratio (0.48%) indicates relatively high productivity. There was no detectable overwinter lamb or other sheep mortality. Coincident with June 14, 2018 peregrine monitoring, a minimum of 7 lambs and 12 ewes were observed at the licks on the cut slope above the rockfall berm. Assuming that there was no mortality in the herd since the end of winter, the herd numbered 48 animals at that time. Based on that 2018 productivity, knowing the minimum number of ewes in the herd, and other assumptions, the herd likely

numbered at least 53 sheep at that time. The East Vail sheep herd exhibited good productivity in 2017 and 2018.

A May 14, 2018 meeting was held between VR and CPW representatives to discuss the East Vail Workforce Housing project. All biologists agreed that the issue of potential development on the 5.4-acre parcel related to sheep was not the loss of habitat on the parcel as much as the potential for impacts (i.e., displacement and reduced habitat effectiveness on nearby winter range) from East Vail parcel residents recreating in the high quality sheep winter range below the Booth Creek cliffs and in the NAP area where winter range enhancement is expected. Some mitigation concepts/ measures were discussed along with the development of a comprehensive Wildlife Mitigation Plan that covers the entire affected wildlife community as part of the Environmental Impact Report.

1.3.2 Elk

Elk were captured on three of four cameras on the East Vail parcel and on the camera below the Booth Creek cliffs. Evidence suggested that a minimum of 15 animals were occasionally present moving back and forth between the Pitkin and Booth Creek drainages. Tracking and camera data indicated that elk occasionally foraged in mountain shrub habitat below the Booth Creek cliffs, in the mountain shrub with young sparse aspen in the upper NAP portion of the East Vail parcel, and on the cut slope above I-70, east of Pitkin Creek. Compared to the sheep, the local elk were more wary of human activity areas. Although some of their movements closely approached I-70 and the Frontage Road, they only did so under cover of darkness. Current CPW elk mapping in the vicinity of the East Vail parcel is incorrect. Although there are areas of the parcel that may not be used because of terrain and proximity to human disturbances areas, the entire parcel should be mapped as elk winter range. Despite the collective elk winter range losses that have occurred in Eagle County, this relatively high elevation winter range continues to be used by a small group of elk. The availability and use of this habitat as winter range takes pressure off of the lower elevation, down valley winter ranges and helps maintain overall herd viability.

1.3.3 Peregrine Falcon

A cliff south of I-70's East Vail Interchange has been used in recent years for peregrine falcon nesting. The cliff is located 0.33 mi. from the closest point on the East Vail Parcel, on the opposite side of the Frontage Road, I-70, interchange on/off ramps, and the East Vail Park and Ride, Vail Trail, Gore Creek, a social trail, and the East Vail Memorial Park. Annual (2011-2017, n=5 yrs.) cliff monitoring indicated that the pair(s) successfully fledged at least two birds during all five years. Monitoring of the nest cliff in 2018 indicated that the nesting attempt failed approximately 19 days after incubation was expected to have started. It is unknown why the 2018 nesting attempt failed. Construction of a new sanitary water line on the south side of I-70's East Vail interchange and the falcons selecting a different nest ledge on the cliff in 2018, compared to prior years, were the only known independent variables that differed with that of past years. There could have been other common causes of the nest failure. Subsequent behavior of the female observed on June 14 suggested that the pair may have been in the process of a second nest attempt. However, cliff monitoring was discontinued for the 2018 season after surveys out to July 1 failed to detect any evidence of peregrine presence. The avian prey associated with the East Vail parcel and surrounding habitats contributes to the local pair's potential prey base.

1.3.4 Mule Deer

The subject parcel and surrounding area are not deer winter range. During most of the study, deer were absent from the project area while using lower elevation winter ranges to the west. Mule deer were first

detected on the trail cameras starting on May 1. Most deer photographed were travelling along a lightly-used trail that extends through the 5.4-acre development area.

2.0 INTRODUCTION

Vail Resorts (VR) owns the ± 23.3-acre East Vail Workforce Housing parcel and is interested in locating affordable housing on the 5.4-acre western portion of the parcel ("the potential development area"). A number of wildlife species that occur in the vicinity of the subject parcel were identified during the 2017 rezoning process (Thompson 2017). Bighorn sheep were identified as the focal wildlife species of concern. While Colorado Parks and Wildlife (CPW) mapping and public testimony have indicated that the subject parcel is bighorn sheep summer range, winter range, and severe winter range,[1] results of a limited number of summer field surveys[2] suggested that there was no sheep use of the parcel per se, likely due to aspen encroachment, although evidence of sheep use was detected in the mountain shrub habitat above and below the Booth Creek cliffs to the west of the subject parcel and along the top of the upper cliff band to the north of the parcel. Greater knowledge of actual sheep and other wildlife use of the parcel will be required for any Environmental Impact Report (EIR) submitted to the Town of Vail for the Workforce Housing parcel development proposal.

At the request of VR, a wildlife study was designed and implemented to document wildlife use of the East Vail Workforce Housing parcel over the 2017/18 winter, focusing on bighorn sheep. The study was considered to be a reasonable level of effort, using multiple field techniques tailored to site conditions, to document sheep use of the subject parcel, the surrounding area, and to show what habitats sheep are actually using in the study area. The subject parcel and surrounding habitats are used by a wide variety of wildlife that will be of interest should the development proposal move forward. Some of those other species observed incidental to the sheep study are addressed herein. However, this report does not describe all wildlife use associated with the parcel. A comprehensive description of wildlife use will be part of the EIR.

3.0 METHODS

3.1 ANALYSIS AREAS

Three analysis areas were considered in this study: (1) the 5.4-acre western portion of the East Vail Workforce Housing parcel, where affordable housing would be located, (2) the 17.9-acre portion of the parcel that is zoned Natural Area Preservation (NAP), and (3) CPW's approximate 1,880-acre sheep winter range polygon. Monitoring by game/ trail cameras and winter tracking surveys focused on and around the 5.4-acre development area to document wildlife use of that portion of the parcel proposed for developed. These same surveys extended to the potential enhancement area on the eastern part of the subject parcel and to the eastern edge of the high quality sheep habitat below Booth Creek cliffs. Binocular and spotting scope surveys extended east and west from the subject parcel and Booth Creek cliffs attempting to document the occurrence and distribution of sheep within and beyond their designated winter range polygon.

[1] Based on the most recent kmz mapping available (Dec. 6, 2017 update), which did not differ from the Nov. 17, 2016 mapping used in the rezoning wildlife report (Thompson 2017).

[2] Conducted by Thompson on Aug. 4, Sep. 11 and 19, and Oct. 3 and 13, 2017.

3.2 SURVEY PERIOD

Field surveys, focused on bighorn sheep winter range use, extended from December 13, 2017 to May 15, 2018, and included six, two-day surveys spaced equally apart. Additional one-day surveys occurred on January 22, 25, and April 30, 2018 when the author was notified that sheep were near or on the parcel. The sheep surveys were preceded with reconnaissance surveys associated the East Vail parcel's rezoning process and a more widespread October 13, 2017 survey to facilitate study design. The study was extended with a June 14, 2018 survey to monitor the East Vail cliff for peregrine falcon (*Falco peregrinus*) nesting activity, and opportunistically monitor sheep use of the mineral lick above the Booth Creek rockfall berm.

3.3 SURVEY TECHNIQUES

3.3.1 Trail Cameras

Five trail cameras (TC)[3] were strategically deployed and maintained on and around the subject parcel to document local wildlife use (Fig. 3-1). The benefit of such cameras is that they can document wildlife use within the camera's motion detection range 24/7 and within the camera's visual range during daylight hours for the entire study period. Three cameras (#2, 3, and 4) were located within and overlooking the 5.4-acre development area, another (#1) was located overlooking the potential, on-site, habitat enhancement area in the NAP portion of the parcel, and another (#5) was located overlooking the eastern edge of the high quality sheep habitat below the Booth Creek cliffs, west of the subject parcel. The four cameras monitoring the East Vail parcel had a combined 2.04-acre and covered all game trails through the parcel. Camera cards and batteries were replaced monthly. In general, the overall East Vail parcel supports a dense shrubby understory that is problematic for trail camera use.[4] For all camera sets in areas with a dense shrubby understory, problematic vegetation within the cameras' trigger zones were cleared with a machete and camera sensitivity was adjusted to minimize false triggers. All cameras were programed to take time lapse images every 1-10 minutes from dawn to dusk,[5] capturing animals present that were beyond the cameras,' advertised, 80-foot motion detection range. Cameras recorded date, time, and temperature at the time each image was taken. Images were downloaded and reviewed for proper camera operation and field of view after the first survey period. Minor field of view adjustments to two cameras were made the following field day. Images were downloaded from cards shortly after each survey. A complete set of backup images was kept on an external hard drive.

Camera placement rationale varied. Camera 1 was located in the 17.9-acre portion of the East Vail parcel that is zoned Natural Area Preservation (NAP). It overlooked the largest open area (0.75 ac.)[6] of mountain shrub habitat with seedling and pole stage aspen encroachment that could be enhanced for

[3] Moultrie M-40i, 16 MP, with an 80 foot, passive, infrared, motion detection range and time lapse capabilities. The infrared flash associated with these units is not visible to humans or game, even at night, and allowed animal documentation 24/7 whenever an animal came within the motion detection range. Time lapse mode allowed animal documentation during daylight hours whenever animals were within the field of view (in some cases [TC5] out to 286 yards).

[4] Because of reduced field of view and the camera's motion detectors being activated by wind and snow influences on branch and shadow movements within the motion detection range.

[5] Photoperiod length, tracking sunrise and sunset, was increased monthly over the study period.

[6] Calculated using a rangefinder and protractor in the field to measure the distance to the furthest visible points on a trail camera image and the camera's angle of view, respectively, then using formulas for the areas of a triangle and trapezoid. The smaller areas are reported.

Figure 3-1. Location of Vail Resorts' 23.3-acre East Vail parcel (outlined in red), subdivided into the western 5.4-acre area to be developed for workforce housing and the eastern 17.9-acre area zoned Natural Area Preservation (NAP). Trail camera (TC) locations and other surrounding features are labelled.

bighorn sheep winter range (Fig. 3-2). A game trail occurred approximately six feet in front of the camera. Another game trail, contouring through the entire 17.9-acre parcel that is used by animals for more extended movements, was located within 45 feet of the camera and within the camera's motion detection and flash range. The field of view of this camera was adjusted after the first month of operation because it was being motion-activated by vehicles on the east-bound lanes of 1-70 (as small as 28-foot-long trucks, representing 0.18% of the camera's field of view) that were 894 feet from the camera.

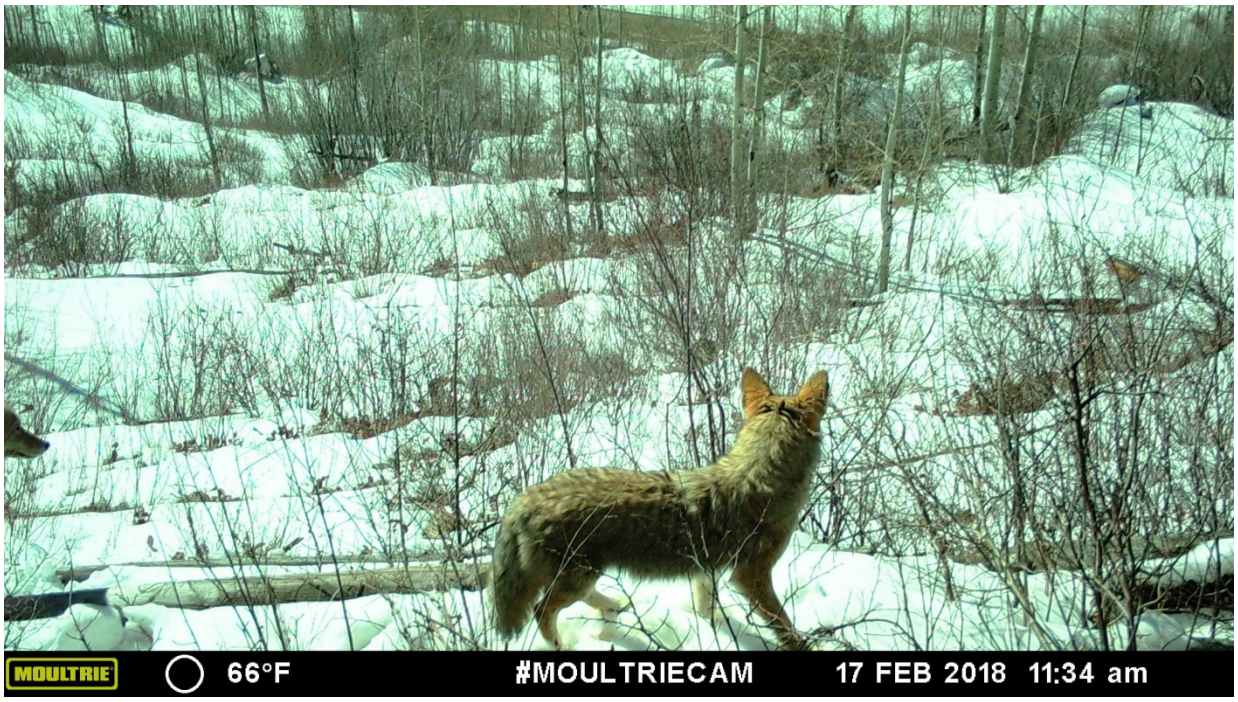

Figure 3-2. Red fox pair in 0.75-acre field of view from TC1 in the NAP parcel overlooking mountain shrub habitat with seedling and pole stage aspen encroachment that could be enhanced for bighorn sheep winter range (TC1, Feb1718, 5586a).

