MOUNTAIN GOAT–KLONDIKE HIGHWAY INTERACTIONS IN THE SOUTHERN YUKON

Report for WCS-Canada

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EXECUTIVE SUMMARY

The Klondike Highway is an international transportation corridor linking Skagway, Alaska, USA and Dawson City, Yukon, Canada. It is an important commercial trucking route, and increasingly, a popular tourist route between Skagway and the small community of Carcross, the main population center along the 183 kilometers/114 miles of highway between Skagway and Whitehorse (Yukon's capital). During fieldwork conducted in the southern Yukon in May to August 2018, observations of highway crossings by mountain goats (*Oreamnos americanus*) were made south of the Government of Yukon territorial campground at Conrad (16 km south of Carcross) between Pooly Creek and Yukon's border with British Columbia (B.C.). Two distinct mountain goat highway crossing areas were documented along a less than 5-km stretch of two-lane road: 1) the first crossing is below Pooly Canyon with two routes leading to the highway from either side of Pooly Creek for a total of four routes, and 2) a second crossing further down the highway towards the B.C. border at a wide, gravel roadside pullout with one well-used route and a second opportunistic route also documented. Between one and 12 mountain goats were recorded by remote cameras to move downslope at any one time. These two crossing areas had three main terrain aspects in common: they occur where the landmass extends out into the Windy Arm of Tagish Lake, they have beach access, and goats' routes to the highway follow creeks. There appear to be three reasons why mountain goats move downslope to the highway including: 1) to access lake water, 2) to browse on plants including currants, raspberries, wild rose, and 3) to lick gravel possibly for minerals or coolant/antifreeze deposited on the sides of the highway at the two crossing areas where there are breaks in the highway barrier and a relatively wide shoulder on what is a narrow, shoulder-less stretch of road. As in Glacier National Park (Montana), where goats access a natural mineral lick across a highway (now via underpasses), Klondike Highway crossings by mountain goats were largely nocturnal/crepuscular (median hour of movement captured by remote cameras was 4:04 AM). If, upon further study, vehicle fluids are deemed to be the main draw, it may be advisable that motorists not pull over along this short stretch of road so that antifreeze is not deposited, unless propylene (instead of ethylene) glycol is in use. If mountain goats still cross the highway for lake and plant access, then the safety of the two crossing points—for goats and motorists—may need improving possibly with signage, animal-activated highway crosswalks, or structures. The first crossing area by Pooly Creek has an existing culvert that might be conducive to widening into an underpass, similarly to those created at Glacier NP. No information has yet been documented about mountain goats' use of this stretch of the Klondike Highway in other seasons, but one member of the Carcross/Tagish First Nation who hunts mountain goats in the area during hunting season reported them to descend low down above the highway in winter.

Purpose of this report: To evaluate risks to mountain goats of a human transportation corridor intersecting goat range using data collected in the southern Yukon during summer 2018.

Of interest to: Carcross/Tagish First Nation Renewable Resources Council and Land Management Board; Government of Yukon Departments including Environment, Highways, and Tourism.

COVER PHOTO: Mountain goats on the Klondike Highway in early morning of July 23, 2018 below Pooly Canyon. Photo Credit: Atsushi Sugimoto

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INTRODUCTION

The goal of this report is to describe crossings by mountain goats (*Oreamnos americanus*) of the Klondike Highway observed in the southern Yukon, Canada, during summer 2018. Baseline information about two documented crossing points is provided. Wildlife-vehicle collisions—resulting in mountain goat deaths, human injuries, or vehicle losses—are a risk and this report aims to explore how this risk can be mitigated. Roads negatively affect mountain goats further by blocking access to resources, creating disturbance from traffic, and through the deposition of vehicle fluids (potential attractants) along the roadside.

Highways create barriers for wildlife but also draws—usually in the form of salt—affecting wildlife movement, behavior, distribution, and population persistence (Rytwinski and Fahrig, 2015; Environment Canada and Health Canada, 2001; Fraser and Thomas, 1982). While in North America, we are perhaps most familiar with seeing members of the deer (Cervidae) family along roads including elk (*Cervus canadensis*), moose (*Alces alces*), white-tailed (*Odocoileus virginianus*) and mule deer (*O. hemionus*), other hoofed mammals also cross or use roads for example bighorn sheep (*Ovis canadensis*). Such crossings can result in negative effects for people most commonly highway accidents, and for wildlife, from loss of genetic diversity (Epps et al., 2015) to road mortality, which can decimate entire herds (Scott, 2012).

In the case of bighorn sheep, drawn to roads for salt and minerals, a number of mitigation measures have been tried on Montana Highway 200 in the United States (U.S.). These measures included flashing yellow caution signs and electronic reader boards to slow down drivers and reduce collisions, while also strategically installing salt licks off-road to draw sheep away from the highway. Unfortunately, none of these measures was successful including because drivers did not slow down and sheep were not successfully lured away from the road (Scott, 2012). Odor repellents, intended to keep animals away from areas, have also been tested in reducing wildlife-vehicle collisions and, while they present an affordable option, their efficacy is notably less than that claimed by the manufacturers of such products (Bíl et al., 2017; Brown et al., 2000). More expensive but effective mitigation options are wildlife crossing structures in the form of underpasses and overpasses, and associated fencing, “the tried and true solutions” according to Rob Ament (Road Ecology Program Manager at the Western Transportation Institute at Montana State University, pers. comm., 2018; see also, Rytwinski et al., 2016).

A perhaps unlikely species to be seen near roads is the mountain goat, an alpine specialist which inhabits steep terrain from the Yukon and Alaska (its native northern range limit) to the southern Rocky Mountains in Colorado (where it is introduced). The most thorough overview to date of interactions between mountain goats and highways comes from near Glacier National Park (GNP), Montana. To the south of GNP is an area known as Walton Goat Lick where mountain goats were documented, as far back as the 1970s, to cross U.S. Highway 2 to reach a natural mineral lick (Singer, 1975, 1978, 1985). The lick is 100 meters (m) downslope of U.S. Highway 2 and along the banks of the Middle Fork of the Flathead River (Singer, 1985); an estimated 90-120 goats from GNP visit the lick between April and August of each year (Singer, 1978). Because of collision hazards and high disturbance during crossings, Singer (1975) suggested that a crossing structure be built and that visitors be restricted from entering the crossing area.

Thanks to Singer's work, a bridge permitting underpassage by mountain goats was constructed and mountain goats readily use it until today. There are now also several roadside viewing areas where visitors can observe the lick and goats. The "goat bridge" underpass is 3-8 m high and 23 m wide and accommodates the main goat highway crossing area (Singer, 1985); a second underpass accommodates another passage (3 m high x 3 m wide x 11 m) (Singer, 1985). During bridge construction, goat trails were obliterated and new trails dug leading to both bridge areas; in addition, a sheer wall downhill and a cyclone fence uphill restrict goats' movements funneling them in the direction of the underpasses (Singer, 1985). While Singer (1985) reports that initially, goats would run under bridges or show fear if stopping under bridges and hearing road traffic overhead, it appears that goats have habituated to traffic noise and now even rest underneath the bridges and use the underpassage areas for shade during summer (Sumio Harada, pers. comm., 2019; Fig. 1).

Figure 1 Mountain goats using the shade of an underpass at Glacier National Park, Montana. Photo Credit: Sumio Harada

There is also road use by mountain goats at Logan Pass (highest elevation reachable by car in GNP at 2025 m) which is a more recent phenomenon and associated with goats' attraction to vehicle fluids, human urine and even sweat (Doug Chadwick, pers. comm., 2018; Sarmento and Berger, 2017). Here, a mitigation method has included the use of a trained herding dog to keep mountain goats and bighorn sheep away from people (NPS, 2016). The use of the dog was instituted after the animals habituated to other methods including the use

of noise in the form of shouting, sirens, and shaking of cans of rocks. In areas within mountain goat range frequently visited by people, habituation (and deposition of attractants in the form of vehicle and human bodily fluids) presents a real risk (Fig. 2).

Figure 2 Mountain goats interact with a car on the Going to the Sun Road in Glacier National Park, Montana in the 1990s. Photo Credit: Sumio Harada

Mountain goats are uncommon in the Yukon, Canada, and number approximately 1400 (Festa-Bianchet 2008), with 35-40% of the entire Yukon population tucked away in remote parts of Kluane National Park (Champagne and Aishihik Traditional Territory Fish and Wildlife Planning Team, 2017). A small population estimated in 2016 to number 120 individuals (Kyle Russell, pers. comm., 2018) occurs on Montana Mountain in Carcross/Tagish First Nation (CTFN) Traditional Territory. The area has had and continues to experience considerable human activity including recreation (camping, hiking, mountain biking, boating), hunting, mining, and road traffic along the Klondike Highway.

The Klondike Highway is a 715 km- / 445 mile-long, mostly paved, transportation corridor that links the towns of Dawson City (Yukon) and Skagway (Alaska). It divides the slopes used by mountain goats in the Montana Mountain area (south of Carcross between the Conrad campsite and the Yukon-British Columbia (B.C.) border) from the western shores of Tagish Lake (Windy Arm of). The speed limit along this stretch of highway is 60 kmph / 40 mph.

During summer 2018, mountain goats were observed to use the slopes above the Klondike Highway between just south of the Conrad campsite and the B.C. border but mainly between Pooly Canyon to just short of the provincial border. Two highway crossing areas were documented: one at Pooly Canyon/Creek/Point and a second at a roadside pullout not far from the provincial border. The goal of this report is to describe these two crossings, the associated risks to mountain goats and motorists, and explore means of reducing these risks.

A description of what motivates mountain goat highway crossings is given to inform a more detailed focal study in the future. As mountain goats are not numerous in the Yukon, and females (nannies) with young offspring (kids) are highly mobile in summer, any highway-related mortality can make their population susceptible to negative road effects.

SITE

The slopes above the Windy Arm of Tagish Lake and the Klondike Highway (60°01'20 N, 134° 37'59 W) fall within the Yukon Stikine Highlands Ecoregion, within CTFN Traditional Territory, and within native mountain goat range. The slopes consist mainly of open rocky terrain (Fig. 3). Vegetation on the slopes is maintained in un-forested or scrub forest / shrub seral conditions with patchy meadows because of avalanche activity in most winters and poor growing conditions (little soil, low soil moisture due to southeast exposure with much sun, and high outflow (katabatic) winds). True subalpine plant species are generally absent. This vegetation community structure and composition, coupled with good escape terrain, make these slopes favorable mountain goat habitat. The slopes abutting the road are characterized by steep gradients from approximately 670 m at the highway level to above 1000 m (our highest remote cameras were installed at just over 1000 m). Mountain goats were observed to descend downslope to road level at night from higher than this starting at ~1200 m, representing what is therefore a ~500-meter descent. Montana Mountain (2205 m), the area's highest peak, is not visible from the highway.

In addition to mountain goats, the area supports other mammals including Dall sheep (*Ovis dalli*), black bear (*Ursus americanus*), grizzly bear (*Ursus arctos*), and lynx (*Lynx canadensis*). All of these taxa, except for Dall sheep, were captured by our remote cameras during summer 2018; in addition, we made a record of an American kestrel (*Falco sparverius*) nest near one of our camera trapping sites just above the Klondike Highway.

There is a history and ongoing presence of human activity in the area including hiking (including with dogs), camping, boating, vehicles pulling over for scenic viewpoints, mountain-biking (although this activity tends to be limited to the trails closer to Montana Mountain). There is also hunting (by CTFN). There are 100 or more years of mining history with structures and contamination still present; furthermore, an individual with mining claims and residing in the area at Pooly Point recently expressed interest in resuming mining in the future.

Mountain goats were observed to be skittish, highly observant of any potential human disturbance, and to avoid people, even if sitting in a photography hide/blind. There is abundant escape terrain and vegetation cover near both documented highway crossings (Figs. 4-5), from herein referred to as Crossing 1 and Crossing 2.

Figure 3 View on Klondike Highway and Windy Arm of Tagish Lake from slopes used by mountain goats midway between Crossings 1 and 2. Photo Credit: Atsushi Sugimoto

Figure 4 Crossing 1 area with Pooly Point in background and edge of Pooly Canyon in foreground. Arrows point to mountain goats' road access points.

Figure 5 Crossing 2 area boxed in red in distance at gravel pullout.

Figure 6 Gravel pullout at Crossing 2 as viewed from a mountain goat trail above the highway.

METHODS

Our research was aimed at studying the patterns and phenology of mountain goats' winter coat shedding (Nowak et al., 2018) and not mountain goat interactions with the Klondike Highway. Our methods were therefore not as targeted as would be required for a focal study of highway crossings by wildlife. Our methods included the use of remote camera traps, discussions with people familiar with the area, inspections of roadsides and lake banks for mountain goat signs, and opportunistic observations of mountain goats including on the highway.

We initially set up three remote cameras in mid-May until mid-June 2018 at 1018-1039 m a.s.l. (midway between the two highway crossings, before we learned about them). Once we learned about the crossings, we set cameras lower down at 703-963 m above the two road crossings and until August 23, 2018.

In total, we had a sample of 278 camera trap (CT) nights (Appendix I), and report here our photographic capture rates (based on the number of independent captures in 24-hour periods) in the three areas: mid-way between the highway crossings (May-June), the first road crossing (Crossing 1) above Pooly Point (June-August) and Crossing 2 above the gravel pullout (July-August; Fig. 6) (Fig. 7). CT captures are further described including hours of capture, number of individuals moving together at any one time, and photographic capture rates across months at the CT site with the highest rate of capture (one camera at Crossing 1 at Pooly just above the Klondike Highway).

A capture (each row of data) equated to the following: several individuals moving together across the frame, i.e. captured together, with each following, separate capture during such movements constituting a change in the composition of individuals (usually within 10 seconds of each other). In cases where a series of photos 10-15 seconds apart showed the same individual(s), it was entered as a single capture. In other instances, if the same individual appeared a half hour or so later, it was again entered as a separate capture but a note was made that it was likely the same individual as before (this assessment was often made on the basis of its shedding pattern and extent, or other defining features).

It was thanks to discussions with people living locally that we were first alerted to the fact that mountain goats cross the highway. According to a long-time local resident, both thinhorn sheep and mountain goats cross the highway to drink from the lake.