Camera 2 was located within the geographic center of the potential 5.4-acre development area, approximately 20 yards north of the buried electric line (Fig. 3-3). That camera's placement was intended to capture, via motion detection, any animal moving along what was the major game trail through the development area. Views of a 0.3-acre area through the narrow aspen band, south of the electric line, allowed time lapse images to capture sheep grazing on the cut slope above the Frontage Road (183 ft. away) and even animals on the Frontage Road (213 ft. away).

Camera 3 was located centrally within the 5.4-acre development area near its northern boundary (a USFS boundary sign was in view of the camera to the northwest). The camera overlooked a game trail within its motion detection range and some additional trails though a forest opening within the camera's 0.2-acre field of view (Fig. 3-4).

Camera 4 was located along a game trail overlooking 0.79-acres of a forest opening in the northeast corner of the 5.4-acre development area (Fig. 3-5). In summary, Cameras 2-4 monitored 1.29 acres of habitat, most of which were in the 5.4-acre potential development area, including all major game trails in that area.

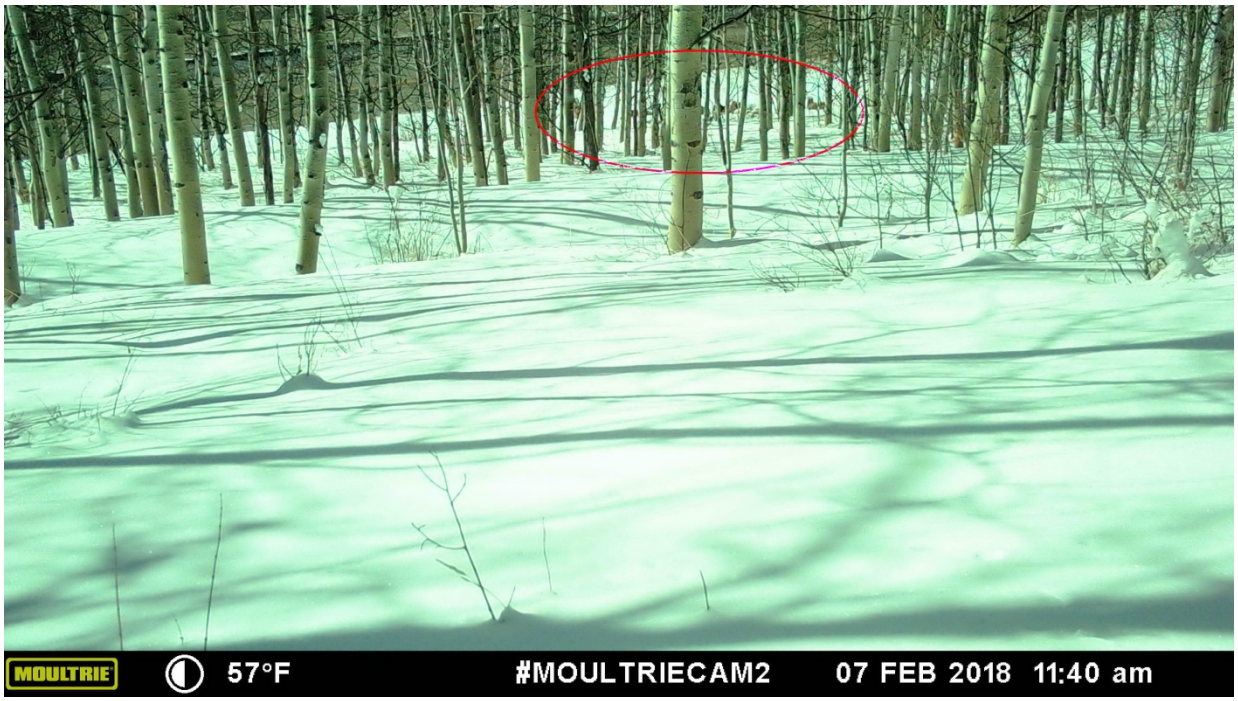

Figure 3-3. Field of view (0.79 ac.) from TC2 in the center of the potential 5.4-acre development area, approximately 20 yards north of the buried electric line (TC2, Feb0718, 8440a). The red ellipse shows part of a group of 15 bighorn sheep that were grazing the smooth brome-covered cut slope above the Frontage Road (clear of snow) beyond.

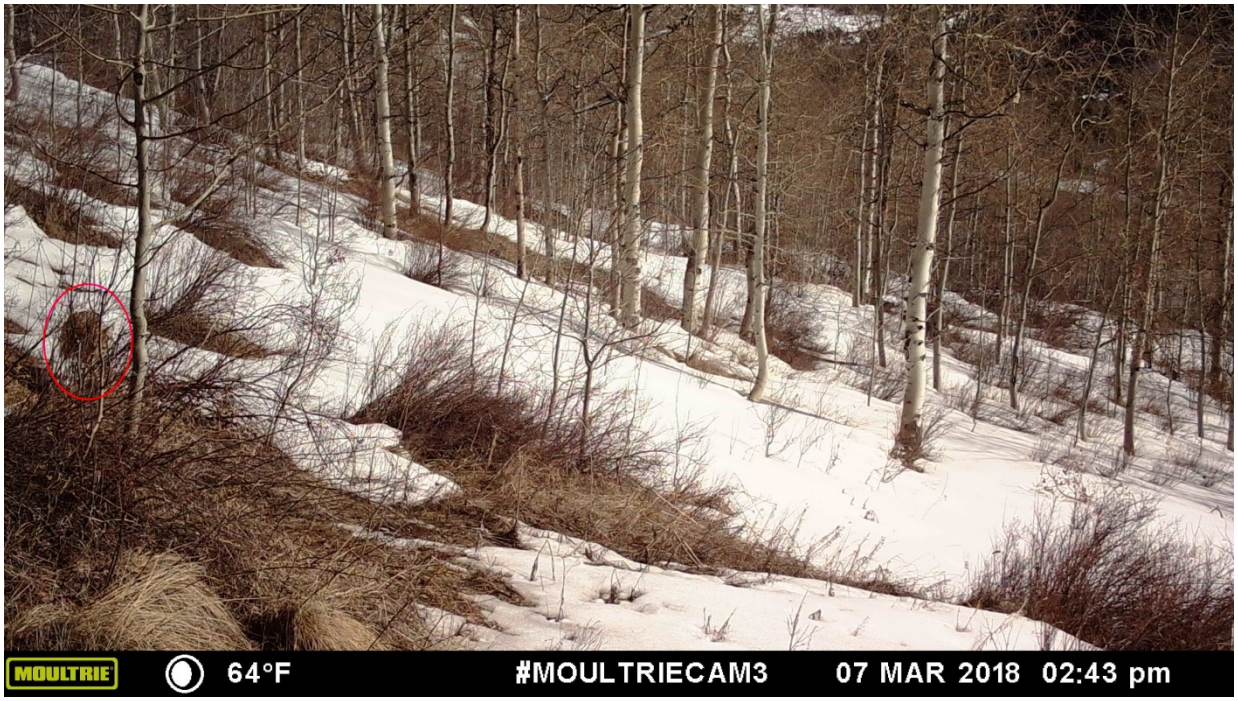

Figure 3-4. Field of view (0.2 ac.) from TC3 of a small forest openings just inside the 5.4-acre development area (TC3, Mar0718, 1489a). The red ellipse shows a red fox that was captured by motion detection behind a snowberry shrub.

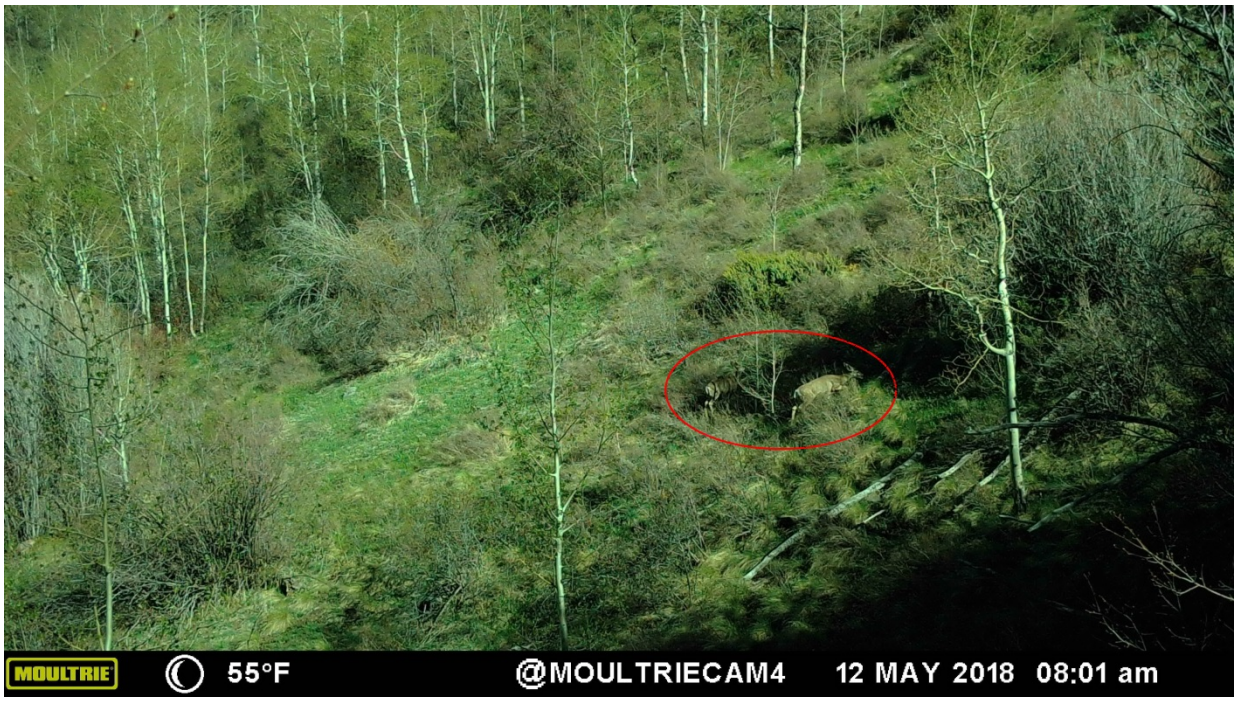

Figure 3-5. Two mule deer does (in red ellipse) from TC4 overlooking 0.79-acres of a forest opening in the northeast corner of the potential 5.4-acre development area (TC4, May1218, 2352a).

Camera 5 was located west of the East Vail parcel, above the rockfall berm access road, in some of the eastern-most, high quality, bighorn winter range below the Booth Creek cliffs (Fig. 3-6). The camera was also located 241 yards below the three, western-most gaps in the lower Booth Creek cliff band that sheep most-routinely used to move up and down through the cliffs. Sheep atop, in, and below the lowest cliff band (including sheep using the main trail through the cliffs that led directly to the mineral lick) were detectable from this camera's location, which covered a 4.4-acre field of view. This camera's placement sampled sheep use of the high quality winter range for comparison with potential use on the East Vail parcel.

3.3.1 Tracking Surveys

Tracking surveys, after Halfpenny et al. (1994), were used as another approach to document wildlife presence. Figure 3-7 shows the distribution of tracking and hiking-based observational surveys conducted on 11 days the vicinity of the East Vail parcel between October 13, 2017 and May 14, 2018. Several transects were surveyed during each monthly site visit, depending on the easiest route used to maintain the trail cameras at the time. Standardized transects included (1) west, up the rockfall mitigation berm road to the berm, (2) east, along the buried electric line, onto the private parcel, then along a loop between all cameras (i.e., 2, 3, 4, and 1; Fig. 1) on the subject parcel, and (3) up the Pitkin Creek trail, then to Cameras 1, 4, 3, 2, and 5. Tracks, other wildlife sign, and wildlife sightings were identified to species. Survey timing considered favorable weather and maximizing the track deposition interval prior to each survey.

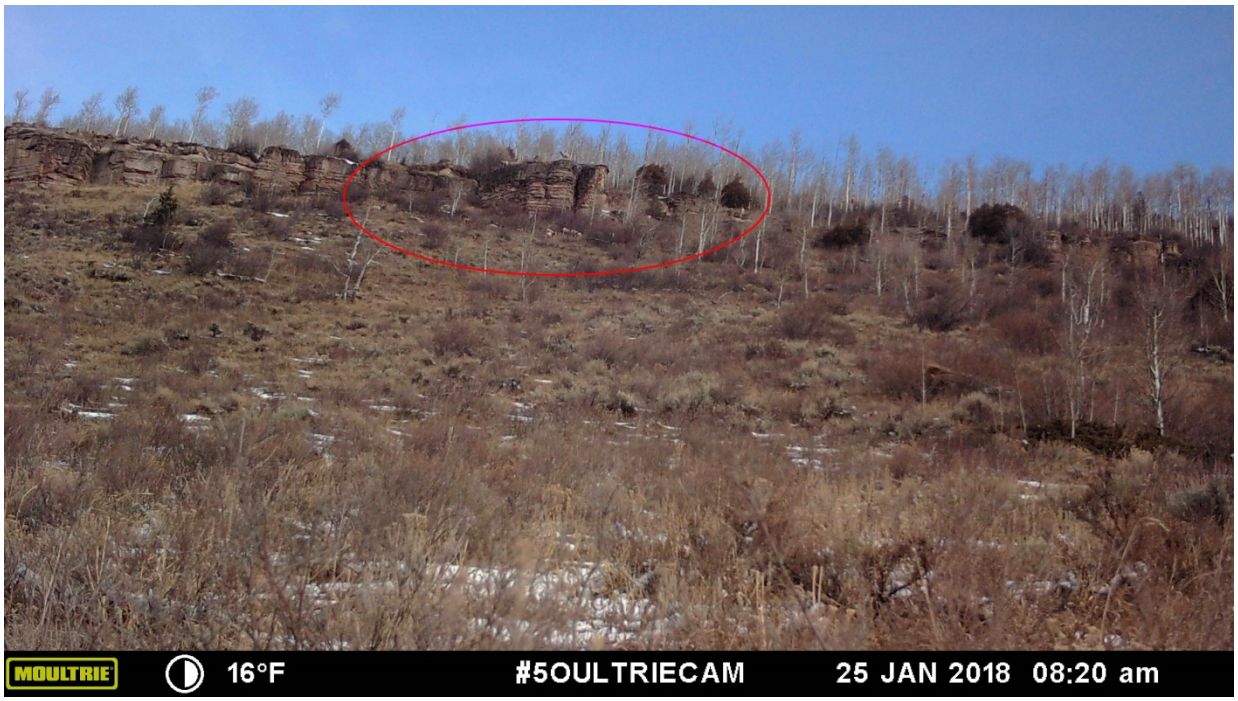

Figure 3-6. Field of view (4.4 ac.) north from TC5 on National Forest System land northwest of the East Vail parcel showing some of the eastern-most, high quality, bighorn winter range below the lower Booth Creek cliff band (TC5, Jan2518, 401a). The red ellipse shows part of a group of 33 (minimum) sheep, captured in time lapse mode, above, in, and below the lower Booth Creek cliff band. The sheep standing atop the cliff in the ellipse's center is 241 yards from TC5 and is standing between the two western-most gaps in the cliff that sheep used to move and down through the cliff.

3.3.2 Binocular/ Spotting Scope Surveys

Binocular/ spotting scope[7] surveys for sheep, peregrine falcons, and other wildlife were conducted on two days each month from strategic vantage points along the valley bottom. Surveys from the East Vail parking area (i.e., SE of the East Vail interchange), from points along the Frontage Road (e.g., the Vail Golf Course public restrooms), from the Vail Mountain School parking lot, and from the proximal ends of Aspen Lane and Vail Valley Drive allowed visual coverage of most of the good quality Booth Creek cliffs winter range and the eastern portion of the subject parcel. Binocular/ spotting scope surveys also extended beyond the overall winter range polygon[8] that was accessible by vehicle on roads other than I-70 because it was considered important to not only know the extent of sheep use on and adjacent to the subject parcel, but also the extent of winter sheep use within and beyond CPW's winter range polygon. Sheep locations were plotted on orthophoto maps.

[7] Swarovski EL 10x42/ Leica APO Televid 82 with 25-50x eyepiece.

[8] From Saddleridge in the Town of Vail, east to the Gore Creek drainage north of I-70.

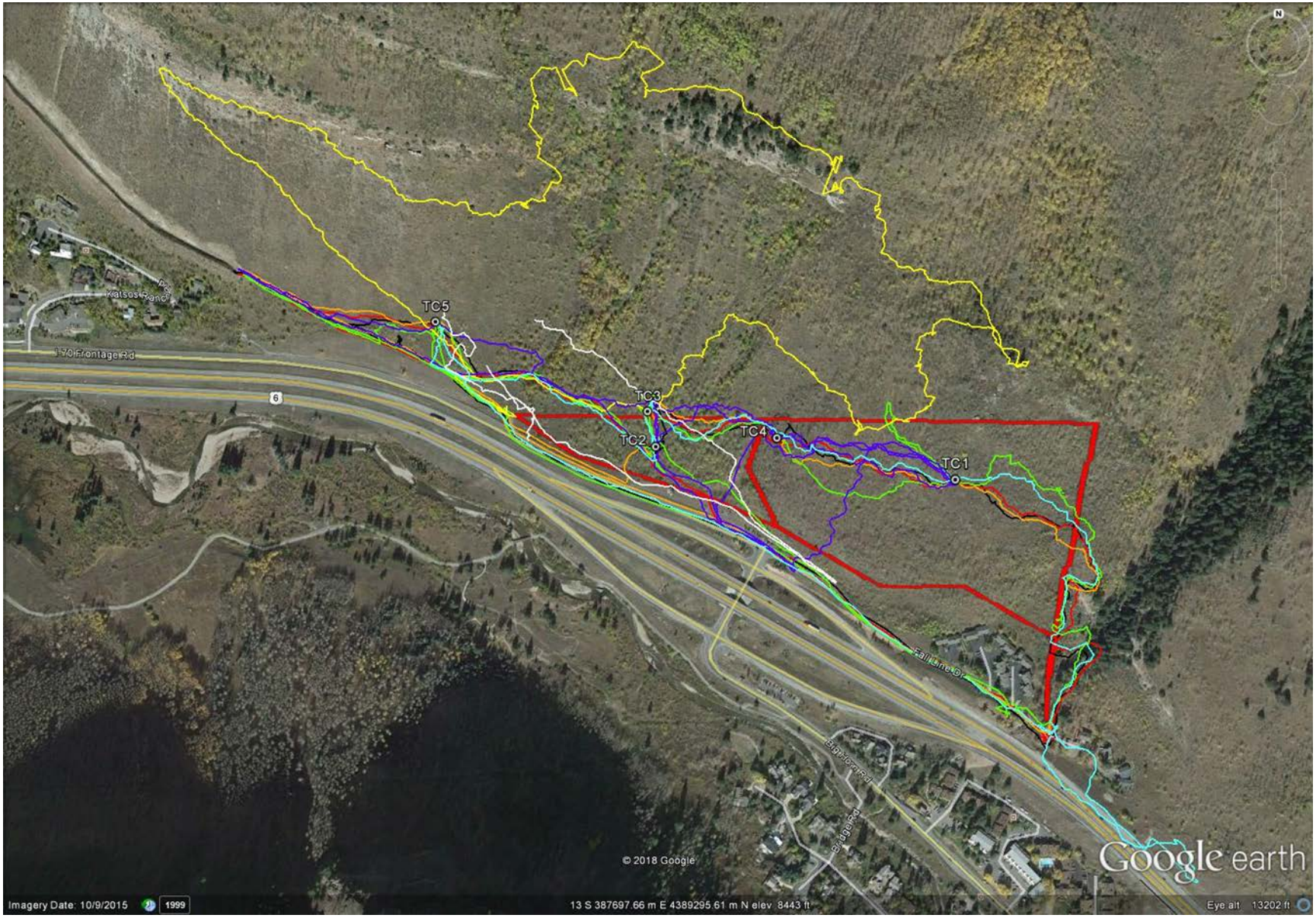

Figure 3-7. Survey routes (color-coded lines) and trail camera locations (TC 1-5) associated with the wildlife study in the vicinity of the East Vail parcel (outlined in red).

3.3.1 Opportunistic Surveys

Some local residents emailed the author when sheep were observed on or near the subject parcel. Such notifications allowed the author to be on-site within 2.25 hours of the sightings to document the circumstances of such use. These notifications allowed to author to document more frequent and detailed sheep use of the East Vail parcel than what would otherwise have occurred. Additional surveys for sheep below the Booth Creek cliffs and peregrine use of the East Vail nest cliff were conducted when the author was in the vicinity for other projects.

3.3.2 Helicopter Survey

A helicopter survey was included in the initial study design to systematically cover CPW's entire sheep winter range polygon to evaluate population size and point-in-time distribution, unbiased by survey vantage point. The current size of the population was uncertain and was based on opportunistic sightings of some unknown subset(s) of the overall population. Knowing the population size would provide more accurate assessments of herd health, winter range availability, development impact potential, and habitat enhancement considerations. The helicopter survey was envisioned before any winter surveys associated with the study had been conducted, when it was thought that some portion of the herd was present at upper elevations of the winter range polygon that were not viewable from the valley floor. However, after the results of several months of surveys, it appeared that all of the sheep in the herd were at lower elevations in a small subset of the overall winter range polygon in areas that are visible from observation points along the valley bottom. As a result, and after concurrence with CPW personnel (B. Andree, CPW, District Wildlife Manager [DWM], pers. comm., Jan. 31, 2018), the helicopter survey was dropped and funds were reallocated to additional opportunistic ground surveys.

3.3.3 Contacts with Colorado Parks and Wildlife

On January 23, 2018, the author and the local CPW DWM (B. Andree) had a phone conversation covering a host of sheep- and habitat-related issues associated with the East Vail herd.

On May 14, 2018, VR representatives (K. Kenney Williams, V.P. Community Affairs, and the author) met with CPW representatives (B. Andree, DWM, and Perry Will, Area Wildlife Manager) to discuss the East Vail Workforce Housing project. Although the study was ongoing and no data had been analyzed at the time, the author presented the methodology and general results of how sheep and elk, in particular, were using the parcel and surrounding area. All biologists seemed to agree (i.e., there was no voiced dissent) that the issue of potential development on the 5.4-acre parcel related to sheep was not the loss of habitat on the parcel as much as the potential for impacts (i.e., displacement and reduced habitat effectiveness on nearby winter range) resulting from East Vail parcel residents recreating in the high quality sheep winter range below the Booth Creek cliffs, to the west of the proposed housing, and in the NAP area, to the east of the proposed housing, where winter range enhancement is expected. Some mitigation concepts/ measures were discussed along with a the development of a comprehensive Wildlife Mitigation Plan that covers the entire affected wildlife community as part of the Environmental Impact Report.

4.0 RESULTS

This study was primarily designed to detect and characterize winter bighorn sheep use on and in the vicinity of the East Vail parcel. Winter severity[9] affects spatial and temporal, winter, big game use patterns. Table 4-1 presents some relevant annual snowfall metrics from Vail Ski Area so winter severity during the 2017/18 study period can be compared with those of other recent years.[10] Compared to the last nine years, winter 2017/18 was below average for total snowfall (-35%), total snowfall days (-40%), and mean base snowfall depth (-12%), and above average for maximum base depth (+3%). The most recent milder winter than 2017/18 was 2011/12. Shallower and less persistent snow in the East Vail project area over the 2017/18 winter should have allowed sheep to use higher elevation habitats, more forested habitats,[11] and a larger portion of their winter range than during average and harsher winters.

Table 4-1. Snowfall metric comparison between the 2017/18 winter study period and recent past years at Vail Ski Area. Years with the highest and lowest snowfall values are highlighted.

	Snowfall Year									
Metric	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Means**
Total Snowfall	271	459	164	285	263	236	313	215	171	264
Total Snowfall Days	140	99	47	81	65	56	74	69	45	75
Mean Base Depth (in.)	36	58	29	32	55	42	49	44	37	42
Max. Base Depth (in.)	75	89	51	71	49	65	77	65	70	68

[a] Source: https://www.onthesnow.com/colorado/vail/historical-snowfall.html?&y.

4.1 TRAIL CAMERAS

All trail cameras functioned properly over the entire study period. None were discovered, tampered with, or stolen. A total of 125,699 images were taken, ranging from 11,111 to 47,263 on Cameras 5 and 1, respectively. Most cameras took a larger number of images than expected due to wind blowing foreground vegetation triggering the motion detection. Vehicles on I-70 and the Frontage Road triggered additional images in Cameras 1 and 2 before their fields of view were adjusted. Cameras 4 and 5 had occasional snow build-up covering the lenses until melting and sublimation cleared the lens. Some cameras were motion-triggered occasionally at night, but the flash was inadequate to show the animal (most likely red foxes),[12] if present.

[9] Winter severity is generally an interrelated function of snowfall (amounts and persistence) and temperature.

[10] Note that while the data from Vail Ski Area are applicable as annual measures of winter severity in the East Vail project area, the values are not comparable because the ski area is higher and north-facing, while the East Vail project area is south-facing, with better snow-shedding characteristics, resulting in less snow and less snow persistence. Furthermore, the high quality winter range below the Booth Creek cliffs is open, mountain shrub habitat where the lack of a forest canopy further increases snow shedding characteristics.

[11] Which support deeper and more persistent snow depths than non-forested habitats, all else being equal.

[12] The camera's motion detection range was greater than its effective flash range.

The cameras documented a level of wildlife use that would not have occurred with other surveys methods. Table 4-2 quantifies the minimum number of animals and the number of different days that animals were documented on each of the trail cameras. See Section 3 and Figure 3-1 for descriptions of camera locations. Additional disclaimers warrant emphasis in regard to the trail camera results. Although the cameras on the East Vail parcel were located and programmed to maximize the detection of large mammals, all wildlife use of the parcel was not detected by the cameras, including that of large mammals,[13] hence the need for multiple survey techniques. The study's focus on potential, winter, bighorn sheep use resulted in no detection of bears (which were hibernating), although they are seasonally common on the parcel, particularly during fall. Similarly, no mountain lions were detected because they were most likely further down valley on lower elevation big game winter ranges.