Upon inspections of the roadside (in mid-June, after the kidding period, when we re-entered the area to check our cameras), the first highway crossing area near Pooly Canyon was confirmed on the basis of shed mountain goat hair, tracks, and obvious trails leading to the highway (Fig. 8). In July, the second crossing area was discovered. In addition, we inspected the western shores of the Windy Arm of Tagish Lake by packraft (in July) between Conrad campsite and Pooly Point but did not find mountain goat signs along the lakeshores. The only such evidence (in the form of shed hair) was below Crossing 2's gravel pullout (Fig. 9) and near Crossing 1's Pooly Point beach (more details to follow).

Observations at and around the two crossings were also made from inside a parked vehicle in early morning in late July with two early mornings of observation resulting in two sets of observations of mountain goats crossing (e.g., cover photo by Atsushi Sugimoto).

RESULTS & DISCUSSION

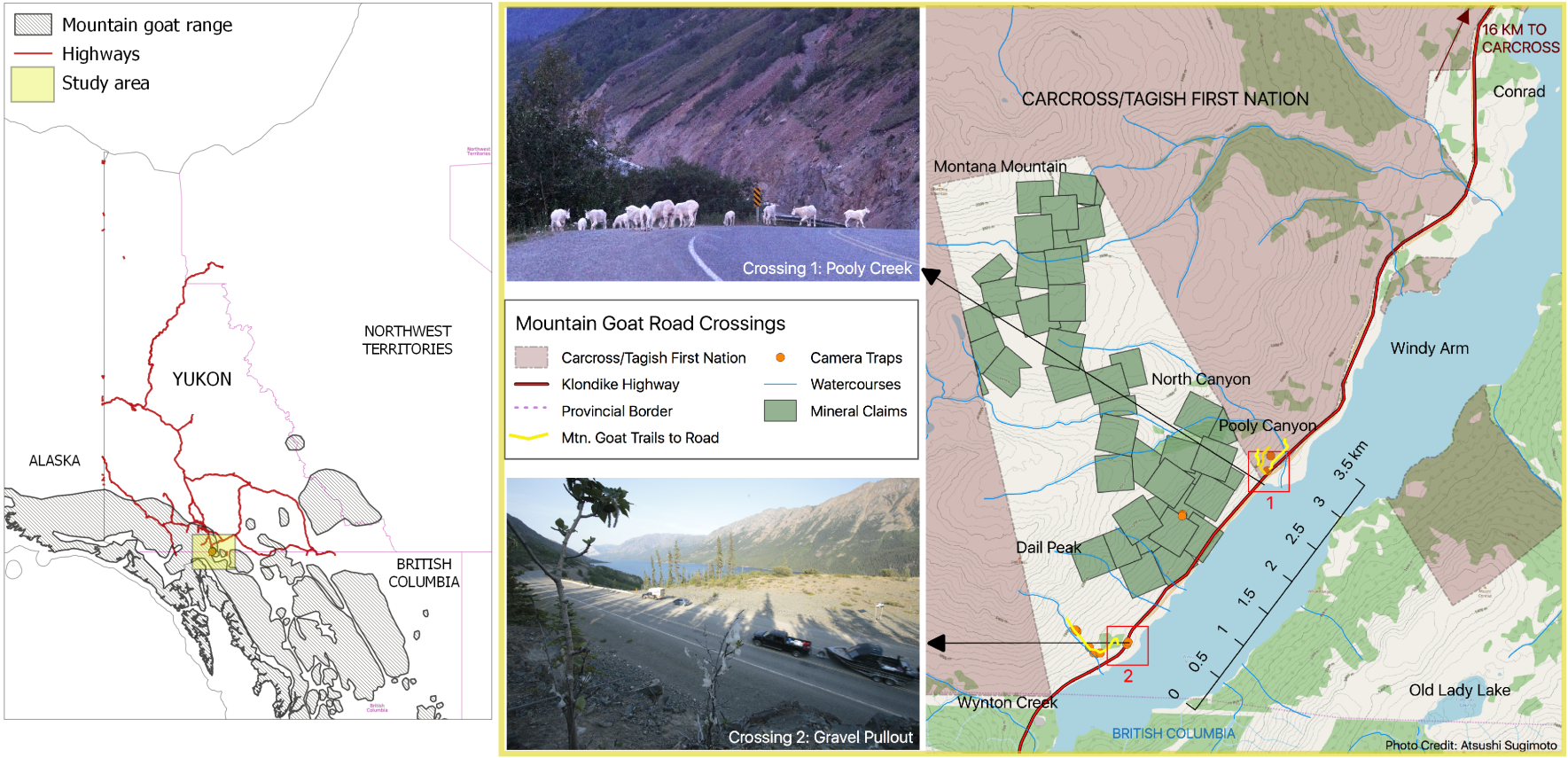
The highway sits above the lake with steep slopes down to the lake. It is two-lane with paved shoulders, and a safety barrier on the lake side of the road runs along its entire length between the crossing areas. The barrier is made of galvanized metal (c. 40 cm high) supported c. 80 cm off the ground with wooden poles, thereby creating an impassable barrier to goats. The crossing sites have no barrier coupled with slopes that can be negotiated down to the lake.

Crossing Points

Two crossing areas were documented along the stretch of road between Conrad campsite and the B.C. border (Fig. 7). The first (Crossing 1; Fig. 8) has at least four routes (mountain goat trails) leading to the road from slopes above and beyond Pooly Canyon, while the second crossing has one main route and a second opportunistic escape route (Fig. 9). The opportunistic route is thought to have been used by a nanny with kid in response to our vehicle presence on the highway; it is thought that goats primarily use the one main route near-directly across from the gravel pullout.

These areas were discovered after we were alerted to highway crossings by mountain goats and Dall sheep by a local resident. Roadsides were then inspected and, in both crossing areas, much shed hair was found near the highway barrier gaps especially near Pooly Point (an area of land that especially juts out into the Windy Arm of Tagish Lake along this stretch) and in the roadside gravel pullout area near the B.C. border. Inspection of the western shores of Tagish Lake by packraft between the Conrad campsite and Pooly Point did not turn up any mountain goat signs with the exception of areas below these two crossings, both of which have beach / water access, further corroborating that these may be the mountain goats' two main crossing points.

Shed hair was found in a small area below the second crossing accessed on foot by climbing down a steep slope; and an area on the lake side just beyond the highway barrier above the beach at Pooly Point. There were no signs along this beach itself, possibly because it is rocky in the area where goats may be descending to drink. Targeted camera-trapping along this (privately owned) beach on Pooly Point below the culvert would be informative.



Two mountain goat highway crossing areas were documented between May and August 2018 in the southern Yukon. Specifically, these crossings occur in a less than 5-km stretch of the Klondike Highway between Pooly Creek below Pooly Canyon and the B.C. border. The first crossing (crossing 1) is characterized by a culvert and easy access to a wide beach at Pooly Point. The second crossing (crossing 2) is characterized by a gravel pullout with a steep descent to a small rocky beach. Mountain goats' crossings were largely crepuscular and nocturnal, and motivated by water access at the Windy Arm of Tagish Lake, plants including currants, wild rose, and raspberries, and also licking of coolant/antifreeze by the roadside. Descents down to the road (at about 650m a.s.l.) were steep and goats started descents from above 1000m.