Table 4-2. Minimum number of animals (#A) and the number of different days (#D) that animals were detected on each of the trail cameras between December 13, 2017 and May 14, 2018.

	TC1		TC2[a]		TC3		TC4		TC5	
Species	**#A[b]**	**#D[c]**	**#A[b]**	**#D[c]**	**#A[b]**	**#D[c]**	**#A[b]**	**#D[c]**	**#A[b]**	**#D[c]**
Bighorn Sheep			59	3	32	2			534	40
Elk	16	5	12	2			7	4	26	4
Mule Deer					5	2	3	2		
Red Fox	2	1	18	18	6	5				
Golden Eagle									1	1
Red-tailed Hawk	1	1			1	1			1	1
Black-billed Magpie									1	1
Chickadees [d]	4	3	1	1						
American Robin	3	1	7	2	2	2				
Townsend's Solitaire							1	1		
Steller's Jay									1	1
House Wren					2	2				
Human-related										
Hikers			12	10	14	6				
Dogs [e]			13	10	15	6				
Motorcyclist			2	2						

[a] TC2 also captured animals that were off the East Vail parcel on CDOT land.
[b] Minimum number of animals observed on trail cameras. Blank cells indicate 0 animals detected.
[c] Number of different days that animals were observed on trail cameras. Blank cells indicate that animals were not detected on any day.
[d] Includes both mountain and black-capped chickadees.
[e] All accompanied by at least one hiker.

4.1.1 Bighorn Sheep

Sheep use detected on the East Vail parcel included foraging along the smooth brome-dominated cut slope above the Frontage Road on three occasions, forced travel through the potential 5.4-acre development area on two occasions, and a single animal travelling through the NAP portion of the parcel in May, outside the winter period. The south-facing cut slopes above the Frontage Road are non-forested

[13] Camera 1, in the NAP portion of the parcel did not detect any bighorn sheep use, however, one sheep was detected (by feces and two tracks, on approx. May 12, 2018,) walking past the camera at night, but beyond flash range.

and steeper than the aspen forest portion of the development area, resulting in shallower depths, less persistent snow, and more favorable foraging opportunities.

A total of 32 sheep[14] were caught by the four cameras monitoring the East Vail parcel on two occasions during the 2017/18 winter. An additional 43 sheep were detected by trail cameras immediately adjacent to the parcel on the Colorado Department of Transportation [CDOT] right-of-way (ROW) during the 2017/18 winter. Therefore, a total of 75 bighorn sheep were caught on cameras on and immediately adjacent to the 5.4-acre development (on January 24 [n=24 sheep] and 28 [n=28], February 7 [n= ±15], and March 24 [n=8])). In comparison, 534 sheep were caught on the single camera below the eastern portion of the Booth Creek cliffs (with a 4.4-ac. field of view; Table 4-2). More meaningfully, sheep were detected immediately adjacent to and on the East Vail development area on four days compared to sheep detected on the single camera (TC5) below the cliffs on 40 days. Accounts are summarized below.

4.1.1.1 January 24 Sheep Use

The January 24, 2018, account of sheep on the East Vail parcel cameras is woven with the results of a January 25 tracking and spotting scope survey to more concisely reconstruct and characterize that use. On January 25, the author was notified of a group of sheep foraging west of the parcel. The author was on site several hours later and eventually counted a total of 39 sheep[15] below the Booth Creek cliffs. However, sheep tracks were observed on the cut slope above (north of) the Frontage Road and outside (south of) of the aspen that covers the 5.4-acre development area (i.e., on the CDOT ROW and on East Vail parcel). That sheep use was captured on TC2 starting at 1420 hours on January 24 (photo TC2_J-F_5339). The 24 sheep were classified[16] as they passed single file by TC3 from 1441 to 1450 hours on January 24. Figure 4-1 shows the orientation of the sheep trail[17] as they came down off the winter range below the cliffs, foraged east across most of the cut slope's width, until they reached the end of the smooth brome-dominated hillside, where it dead ends into alders (on a steep slope within 20 ft. of Fall Line Road), east of the East Vail Interchange. At that point, the sheep were startled by something (most likely by people that got out of their vehicles to photograph them). The braided foraging trail of walking animals abruptly changed into trails of scattered running animals, that converged into a single trail, as all of the sheep ran northwest into the aspen-covered interior of the 5.4-acre development area. Their rate of speed slowed once they were away from the road, but most of the sheep remained in single file on the trail until it reached the sparse young aspens just east of the eastern edge of the high quality winter range below the Booth Creek cliffs.[18] Thereafter the group dispersed and resumed foraging. Part way along their movement, in the meadow overlooked by TC3, the sheep paused, one of them took a mouthful of grass from below a snowberry bush (evidence of foraging within the aspen forest; Fig. 4-2), and six of them broke off from the main group and went southwest back to the cut slope above the Frontage Road, where they resumed foraging (caught on TC2 at 1500 hrs.).

[14] This total does not include the double counting of the same 24 sheep that were captured on TC2 and TC3 on Jan. 24. The sheep captured first on TC2 were off the East Vail parcel on the CDOT ROW, while the sheep capture later on TC3 were on the East Vail parcel . Therefore, 32 sheep were documented on the East Vail parcel on two occasions during the 2017/18 winter.

[15] Consisting of 21 ewes, 10 lambs, and eight rams, including One Horn (a legal ram with only a right horn).

[16] Consisting of 14 ewes, 8 lambs, and two rams, including One Horn.

[17] GPSed following the approximate centerline of the gradual, meandering foraging trails along the cut slope, then on the single file trail through the development area when animals were fleeing. See text.

[18] Where the GPS track was ended.

Figure 4-1. Orientation of the trail (white line) used by 24 sheep on January 24, 2018 as they foraged east through the smooth brome-dominated cut slope above the Frontage Road on the East Vail parcel, then were spooked into the interior of the 5.4-acre development area. See text for a full description of the sheep activity.

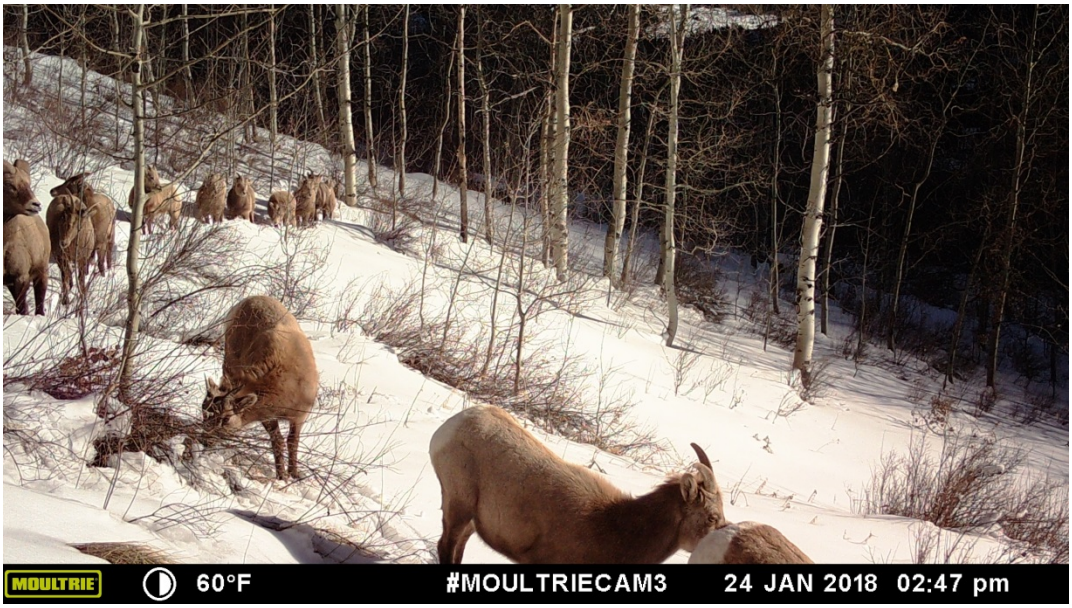

Figure 4-2. Part of a group of 24 sheep that were spooked from the Frontage Road into the interior of the 5.4-acre development area on January 24, 2018, (TC3, Jan2418, 431). Sheep are lined up on the single file trail (at left) that they used from the road to the open habitat below the Booth Creek cliffs. The three foreground sheep split off from the trail with three other sheep and travelled back to the cut slope above the Frontage Road, where they resumed foraging. The lamb at lower left is taking a mouthful of grass from below a snowberry bush, evidence of foraging within the aspen.

4.1.1.2 January 28 Sheep Use

On January 28, 2018, 28 sheep19 grazed east along the smooth brome-dominated cut slope above the Frontage Road. They were photographed by TC2 between 1020 and 1050 hours on the CDOT ROW, close to the East Vail parcel's southern boundary. The author was not on-site, no tracking survey was conducted, and it is unknown if the sheep actually used the East Vail parcel Figure 4-3 shows the sheep, largely on the road, where they were licking salt from the traction sand mix applied as part of normal road maintenance.20 Figure 4-3 illustrates several points: (1) the strong salt drive in some sheep to expose themselves to such close vehicle/ human proximity, (2) a certain level of habituation to vehicles by most members of this herd in some contexts,21 (3) the "sheep-jams" that generally occur along the Frontage Road when sheep approach closely, and (4) how law enforcement (Town of Vail [TOV] police vehicle, lower right) attempts to keep traffic moving. The scene in Figure 4-3 may have been similar to what occurred on January 24, when the sheep where confined by terrain to a much smaller area, when something spooked them, causing them to flee into the aspen forest. If the TOV continues to use only

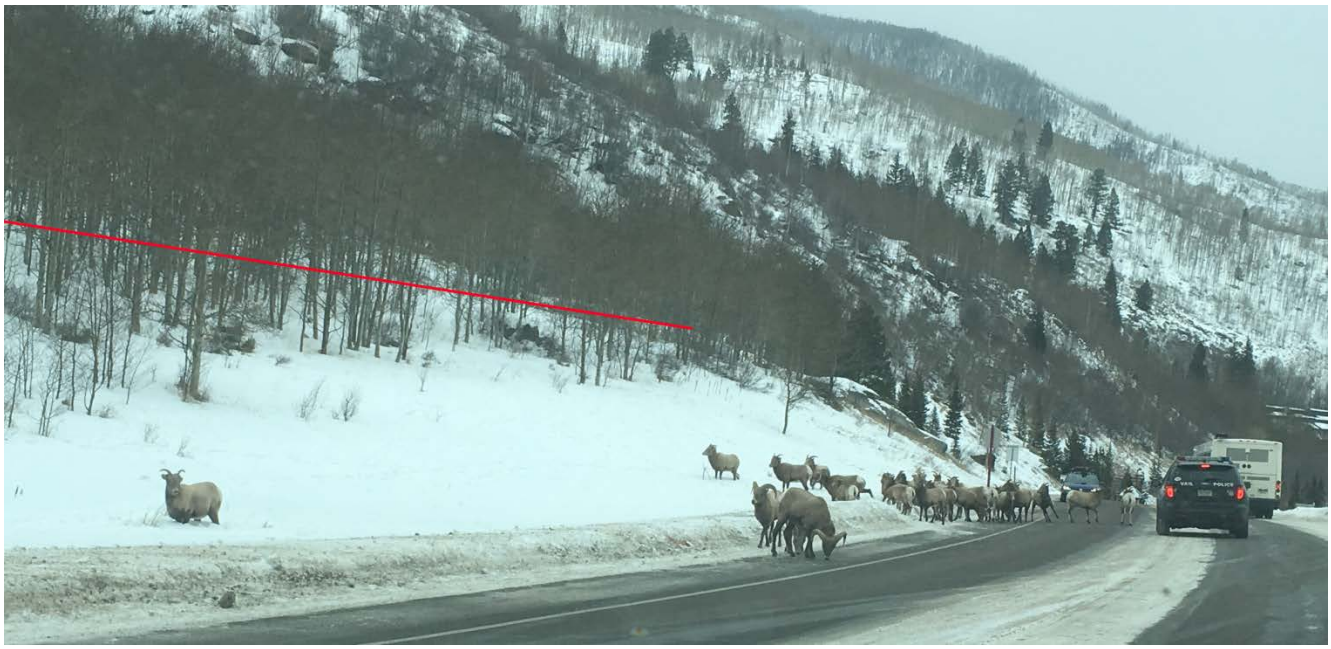

Figure 4-3. Group of 28 bighorn sheep on the CDOT ROW (below the EV parcel boundary [red line, approx.]; Jan. 28, 2018) that had foraged east along the narrow cut slope between the Frontage Road and the aspen forest, most of which are being chased off after attempting to lick road salt.

[19] Consisting of 21 ewes, 3 lambs, and four rams, possibly including One Horn.

[20] Per the author's request seeking confirmation of road salt, the TOV responded that they had been using a sand mix containing 5% salt [to keep the sand from clumping], but because of potential conflicts between sheep and motorists the TOV switched to cinders in that one mile of road and installed temporary bighorn sheep signs to warn traveling motorists (C. Turnbull, TOV, pers. comm. Feb. 13, 2018).

[21] Habituation is an animal's loss of fear response to the presence of humans after repeated, non-consequential encounters that neither rewards nor harms the animal (e.g., Herrero et al., 2005; McNay, 2002). By ignoring a non-threatening or unrewarding stimulus, animals can spend their time and energy more efficiently. Habituation typically is viewed by biological scientists and wildlife managers as a negative consequence of human interactions with wildlife (Higham and Shelton 2011) on the grounds that habituation, by definition, is undesirable.

cinders (i.e., without salt) on the one mile section of Frontage Road north of I-70 and Fall Line Drive, the sheep may eventually stop coming down to the road (and such sheep-jams may be reduced in number), although the forage contiguous with the road will remain attractive.

4.1.1.3 February 7 Sheep Use

On February 7, 2018, approximately 15 sheep grazed east along the smooth brome-dominated cut slope above the Frontage Road on the CDOT ROW, reached the area in front of TC2 at 1140 hrs. (Fig. 4-4), then reversed their movement and started foraging back west. The author was not on-site for this event and it is unknown if the sheep used any portion of the Est Vail parcel.

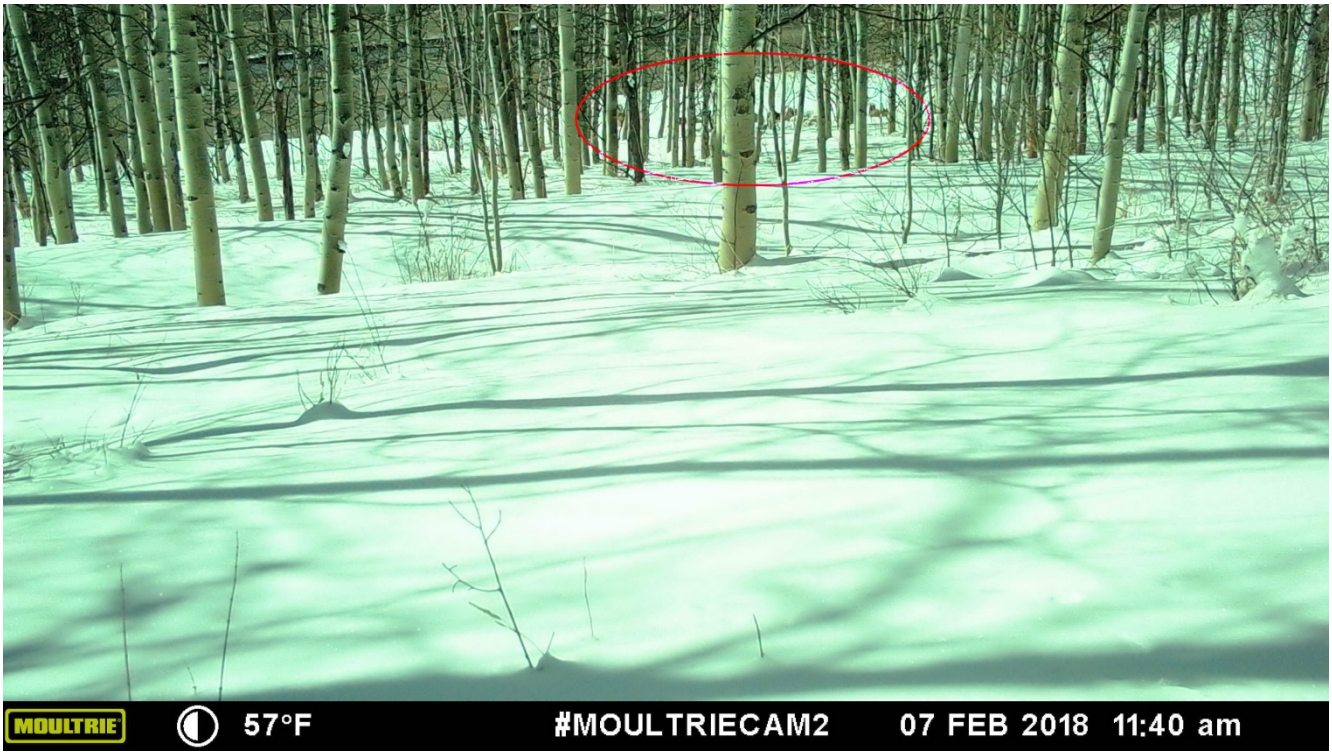

Figure 4-4. Group of approximately 15 bighorn sheep (in red ellipse) foraging on the cut slope above the Frontage Road on the CDOT ROW (Feb. 7, 2018, TC2_J-F 8440a).

4.1.1.4 March 24 Sheep Use

On March 24, 2018, at 1255 hours, eight ewes ran downhill in front of TC3, located on the northern edge of the 5.4-acre development area. Something on NFS land above had spooked them. They had not been running long. They were running so fast that only one image was taken (Fig. 4-5); the camera had insufficient time to recycle (1 sec.) before all sheep moved past the camera.

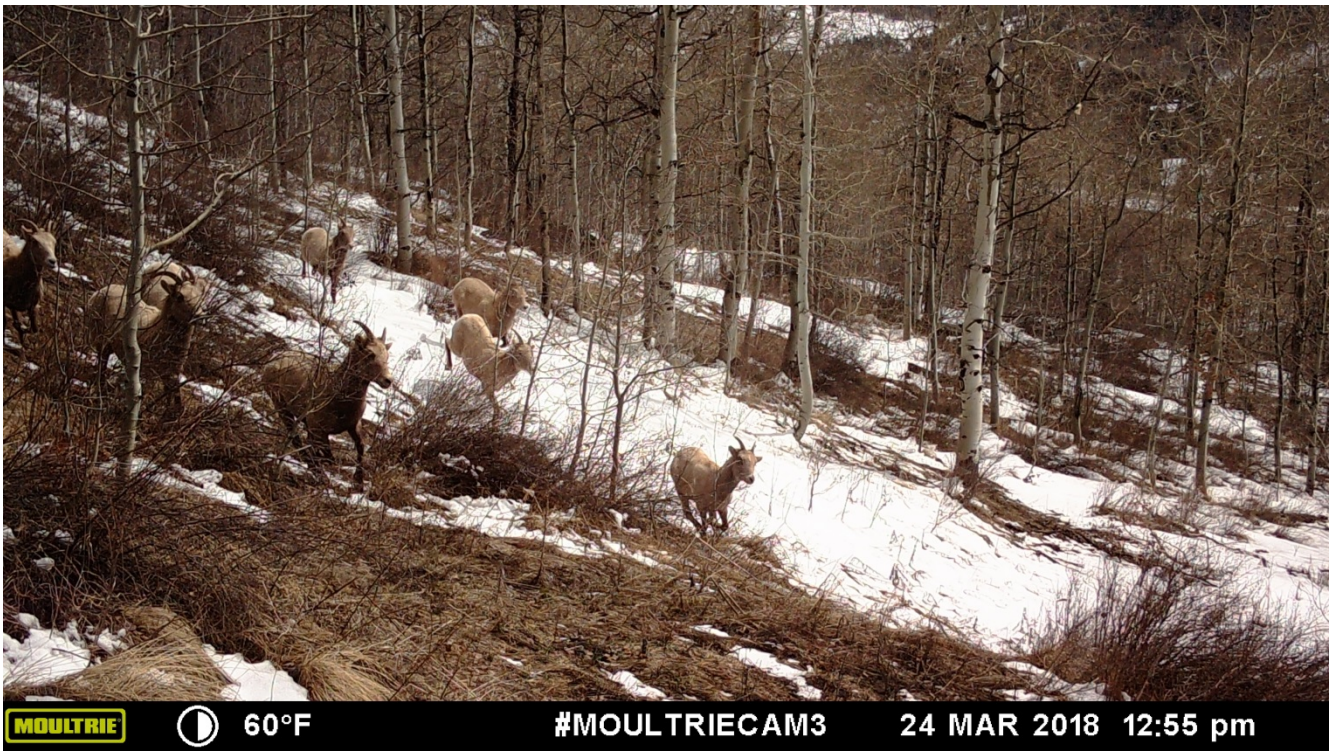

Figure 4-5. Eight ewes running past TC3 on the northern edge of the 5.4-acre development area in the East Vail parcel (Mar. 24, 2018, TC3_770).

4.1.2 Elk

Elk were captured on three of four cameras on the East Vail parcel and on the camera below the Booth Creek cliffs (Table 4-2). Evidence suggested that a minimum of 15 animals[22] were occasionally present moving back and forth between the Pitkin and Booth Creek drainages. Using the spike in the group as a marker, the same group of elk was captured on TC1, TC2, and TC5 in the same night. Compared to the sheep, the local elk were more wary of human activity areas. Although some of their movements closely approached I-70 and the Frontage Road, they only did so under cover of darkness. Elk were only captured on trail cameras at night and their movements between the Pitkin and Booth Creek drainages were completed at night. Evidence of elk foraging was captured on all cameras except TC2, which was closest to I-70 and the Frontage Road. That may have been due to concerted travel behavior in that location close to human activity, limited sample size, and/or the camera's more limited field of view. Concerted foraging was noted on Cameras 5 (below the cliffs) and 1 (in the NAP area). Foraging in the meadow in the development area's northeast corner was opportunistic as animals were traveling.

4.1.3 Mule Deer

The subject parcel and surrounding area are not deer winter range. During most of the study, deer were absent from the project area while using lower elevation winter ranges to the west. Mule deer were first detected on the trail cameras (TC3 and 4) starting on May 1. Most (6 of 8) deer photographed were travelling along a lightly-used trail that extends through the 5.4-acre development area, while the other two were foraging (Table 4-2).

[22] Composed of 12 cows, 2 calves, and a spike.

4.1.4 Other Wildlife

Other wildlife detected by trail cameras are listed in Table 4-2. Because those species are not of particular concern with respect to their occurrence in the area, they are not addressed further in in this section.

4.2 TRACKING SURVEYS

Tracking and hiking-based observational survey routes covering 16.9 miles in the vicinity of the East Vail parcel are shown above in Figure 3-7. Wildlife detected during those October 13, 2017 to May 14, 2018 surveys are listed in Table 4-3. Table 4-3's contents represent a subset of all wildlife present over the course of the year. The study covered the period when most Neotropical migrant birds, representing a sizeable proportion of the wildlife community, were absent. The tracking and observational surveys detected more species than the trail cameras.

Table 4-3. Wildlife[a] detected during tracking and hiking-based observational surveys on and in the vicinity[b] of the East Vail parcel during 11 days between October 13, 2017 and May 14, 2018.

Birds	Mammals
Cooper's Hawk	Least Chipmunk
Sharp-shinned Hawk	Yellow-bellied Marmot
Red-tailed Hawk	Pine Squirrel
Golden Eagle	Northern Pocket Gopher
Peregrine Falcon	Deer Mouse
Broad-tailed Hummingbird	Masked Shrew
Common Flicker	Coyote
Red-naped Sapsucker	Red Fox
Hairy Woodpecker	Black Bear
Violet-green Swallow	American Marten
Steller's Jay	Ermine
Black-billed Magpie	Long-Tailed Weasel
Common Raven	Striped Skunk
American Crow	American Elk
Black-capped Chickadee	Mule Deer
Mountain Chickadee	Bighorn Sheep
House Wren	
American Robin	
Townsend's Solitaire	
Blue-gray Gnatcatcher	
House Finch	
Green-tailed Towhee	
Dark-eyed Junco	
Song Sparrow	

[a] Wildlife are listed phylogenetically. Scientific names follow Colorado Bird Atlas Partnership (2016) and Armstrong et al. (2011).
[b] Animals detected in the vicinity of the East Vail parcel included only those that were observed in the same habitats as those on the parcel and were, therefore, also likely present on the parcel based on habitat affinities.

4.2.1 Bighorn Sheep

4.2.1.1 January 22, 2018 Sheep Use

On January 22, 2018, the author was notified of a group of sheep foraging near the western tip of the East Vail parcel (Fig. 4-6). The author was on-site several hours later, walked (and GPSed) the eastern extent of the foraging bout where it extended onto the East Vail parcel, mapped the recent (i.e., within the last approx. 16 hours [since the snowfall ended]) extent of foraging from tracks, and counted a total of 37 sheep[23] below the Booth Creek cliffs. At the western tip of the East Vail parcel, the 18 sheep present in Figure 4-6 were primarily eating big sagebrush, and the tips of snowberry, chokecherry, and aspen seedlings. Along the Frontage Road's cut slope, they were sparingly eating smooth brome (i.e., eating only the tips, not the entire blade of the grass). None of the sheep crossed the Frontage Road, jumped the guardrail, or foraged on the cut slope below the Frontage Road and above I-70.

Figure 4-6. Eighteen bighorn sheep (on this side of the rockfall berm road gate; another seven, including One Horn, on the far side of the gate) that had recently foraged on the western tip of the East Vail parcel on January 22, 2018, their trails visible in the fresh snow (photo taken at 0940 hrs.).