Figure 7 Combined information about mountain goat crossings of the Klondike Highway. Only highways in the Yukon are shown in the inset map (top left) that highlights the study area in yellow. The 2- and 3D maps provide further detail.

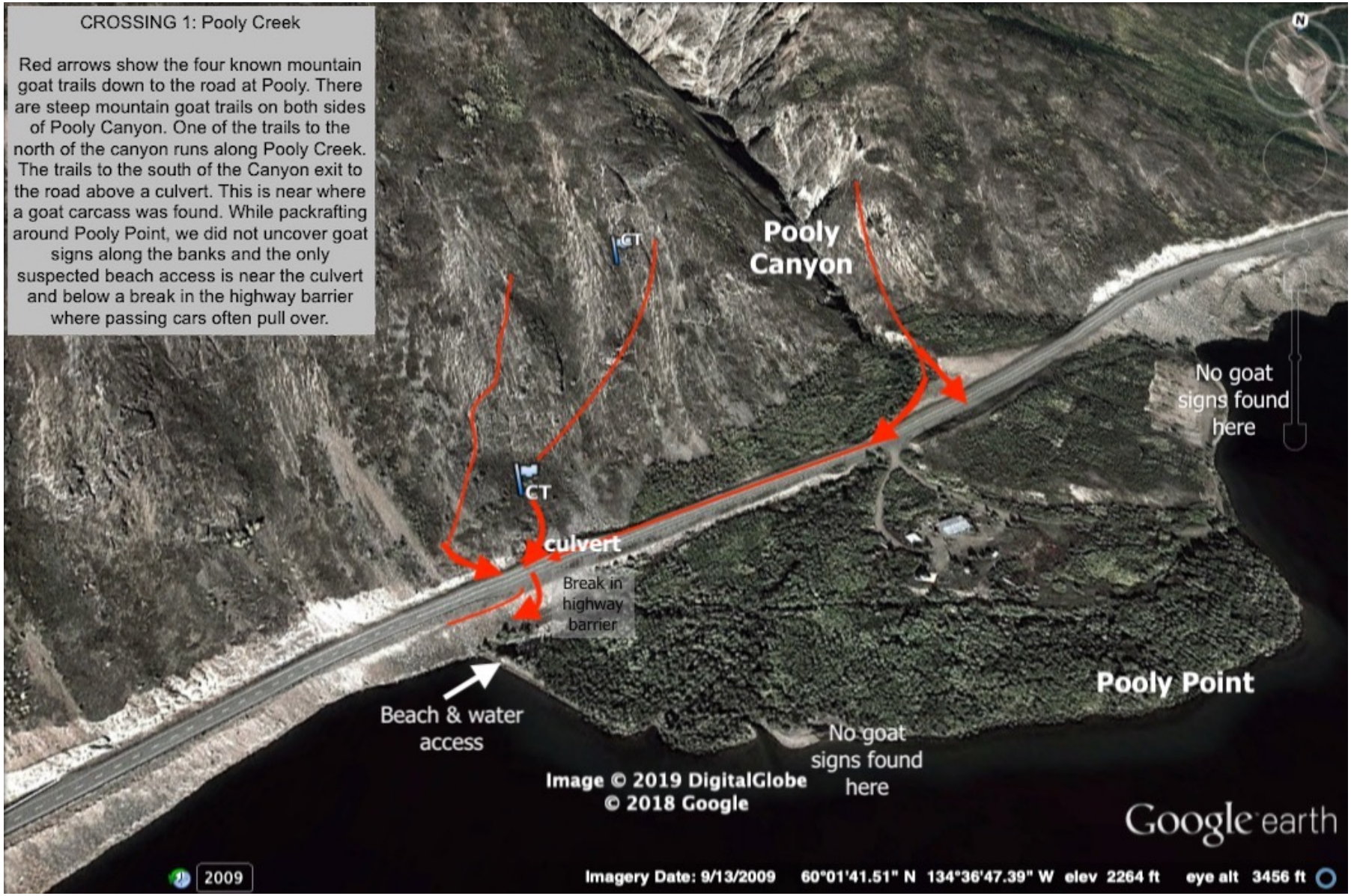


Figure 8 Google Earth annotated image of Crossing 1 at Pooly showing four mountain goat routes to the highway (red lines represent goat trails). The stretch of highway between Pooly Canyon and the culvert is a funnel for goats to reach the break in the highway barrier and access the lake as evinced by goat tracks running along the road shoulder and shed hair at the break.