The 18 sheep in Figure 4-6 grazed west along the north side of the Frontage Road to where a new home was under construction, reversed their route, grazed up and around the eastern end of the Booth Creek residential area, and were at the west end of the rockfall berm by 1424 hours on January 22, 2018. At some point they were joined by 19 additional sheep. Figure 4-7 shows the extent of foraging by the 37 sheep between 2200 hours on January 21, 2018 (when they were first captured that night on TC5) and 1424 hours on January 22, 2018, including that of the 18 sheep that foraged onto the East Vail parcel.

[23] Consisting of 23 ewes and young rams, 9 lambs, and five rams, including One Horn.

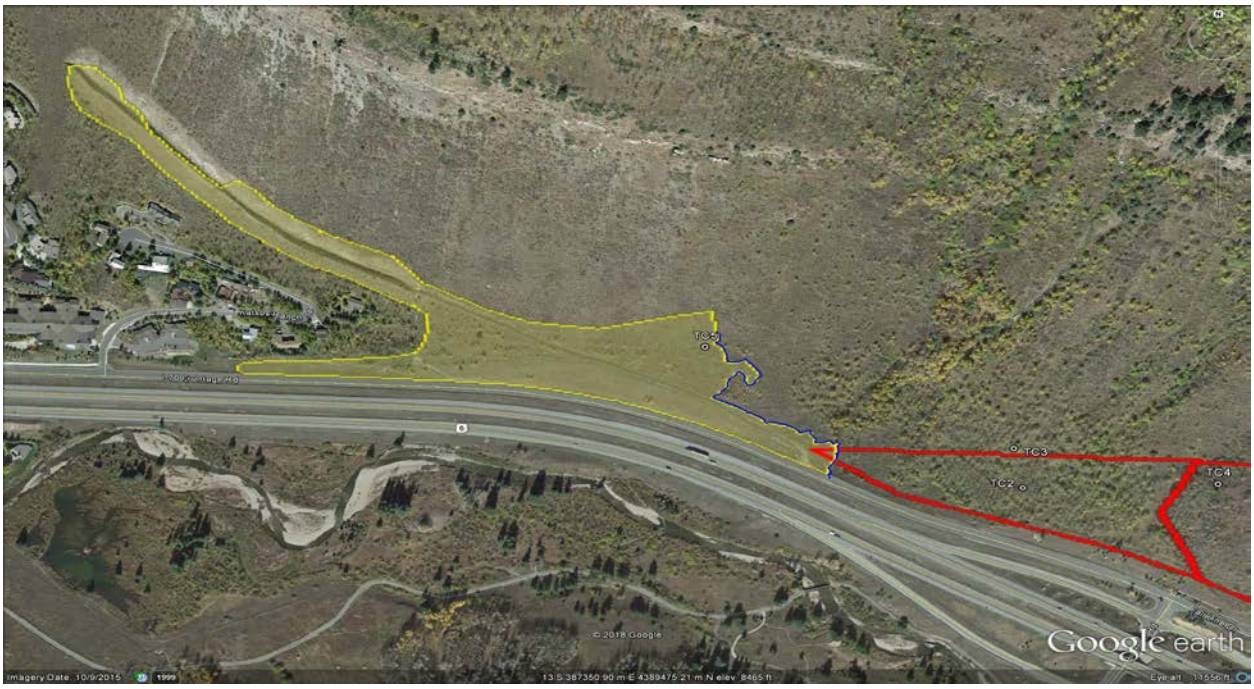

Figure 4-7. Distribution (outlined, 16.5-ac. yellow polygon) of 37 bighorn sheep foraging between approximately 2200 hours on January 21, 2018 and 1424 hours on January 22, 2018, including that of the 18 sheep that foraged onto the western tip of the East Vail parcel (red outline). The sheep approached this foraging polygon from above (not shown). The blue line is a GPS track establishing the eastern extent of the foraging.

4.2.1.2 January 24, 2018 Sheep Use

The January 24, 2018 account of sheep travelling through the East Vail parcel is described above in Section 4.1.1.1. The eastbound route used by the sheep along the length of the cut slope above the Frontage Road followed the general orientation of a game trail that was noted during 2017 summer surveys. At the time, that trail, one of the most well defined on the parcel, was assumed to have been maintained by mule deer (deer tracks were present on the trail during summer), however, the trail may also be seasonally used by sheep.

4.2.1.3 May 14, 2018 Sheep Use

On May 14, 2018, when trail cameras were being collected at the end of the study, two sheep footprints and a pile of sheep feces were observed on the main discontinuous trail contouring through the NAP portion of the East Vail parcel.[24] The evidence was considered to be from a single animal (probably a ewe) travelling east through the parcel. While that evidence was detected outside of the winter range period, it indicated that at least some sheep are currently using the portion of the parcel under consideration for winter range enhancement.

[24] Located southeast and southwest of TC1.

4.2.2 Elk

Elk use of the project area is summarized in Section 4.1.2, above. In addition, tracking data indicated that elk occasionally foraged in mountain shrub habitat below the Booth Creek cliffs, in the mountain shrub with young sparse aspen in the upper NAP portion of the East Vail parcel, and on the cut slope above I-70, east of Pitkin Creek and the East Vail parcel.

4.2.3 Mule Deer

Mule deer were detected by tracking surveys and sightings on and adjacent to the East Vail parcel during the October, 2017 and May, 2018 surveys, but they were absent on the parcel during the winter range period.

4.2.4 Other Wildlife

Other wildlife detected by tracking surveys and sightings on and adjacent to the East Vail parcel are listed in Table 4-2. Because those species are not of particular concern with respect to their occurrence in the area, they are not addressed further in this section.

4.3 OBSERVATIONAL SURVEYS

Two species monitored by observational surveys during the study warrant additional discussion, bighorn sheep and peregrine falcon.

4.3.1 Bighorn Sheep

In total, 93 sheep were detected on (n=50 sheep on 3 days) and in the immediate vicinity (n=43 sheep on 2 days) of the 5.4-acre East Vail development area during winter 2017/18. This includes 75 animals detected by trail cameras and 18 animals detected by observational surveys. Virtually all foraging on the parcel occurred on the smooth brome cut slope above the Frontage Road, most of which is on the CDOT ROW. Use of the aspen forest composing the majority of the parcel was limited to escape routes on two occasions.

Figure 4-8 shows the distribution of 847 bighorn sheep sightings over the course of the study in relation to the East Vail parcel and CPW's sheep winter range,[25] severe winter range,[26] and winter concentration area[27] polygons. Those sightings include the 625 sheep sightings recorded by all trail cameras during the study, all of which were within the sightings distribution of 222 sheep made via binocular and spotting scope surveys. No sheep sightings were made outside of CPW's winter range polygon. That distribution represents a spatial subset of overall habitat use over the relatively mild 2017/18 winter. For example, the four large rams that generally remained together and were sighted 701 yards east of Elkhorn Drive, were also sighted above and below the Booth Creek cliffs, so those apparently disconnected habitat patches

[25] Winter range is that part of the overall range where 90% of the individuals are located during the average five winters out of ten, from the first heavy snowfall to spring green-up.

[26] Severe winter range is that part of the winter range where 90% of the individual animals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten.

[27] Winter concentration area is a subset of the winter range where animal densities are at least 200% greater than the surrounding winter range density during the same period used to define the winter range, in the average five winters out of ten.

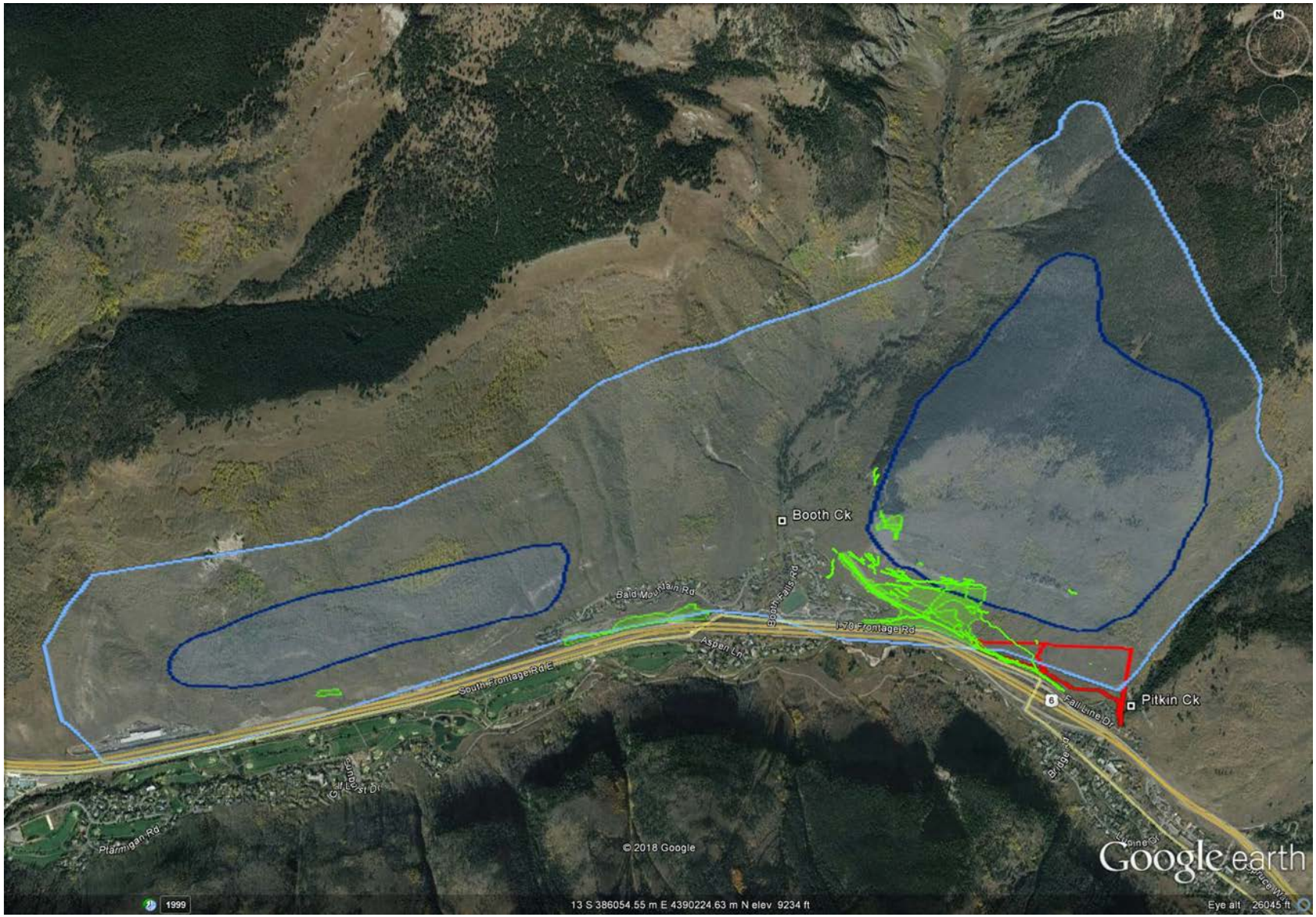

Figure 4-8. Polygons (green) encompassing 847 bighorn sheep detected over the course of the study in relation to (1) CPW's overlapping sheep winter range and severe winter range polygons (light blue), their winter concentration area polygons (dark blue), and (2) the East Vail Parcel (red).

shown in Figure 4-8 were, in fact, connected over the winter. Furthermore, there were entire days when no sheep were detected from the valley bottom. Those sheep were presumably within the winter range polygon, but possibly outside areas where other sheep sightings occurred.[28]

Connecting the peripheral sheep sightings and assuming that all habitats within that single polygon were used, then 277 acres (15%) of CPW's winter range polygon was used during winter 2017/18. That may be a function of (1) CPW's polygon reflecting many winters of sheep use, including the 1990's when the herd was at peak numbers (125 sheep, USFS 1998; 80-100 sheep, B. Andree, CPW, 2017, pers. comm., Jan. 18, 2018),[29] compared to the present population of 41 sheep, (2) sheep now using the highest quality habitat available, (3) sheep avoiding forested habitats, and (4) sheep restricted from some portions of their winter range by jackstrawed logs.

Figure 4-8 also shows that the sheep were at lower elevations within their overall winter range polygon and used southwest- and south-facing aspects that had the best snow-shedding characteristics, even though it was a mild winter. Shallower and less persistent snow in the East Vail project area over the 2017/18 winter should have allowed sheep to use higher elevation habitats, more forested habitats, and a larger portion of their winter range than during average and harsher winters. The cluster of sheep sightings below the Booth Creek cliffs suggests that area is the most heavily used and most important block of winter range within the overall winter range polygon. That conclusion is corroborated by the trail camera results (see Section 4.1.1, Table 4-2).

4.3.2 Elk

No elk were observed during the study other than on trail cameras. Elk tracks observed provided no additional meaningful insight into elk use than that inferred from trail camera data.

4.3.3 Peregrine Falcon

A cliff south of I-70's East Vail Interchange has been used in recent years for peregrine falcon nesting. The cliff is located 1,731 feet (0.33 mi.)[30] from the closest point on the East Vail Parcel, on the opposite side of the Frontage Road, I-70, interchange on/off ramps, and the East Vail Park and Ride, Vail Trail, Gore Creek, and the East Vail Memorial Park. Annual 2011-2017 cliff monitoring by Anne Esson,[31] where notes are available (n=5 years, excluding 2013 and 2014), indicated that the pair(s) successfully fledged at least two birds during all five years (A. Esson, June 17, 2018 pers. comm.).

The author started monitoring the nest cliff on March 14, 2018. Anne Esson began monitoring on April 15 and conducted most of the 2018 monitoring. Both members of the peregrine pair were first observed at the nest cliff on April 16. On May 12, the first incubation exchange was observed. This was the first clear evidence that the majority of eggs had been laid and that incubation had started. It general takes a bird eight days to lay the average clutch of four eggs (Cade et al. 1996) and incubation typically lasts 33 days (Craig and Enderson 2004). Anne Esson thought egg laying and incubation started sometime during the week of Apr. 30 and by May 7, respectively, approximately their normal times. May 28 was the last observed incubation exchange. Egg hatching was anticipated to have occurred in early June. The last incubation exchange

[28] Despite excellent optics, it is difficult to detect sheep in shrub and forest cover under snow free conditions.

[29] One would not expect sheep to use the entire winter range polygon in any one year.

[30] Measured in Google Earth.

[31] A long-time Vail resident who has annually monitored the nest cliff since peregrine occupancy began ca. 2011.

occurred 16 days after the first incubation exchange was observed on May 12 and approximately 19 days after incubation was expected to have started (May 7). The last exchange observation was made approximately one-half way through the typical 33 day incubation period (Craig and Enderson 2004). Various observations suggested that the first clutch had failed approximately 19 days after incubation was expected to have started. On June 14, after four days of surveys with no sign of the birds, the pair was observed on and in the vicinity of the nest cliff. The female's behavior suggested that the pair may have been in the process of recycling and a second nest attempt (Cade et al. 1996). However, cliff monitoring was discontinued for the 2018 season after surveys out to July 1 failed to detect any evidence of peregrine presence.

It is unknown why the 2018 nesting attempt failed. On April 30, site preparation work started on a new sanitary water line (extending from the distal end of I-70's East Vail interchange, east-bound off ramp, east to Bridge Street) and continued daily during the work week (and some Saturdays) from approximately 0730-1700 hrs. This initial work started just prior to egg laying. Construction and equipment activity varied over the construction period.[32] Up to two excavators, a front-end loader, a bulldozer, a backhoe, construction trucks, and up to eight people were present during the author's observations. The project was entirely on the opposite site of Gore Creek from the nest cliff. As of July 5, work was still ongoing. This project is described because it is close to the nest cliff and because, other than the falcons selecting a different nest ledge on the cliff in 2018 (i.e., compared to prior years; A. Esson, June 14, 2018, pers. comm.),[33] this is the only known independent variable that differs with that of past years. There could be other common causes for the nest failure. A more detailed account of the 2018 nesting attempt is in preparation for submittal to CPW and the USFS, but that is not part of the East Vail parcel wildlife study.

During the peregrine monitoring conducted by the author, the birds always arrived at the East Vail cliff from the west and departed towards the west, with one notable exception. On May 15, the female departed the nest cliff and soared thermals above the nest cliff until she was lost from view in the spotting scope. Hunting from thousands of feet above the valley, she could have stooped on and reached prey within a mile of the cliff, literally in seconds. That includes the airspace over any portion of the East Vail parcel. During monitoring, there was no observed peregrine use of, or affinity to, habitats on the East Vail parcel, although it is assumed that avian prey associated with the parcel and surrounding habitats contributes to the local pair's potential prey base.

4.4 WILDLIFE USE IN THE VICINITY OF THE EAST VAIL PARCEL

This section provides additional analysis of some study findings relevant to some of the wildlife species on and adjacent to the East Vail parcel.

4.4.1 Bighorn Sheep

The quantification and behavior of sheep "captured" on the trail cameras, detected from tracking, and observed during surveys can be used to further refine our understanding of the type and extent of sheep use on the East Vail parcel. In summary, 50 sheep were documented on the East Vail parcel on three occasions (Jan. 22, Jan. 24, and Mar. 24), and 43 sheep were documented immediately adjacent to the East Vail parcel

[32] The author observed activity on four occasions during the construction period. Activity reported by Anne Esson over an additional dozen or more days was consistent with the author's observations.

[33] Anne Esson (Vail resident) indicated (Jun1818 email) that the peregrines evaluated other cliff ledges in prior years, but always used the big ledge to the right of the one chosen in 2018.

on two occasions (Jan. 28, and Feb. 7) during the 2017/18 winter. Sheep were detected on the four cameras monitoring the East Vail parcel and the immediate vicinity (i.e., the CDOT ROW) on four days (Jan. 24 and 28, Feb. 7, and Mar. 24) during the 2017/18 winter compared to sheep detected on 40 days on TC5 below the Booth Creek cliffs. A total of 91 sheep[34] were caught on the four cameras monitoring the East Vail parcel and the immediate vicinity compared to 534 sheep that were caught on the single camera below the eastern portion of the Booth Creek cliffs. Figure 4-8 provides a graphic representation of sheep observed within the overall winter range polygon vs. that on the East Vail parcel. Winter sheep use of the East Vail parcel and the immediate vicinity was largely associated with animals foraging on the smooth brome-dominated cut slope above the Frontage Road on three occasions. Those south-facing cut slopes are non-forested and are steeper than the aspen forest portion of the development area, resulting in shallower and less persistent snow depths. The only sheep detected in the interior of the development area during winter were those that were chased into the forested interior on January 24 and March 24. The sign of the single sheep detected in the NAP portion of the parcel on May 14 was that of a travelling individual outside of the winter range period (see Section 4.2.1.3).

Winter sheep use is a function of aspect, slope, and tree cover resulting in different snow-shedding characteristics, moisture regimes, and resulting habitats. These same environmental factors explain the greater sheep use of the high quality, mountain shrub-dominated winter range below the Booth Creek cliffs compared to that on the East Vail parcel. The mountain shrub habitat present on the steeper, southwest-facing slopes,[35] particularly below the western Booth Creek cliffs, has superior snow shedding characteristics and is more xeric at other times of the year. The East Vail parcel's development area is more south-facing, at a lower angle to the low-angled winter sun, and forested, which reduces snow-shedding, impairs foraging, and supports the more mesic aspen community with much fewer protein-rich shrubs in the understory.

Trail camera images of sheep foraging below the Booth Creek cliffs provide additional insight regarding sheep foraging in aspen forest. Four occasions of time lapse images of sheep foraging in the high quality habitat below the Booth Creek cliffs indicated that sheep appeared to select against foraging far into transitional aspen habitat. Figure 3-6 (above in Section 3.3.1) is the first image of a time lapse sequence (see subsequent Figs. 4-9 to 4-17, below) captured between 0700 and 1240 hours (note time stamps in figures) on January 25, of sheep coming down through the lower Booth Creek cliff band, foraging east a short way into the encroaching aspen saplings, then reversing and foraging west into the mountain shrub, and so on as they foraged across the hillside. Figures 3-6 and 4-9 to 4-17 provide the most illustrative sequence, however the same sequential behavior, where sheep appeared to select against foraging far into the aspens, was also captured on February 7 and March 14 and 25. This "avoidance" behavior was more likely related to the quality, quantity, and availability of forage (i.e., the availability of antelope bitterbrush, serviceberry, snowberry, sagebrush, and rubber rabbitbrush in the mountain shrub, versus the chokecherry that dominates the aspen understory) than to predator detection.

[34] This total includes a double counting of the same 24 sheep that were captured on TC2 and TC3 on Jan. 24.

[35] Southwest-facing slopes have better snow shedding characteristics than south-facing slopes, all other variable being equal, because the sun hits them more directly in mid-to late afternoon when temperatures are generally warmer.

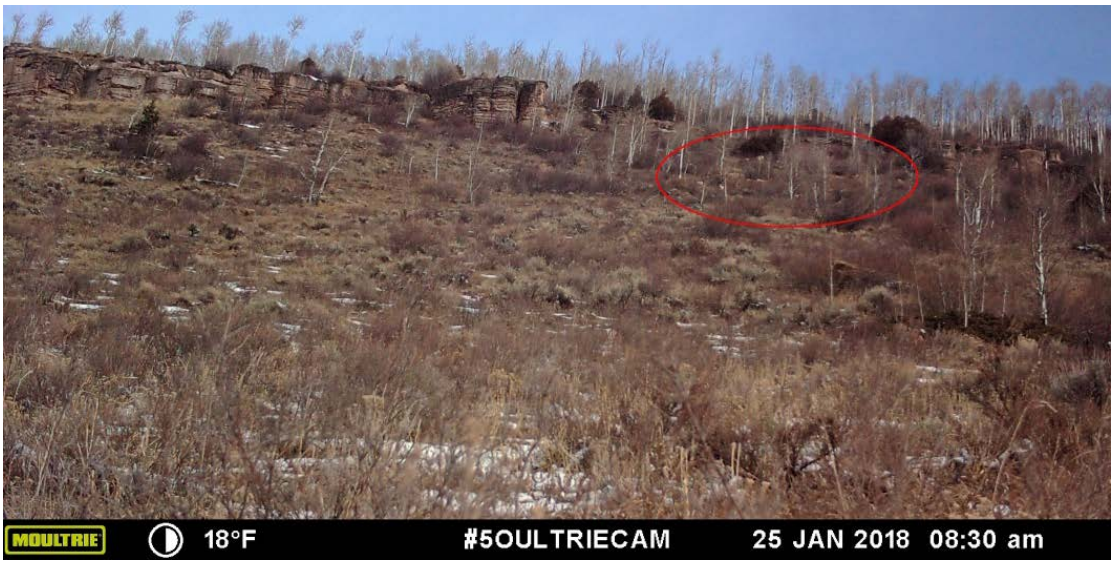

Figure 4-9. Photo 2 (TC5_J-F_402a) in a 0700 and 1240 hours sequence on January 25 showing 33 sheep (inside red ellipse) below the lower cliff band appearing to avoid foraging far into the encroaching aspen saplings below the Booth Creek cliffs.

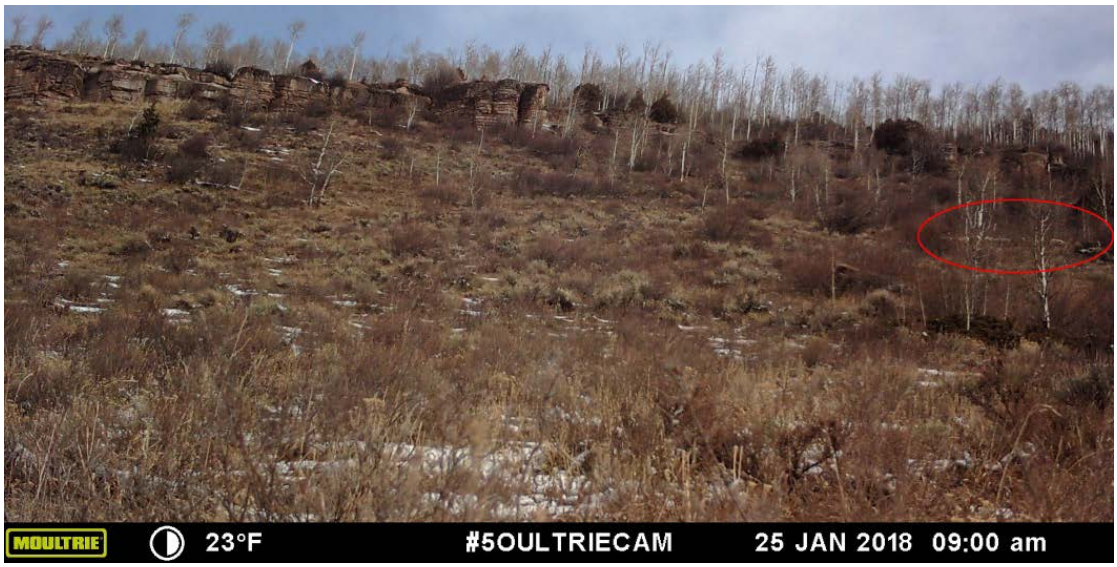

Figure 4-10. Photo 3 (TC5_J-F_405a) in a sequence (see prior figure legend). Here the sheep have foraged downhill and as far east as they would into the encroaching aspen and are about to start grazing west.

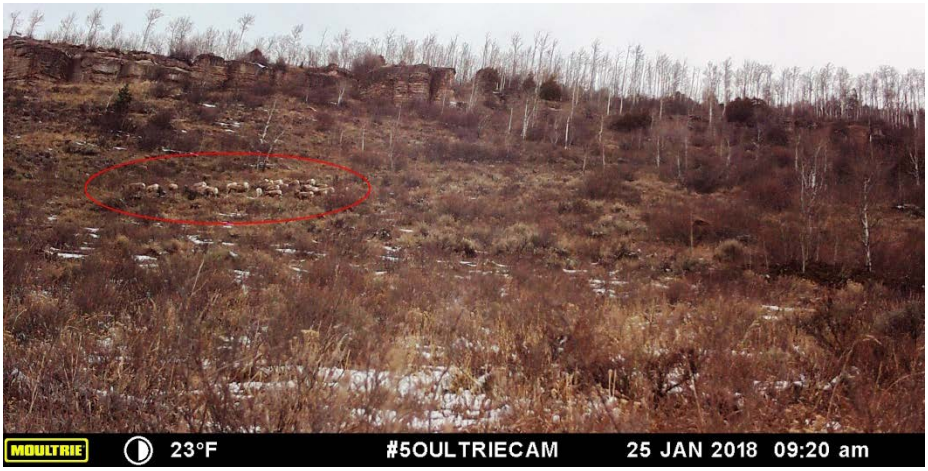

Figure 4-11. Photo 4 (TC5_J-F_407a) in a sequence (see prior figure legends). The sheep have reversed and are foraging west in the high quality mountain shrub habitat.