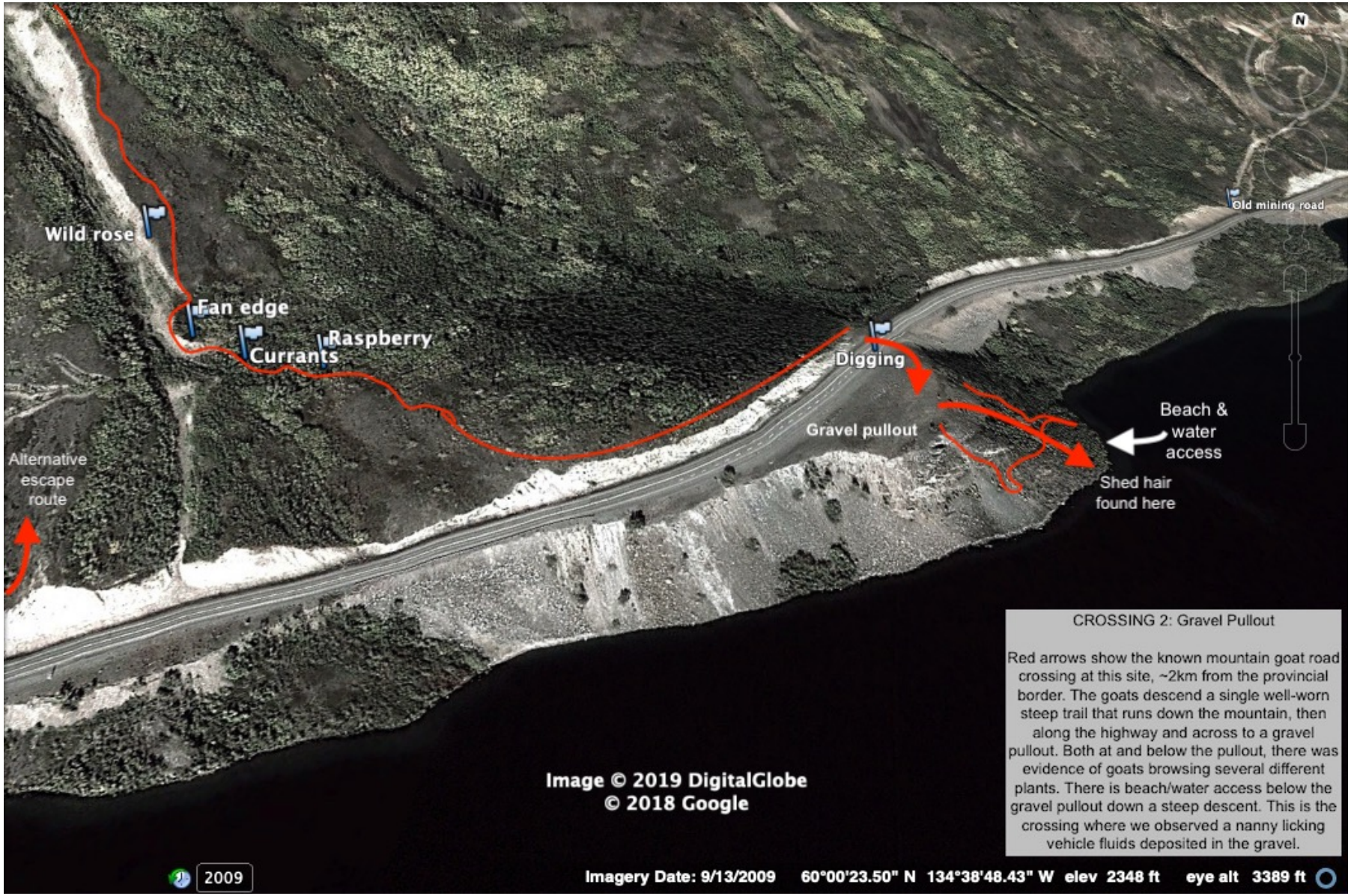


Figure 9 Annotated Google Earth image of Crossing 2 showing mountain goats' main route downslope to the highway (red line) and one alternate escape route up. As rose, raspberry, currants were found on the slopes, plants cannot be the sole motivation for highway crossings. Shed hair was found near the lake shoreline below the gravel pullout suggesting water access.

Terrain at Crossing Points

The two crossing points share the following characteristics: 1) the land area is relatively wider, extending further into the lake, than at other points along this short stretch of road thereby providing a wider shoulder (Fig. 10), 2) mountain goat routes down to the road run alongside creeks and canyons, and 3) there is lake beach access below both crossings.

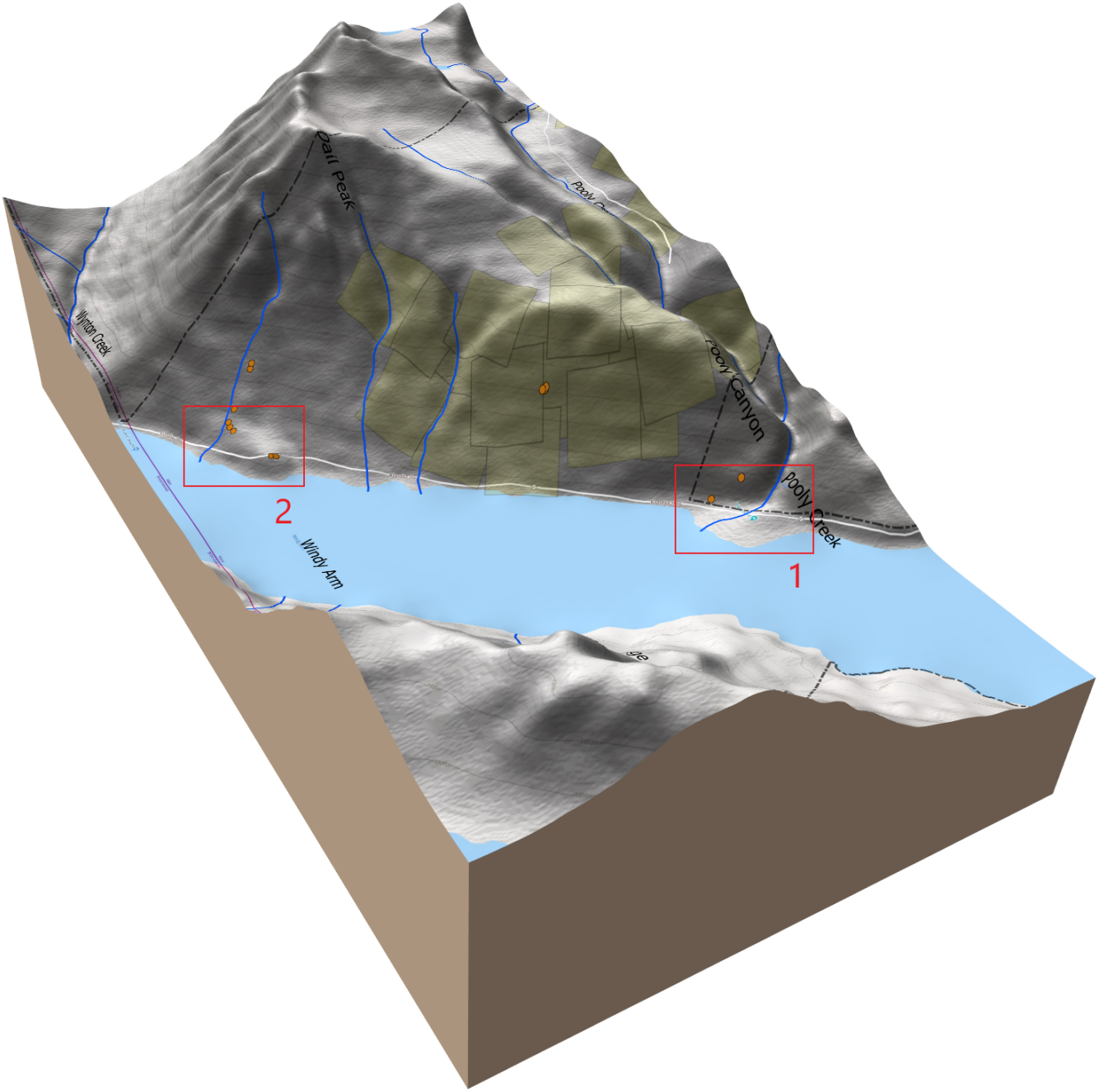


Figure 10 3D bird's eye view of the two mountain goat highway crossings (1 = Pooly Creek, 2 = roadside pullout near B.C. border) showing how the land extends out into the Windy Arm of Tagish Lake in both areas with mountain goat routes running alongside creeks.

Camera Trap Photographic Rates

On the basis of camera trap (CT) photographic rates, Crossing 1 had more mountain goat activity than Crossing 2 (Fig. 11). More targeted study would ideally be conducted to confirm this by installing the same number of CTs that run uninterrupted from early May until early September in all three areas simultaneously (with the midway area acting as a kind of control for comparison).

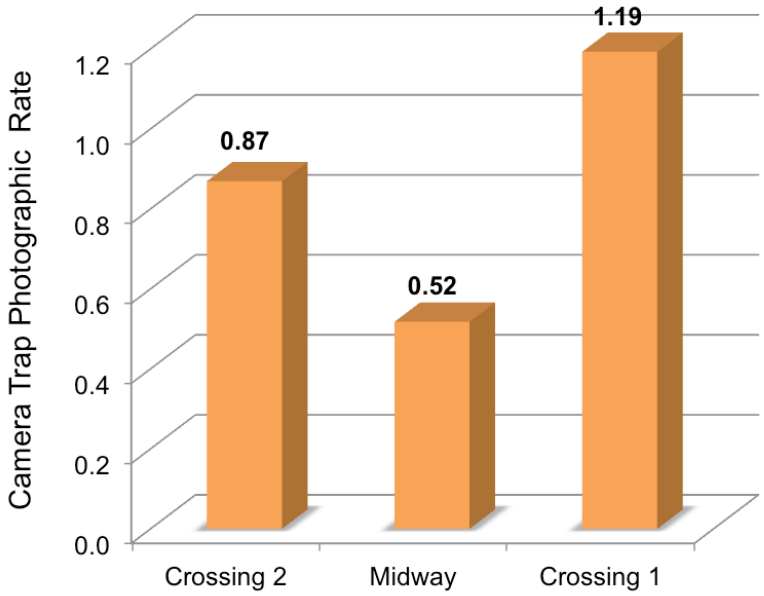


Figure 11 Camera trap photographic rates at and between crossings suggestive of relatively more mountain goat activity at Crossing 1 than Crossing 2. Figure is ordered by location on the highway from left to right indicating south (Crossing 2) to north (Crossing 1).

A temporal comparison of activity across months (May-August) could not be reliably done with the data at hand because of differences in camera trapping effort across months at the three sites (Appendix I). This was in large part because we had only up to four CTs to work with at any one time at this site, and we experienced some interruptions (due to dead batteries).

This said, taking a single camera trapping location directly above the Klondike Highway at Crossing 1 with the largest number of trap nights (N trap nights = 40; see Appendix I)—although with effort not spread equally across months—suggests that June may be a peak month for mountain goats' road crossings (Table 1).

Table 1 Comparison of Crossing 1 activity at one specific location above Klondike Highway.

Month	N captures	Effort (N trap nights)	CT photographic rate (N captures/N trap nights)
June	94	9	**10.44**
July	7	8	0.88
August	13	23	0.57

Looking more closely at data from the June captures (94 captures over 9 trap nights) at this one CT at Crossing 1 suggests that mountain goats came down to the highway every night for 10 consecutive nights, 18-27 June inclusive (note that the number of trap nights are under-estimated as the rate calculation uses complete 24-hr periods). Unfortunately, the batteries at this CT died by 28 June and were not replaced until 23 July. During the remaining 31 trap nights between 23/7 and 23/8 only 20 captures were made suggesting that June '18 was more active by comparison (possibly because of long day-length and heat). Still, as shown in the cover photo (taken at this exact crossing), mountain goats were using the highway in late July as well.

Movement Times

Downhill movements started in the evenings (c. 11 PM, pers. obs., 2018) and by 6 AM, mountain goats were back upslope. For example, an adult billy (Fig. 12a-b) was captured above Crossing 2 at 18:05 hours at just under 1000 m a.s.l. heading slowly downslope (Fig. 12a) and was then captured by the same camera coming back upslope at 4:30 hours 10.5 hours later (Fig. 12b). The wisp of tail hair was the defining characteristic by which he was identified.

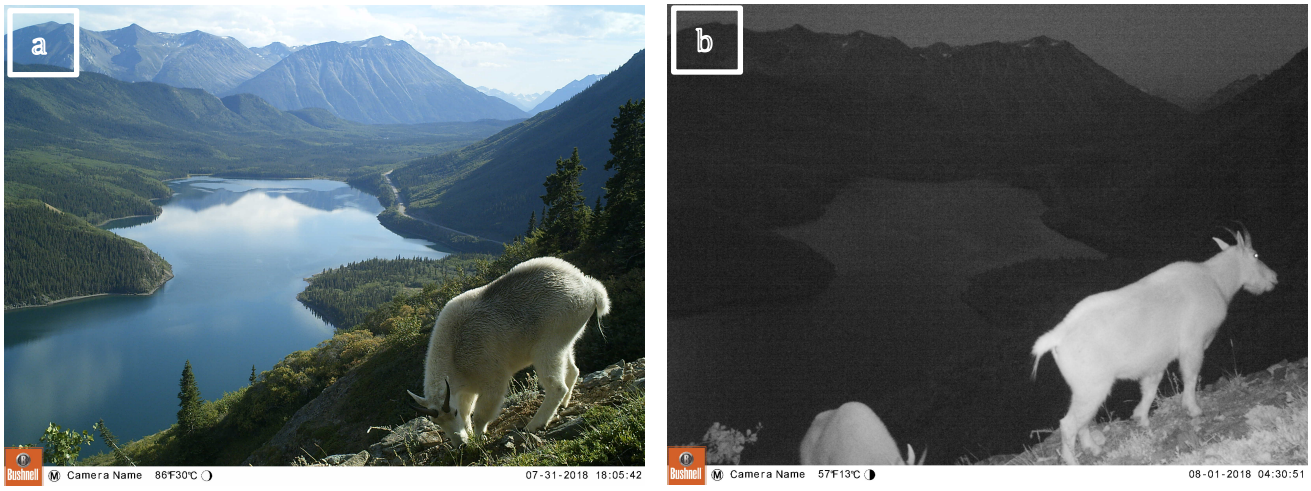


Figure 12 a-b Adult billy heading downslope at approximately 6 PM (a), and captured again 10.5 hours later heading back upslope at 4:30 AM, this time with a companion (b).

According to our CT data (and consistent with our opportunistic observations), mountain goats were moving between 11 PM and 6 AM (Fig. 13), thus avoiding high traffic volumes when crossing the road (as do wildlife elsewhere for example in West Glacier, Montana; Roesch, 2010; Waller & Servheen, 2005).