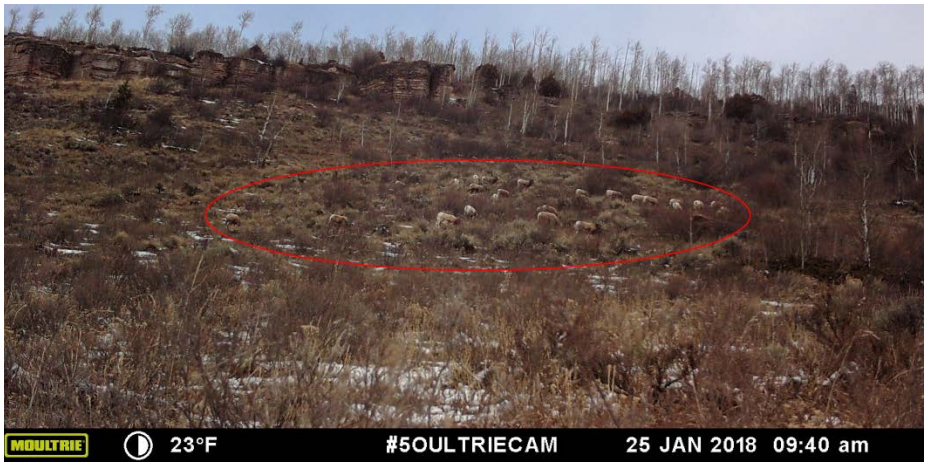

Figure 4-12. Photo 5 (TC5_J-F_409a) in a sequence (see prior figure legends). The sheep have reversed again and are foraging east to the edge of the high quality mountain shrub habitat.

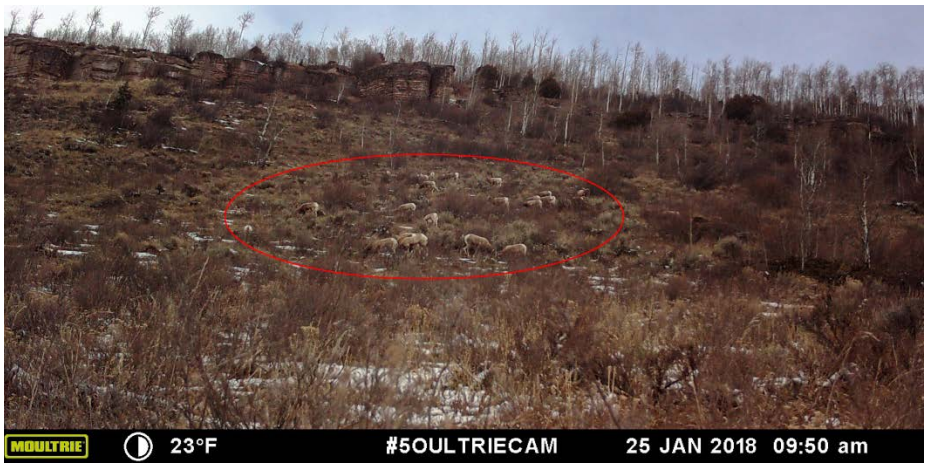

Figure 4-13. Photo 6 (TC5_J-F_4010a) in a sequence (see prior figure legends). The sheep have reversed again and are foraging west. The sheep foraged west out of the field of view, reversed, and came back into the field of view at 1110 hours.

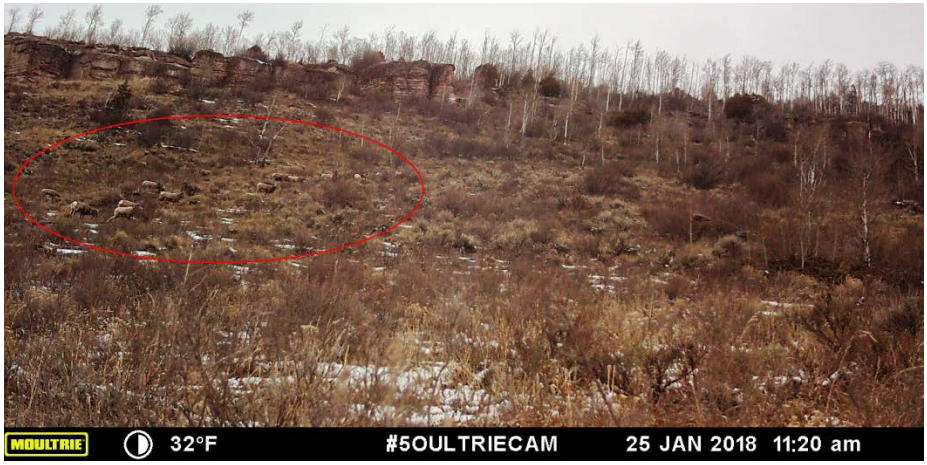

Figure 4-14. Photo 7 (TC5_J-F_4019a) in a sequence (see prior figure legends). The sheep are foraging east towards the edge of the high quality mountain shrub habitat.

Figure 4-15. Photo 8 (TC5_J-F_420a) in a sequence (see prior figure legends). The sheep continued to forage east to the edge of the aspen habitat.

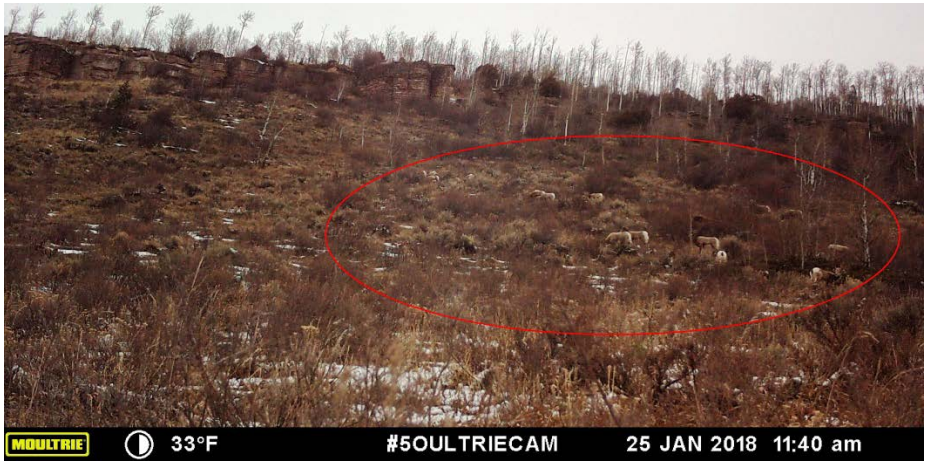

Figure 4-16. Photo 9 (TC5_J-F_421a) in a sequence (see prior figure legends). The sheep have foraged as far as they would into the encroaching aspen, reversed again, and are foraging west.

Figure 4-17. Photo 10 (TC5_J-F_424a) in a sequence (see prior figure legends). The sheep continued to forage northwest up the hillside and moved out of the field of view for the day at 1240 hours.

The sheep foraging behavior described above is intended only to describe the relative values of the mountain shrub vs. aspen habitats. All sheep winter range is important, particularly considering the amount of high quality habitats lost to human developments and winter range deterioration. The non-native, smooth brome-dominated forage on the CDOT ROW immediately adjacent to the East Vail parcel is important as winter range because it contributes to the forage base within the overall winter range polygon. While that forage may only be used over several days each winter, the use of that forage takes pressure off of the higher quality habitat elsewhere on winter range. The same argument can be made of the forage within the aspen-covered interior of the East Vail parcel's development area, even though there was little evidence of sheep foraging in the forested interior during the mild 2017/18 winter, when what foraging that may occur should have been greater than that in average and more severe winters. Furthermore, even though sheep may forage little within the interior of the development area, the use of that habitat as escape routes and travel habitat contributes to the overall functionality of this section of winter range within the vicinity of important Booth Creek cliffs.

Figure 4-8 (above) shows the most recent CPW mapping of winter sheep habitats in the vicinity of the East Vail parcel. The disclaimers associated with all CPW mapping are footnoted.[36] The mapping inaccuracies (e.g., winter range extending onto I-70) are artifacts of the 1:50,000 scale mapping. Polygons are defined by the observations of animal distributions over many years.

[36] NDIS [CPW kmz] mapping was derived from field personnel and is updated periodically [currently every 5 years]. A variety of data capture techniques were used including drawing on mylar overlays at 1:50,000 scale USGS county mapsheets and implementation of the SmartBoard Interactive Whiteboard using stand-up, real-time digitizing at various scales.

Information depicted on NDIS maps is for reference purposes only and is compiled from best available sources. Reasonable efforts have been made to ensure the accuracy of this data. Colorado Parks and Wildlife expressly disclaims responsibility for damages or liability that may arise from the use of this data.

The wildlife distribution maps are products and property of CPW, a division of the Colorado Department of Natural Resources. Care should be taken in interpreting these data. Written documents may accompany these maps and should be referenced. The information portrayed on these maps should not replace field studies necessary for more localized planning efforts. The data are gathered at a variety of scales; discrepancies may become apparent at larger scales. The areas portrayed are graphic representations of phenomena that are difficult to reduce to two dimensions. Animal distributions are fluid; animal populations and their habitats are dynamic.

The entire East Vail parcel should be considered sheep winter range.[37] While sheep may use various parcel habitats differently over multiple years, they can access all portions of the property, and that use contributes to the functionality of the overall winter range.

The validity of the overlapping severe winter range[38] polygon (Fig. 4-8) could not be evaluated over the mild 2017/18 winter.

The winter concentration area (WCA)[39] polygon (Fig. 4-8) might be[40] expanded downward to the Frontage Road and extended west along the slopes below the Booth Creek cliff rockfall berm. The existing WCA polygon does not overlap the East Vail parcel or the CDOT ROW below it and it should not be changed to overlap either area based on use during only five days over the mild 2017/18 winter that would be excluded from the CPW-defined average five winters out of ten.

With respect to minimum herd size and composition, the maximum number of sheep observed during the study at any one time was 39. Based on sex and age composition of sheep observed over the course of the study, the herd was composed of at least 10 lambs, 21 ewes, and 10 rams, totaling 41 sheep. The highest number of lambs seen at any one time was 10 on January 25 and March 14. The 2017, 10:21 lamb: ewe ratio (0.48%) indicates relatively high productivity. There was no detectable overwinter lamb or other sheep mortality. Coincident with June 14, 2018 peregrine monitoring, a minimum of 7 lambs and 12 ewes were observed at the licks on the cut slope above the rockfall berm. Assuming that there was no mortality in the herd since the end of winter, the herd numbered 48 animals at that time. Based on that 2018 productivity, knowing the minimum number of ewes in the herd, and other assumptions,[41] the herd likely numbered at least 53 sheep at that time. The East Vail sheep herd exhibited good productivity in 2017 and 2018.

4.4.2 Elk

Current CPW elk mapping in the vicinity of the East Vail parcel is incorrect. Although there are areas of the parcel that may not be used because of terrain and proximity to human disturbances areas, for all practical purposes, the entire parcel should be mapped as elk winter range. Despite the collective elk winter range losses that have occurred in Eagle County, this relatively high elevation winter range continues to be used by a small group of elk. The availability and use of this habitat as winter range takes pressure off of the lower elevation, down valley winter ranges and helps to maintain overall herd viability.

4.4.3 Peregrine Falcon

The East Vail parcel represents largely intact undeveloped habitat below and within fairly close proximity to the adjacent nest cliff. Its' seral and relatively young aspen forest does not support even moderate concentrations of prey species that would be particularly attractive to birds using the adjacent nesting cliff, but it does support potential avian prey that could contribute to the local pair's prey base.

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[37] Defined in Section 4.3.1 footnotes.

[38] Defined in Section 4.3.1 footnotes.

[39] Defined in Section 4.3.1 footnotes.

[40] If it falls within CPW's protocol of changing multiple years of polygon mapping with the results of a single winter of possibly atypical (i.e., mild winter) habitat use.

[41] Including (1) that the minimum 21 ewes that overwintered had the same productivity (0.58 lambs/ewe = 7lambs:12 ewes) as that observed in 2018 and (2) that there were no more or less (than 21; i.e., there were no young ewes that produced lambs for the first time in 2018 and all ewes that produced lambs in 2017 were also productive in 2018) productive ewes in the herd compared to 2017.

4.4.4 Other Wildlife Species

The East Vail parcel supports a moderate diversity of wildlife species that are representative of the vegetation communities and seral stages present. Some of the species present (e.g., bear, fox, and elk) have adapted their behavioral patterns (i.e., shifting to entirely nocturnal use) to avoid periods of maximum, adjacent human activity. However, most wildlife present have buffer zones so narrow that their home ranges are unaffected by the 24/7/365, human activity associated with the use of the Frontage Road and I-70.

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