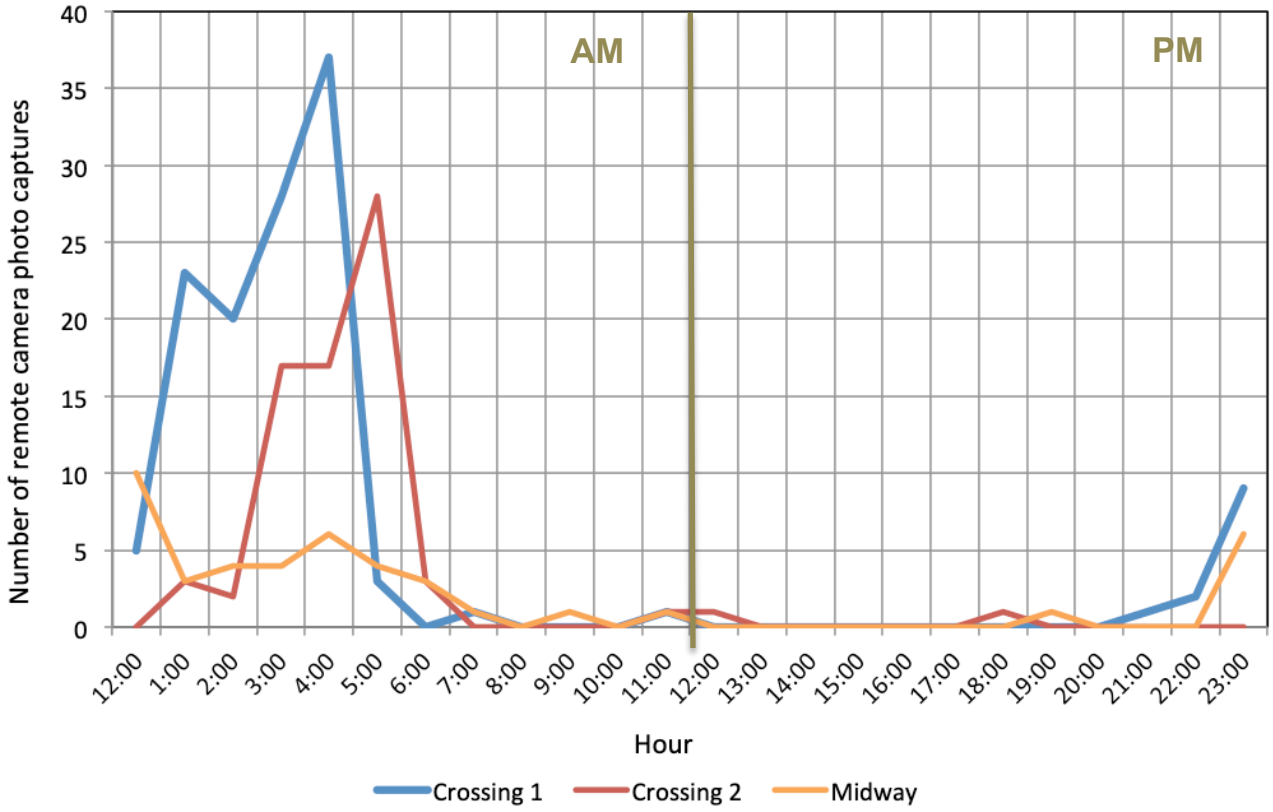


Figure 13 Number and times of day that mountain goats were captured by CTs at the two crossings and midway. Peak movement times were between midnight and 6 AM.

Herd Sizes

The sizes of herds moving past cameras ranged from one to a maximum of 12 (Table 2; Figs. 14-17).

Table 2 Herd sizes moving past cameras in the three locations.

Location	Mean	StdDev	Min	Max	Count
Crossing 1	**2.05**	1.67	1	12	130
Crossing 2	1.71	1.18	1	7	73
Midway	1.25	0.49	1	3	44

While it is difficult to surmise exactly how many goats are crossing the highway, it could be a quarter of the Montana Mountain population (120).

Figure 14 Mountain goat captured at 3 AM on June 24, 2018 by a remote camera tied to the highway barrier near Crossing 1 above the beach at Pooly Point. This individual had already crossed the highway and moved through the highway barrier break point, then swung right and moved alongside the outside of the barrier above the lake.

Figure 15 Two mountain goats (note the adult standing on the edge of the highway in the background) captured above Crossing 2 on July 25, 2018 at 4:51 AM. This one is heading back upslope.

Figure 16 Nanny and kid moving downslope along the commonly-used and well-worn route to the highway at Crossing 1 at 4:06 AM on June 25, 2018.

Figure 17 Two mountain goats moving downslope along the commonly-used, well-worn path above Crossing 1 on June 22 at 5:51 AM.

Figure 18 Five mountain goats heading back upslope on July 29, 2018, at 5:45 AM.

Sought-After Resources

There was evidence that mountain goats browse raspberry (*Rubus idaeus*), currants (*Ribes* sp.), prickly wild rose (*Rosa acicularis*), and possibly other plants along the roadside near these two crossings (Fig. 19a-b). However, as these plants are also available on the slopes above the highway (Fig. 20), they cannot be the only driver of mountain goats' sojourns downslope and across the road.

While no personal observations of drinking were made, evidence in the form of shed hair was found directly near a small beach (below Crossing 2) and just above the beach at Pooly Point (Crossing 1). There were also reports of both mountain goats and Dall sheep drinking from the lake conveyed to us by a local resident who has resided in the area for the past 10 years. Nannies will have higher water demands while lactating, and this might explain some of the relatively high levels of goat traffic up and down the slope in May-July.

Figure 19 a-b Plants (a=raspberry, b=wild rose) browsed and covered in shed hair at the gravel pullout near Crossing 2. Crossing 1 also had such signs.

Unlike at Mount White (another site where we camera-trapped), no obvious mineral licks were found anywhere at this site; it cannot be ruled out that the lake water is a mineral source.

Other water along the slopes included several creeks, including Pooly, which goats drink from (according to our CT evidence). Another creek (midway between crossings) runs orange and is probably not used for drinking (see next section).

Figure 20 Wild rose growing well above Crossing 2 suggesting that plant access cannot be the only driver of mountain goats' descent to the highway area.

In addition to plants and water, mountain goats were observed to be attracted to the highway for a third reason: gravel, which may be mineral-rich or contain vehicle fluids (since road salts are not used in the Yukon). On July 24, a nanny (with that year's kid) was observed digging and consuming either bits of gravel/sand or coolant/antifreeze at Crossing 2 (Fig. 21a-c). This is similar to observations of Dall sheep on the Alaska Highway near Kluane Lake (Rudyk, 2019).

Figure 21 a-c Nanny with kid consuming possibly gravel or coolant/antifreeze along the roadside in the early morning at Crossing 2 on July 24, 2018 (a), with close-up photos (b & c) showing digging.

Discussions with People Living Locally or Nearby

According to persons living locally, disturbance to mountain goats has risen since information about a hiking trail (Sam McGee) was published online and bike routes established. One individual voiced concerns about any wildlife road crossing signs being installed at Pooly Point area as these could attract undue attention.

Another local person, Jacqueline St. Jacques, convinced highway authorities to leave the barrier open where mountain goats cross the highway near the Pooly property. She also asked a trucker friend if he has noticed any changes in habits of the mountain goats since the highway was first built and he said no. “The goats still come down for water in the evenings, and early mornings, never during the day. I have had to go up the road twice this week at 5-5:30 AM and have seen goats both times...to the north and south of the Pooly property driveway. As soon as they hear/see your vehicle they go running across the highway and up the mountain” (Fig. 22a-b shows escape response to vehicle).

According to St. Jacques, Dall sheep come downslope earlier than mountain goats. “I watched some sheep last week…and they were up on the mountain all day and worked their way down around 3:30 PM to get to the lake for water. They were just above the highway (6 feet) and some motor cycles came along and they quickly scampered back up and did not try again to get to the lake.”

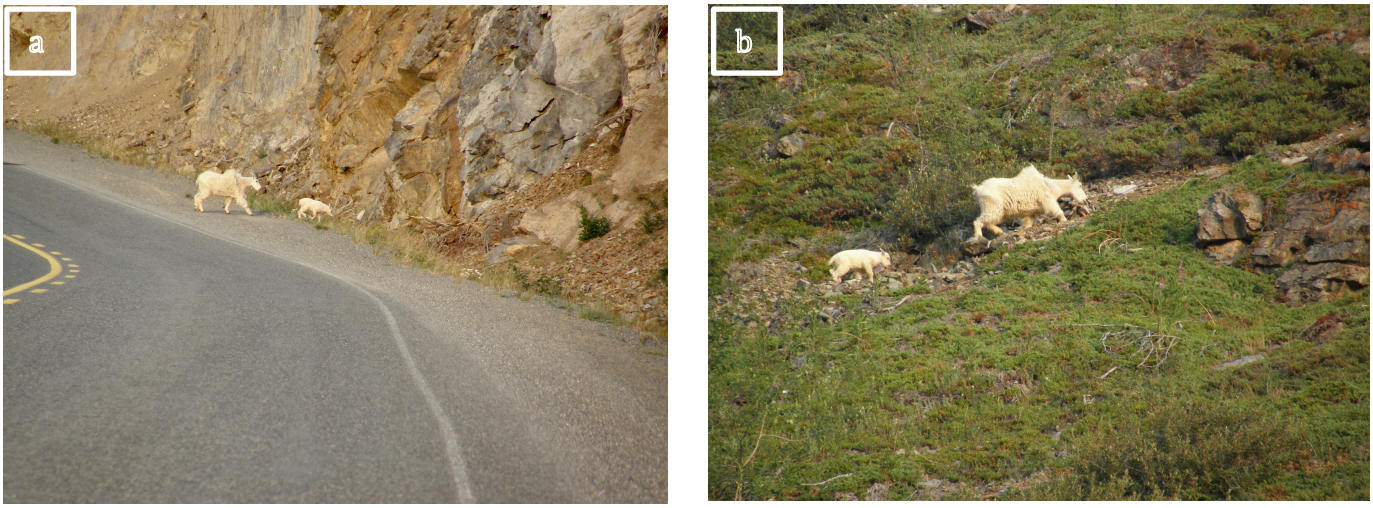


Figure 22 a-b A nanny and kid along the Klondike Highway (a) scamper quickly upslope (b) at the sight of a vehicle. Photo Credit: Jacqueline St. Jacques

St. Jacques is a proponent of installing signs at hiking trail entry points telling visitors to avoid areas during kidding season and maintain appropriate (200 m) distances to mountain goats.

A prominent CTFN member who has hunted mountain goats on these slopes, reports seeing them low down above the road in winter months.

Finally, an older woman who hikes in the area and who was encountered in passing in Carcross described a high elevation lake above North Canyon which she posits could be

more accessible to the goats than Tagish Lake; she therefore expressed surprise at the premise of them descending steep slopes at night for water. Highway crossings for water access have however been reported for other ungulates, for example desert bighorn sheep in Arizona (Gagnon et al., 2014).

Hazards Along Road

Two hazards that characterize this stretch of road are blind spots and large trucks (Figs. 23-24).

Figure 23 Large truck caught on our camera trap opposite the gravel pullout at Crossing 2.

Figure 24 Truck at Crossing 2 in late August.

A large volume of mineral ore concentrate is transported by B-train transport trucks from mines on the north Klondike Highway to Skagway for shipment to southern smelters. There is also regular tanker truck traffic hauling hydrocarbon fuels from Skagway into Yukon. There is therefore significant truck traffic (Figs. 23-24) along this route, presumably year-round. Wildlife on the highway in the mornings and evenings likely pose a greater risk to truck-drivers than to other motorists.

The road is also busy with tourist traffic moving between Skagway and Carcross between May and September. As the Skagway-Fraser border closes at 9 PM, reopening at 9 AM, there is respite and less traffic at night when the U.S.-Canada border is closed. This may be one reason for goats' avoidance of the road area between 6 AM until 11 PM, although crepuscular and nocturnal foraging behaviour has previously been reported (Festa-Bianchet and Côté, 2007) and nighttime movement was observed by us elsewhere (Mt. White and Kluane NP) outside the context of highway crossings. High temperatures during summer in addition to high traffic volumes are thought to explain highway crossings peaking between 0500 and 1100 hours in desert bighorn sheep (Gagnon et al., 2014).

Another hazard is vehicle fluids especially at the pullout areas at both crossings where there are highway barrier breaks. It needs to be determined if their deposition is in fact the main attractant for mountain goats rather than lake water and food plants.

One (adult female) mountain goat carcass was found on the roadside above Pooly Point in early July and she could have been roadkill; however, this could not be ascertained for sure because before an investigation of bone breaks from a possible collision could be made, the carcass was dragged and scattered by a bear. The camera trap above the highway near where this carcass was found captured a lone kid at ~8 AM which was significantly later than typical movements this low down; the kid could have belonged to this nanny. Mountain goat road mortality is currently presumed to be low, but could increase if traffic along this stretch of highway increases, if the Canada-USA border crossing hours change (become 24-hours such as at the Beaver Creek/Alcan border crossing) or if mountain goats' access to lakeside resources becomes more frequent, crepuscular or even diurnal.

Natural predators present another risk to mountain goats in the area and may also be a factor in their nighttime activity. Brown and black bears and lynx were all captured by our cameras. We also encountered several bears including a black bear on Pooly Point beach while inspecting the beach for mountain goat signs (below Crossing 1) and a grizzly bear high above Crossing 2. Both bears avoided us. There is much bear activity in the patch of woods and along the main mountain goat trail used to come down to the road above Crossing 2. The lynx was captured on the camera above Crossing 1 also along a goat trail.

St. Jacques reports more bear activity around Pooly Point since the Conrad campsite opened and she diligently cleans up after campers (including breaking down campfires) at the spillover campsite to the south of Conrad where people often park their vehicles for hiking the Sam McGee trail.

The highway safety barricade itself seems to be a major obstacle for goats, creating a funnel(s) for road crossings.

Other hazards include mining contamination (arsenic and heavy metals) (Fig. 25) and mineral-rich streams, less likely to be palatable for goats (Fig. 26).

Figure 25 Sign warning of arsenic and heavy metal contamination on the side of the Klondike Highway between the two crossing areas.

Figure 26 A stream runs orange midway between the two crossing areas.

RECOMMENDATIONS

As our study was aimed at capturing photos of mountain goats in various stages of winter coat molt, ideally a focused study of mountain goats' highway crossings would be conducted to better understand the timing and frequency of crossings, group sizes and compositions of goats crossing, and goats' use of resources on the eastern side of the Klondike Highway / on the banks of Windy Arm (see Fig. 29 recommended decision-tree at the end of this section).

According to YTG biologist Kyle Russell, "We knew they would come down off the mountains in the evenings and mornings, from road kills and anecdotal sighting reports, but the regularity of the patterns is new information to me." (Kyle Russell, pers. comm., 2018).

The stretch of Klondike Highway that traverses a movement route for mountain goats is approximately the same length as that in Glacier NP (Singer, 1975), i.e. less than 5 km in Yukon, 5.2 km in Glacier. Similarly to the use of the Walton Goat Lick in Glacier, it appears that the use of the lakeside area by the Pooly goats occurs primarily in summer months (May-August). That goats might use the lakewater for minerals cannot be ruled out, and water testing (of both the lake and streams) could be carried out to examine if water access at the lake may be driven by high acidity, sulfate mineral content or mining contamination of natural streams higher up or by specific mineral content or composition (e.g., Calcium) of lake water.

As in Singer's study in Glacier (1975), mountain goats appeared to be very trail-oriented (there was not much hair off-trail, trails were well-worn, and camera traps showed habitual use of trails) and therefore the prospect for mountain goats to use an enhanced or constructed highway crossing is high if these were a future possibility.

The minimum recommendation at this time is monitoring (Fig. 29), although more immediate installation of standard signage (that includes emphasis on speed limit) would alert drivers to the risk of wildlife-vehicle collisions sooner rather than later (Huijser et al., 2015).

A recent study shows good results from camera-triggered warning lights that drivers encounter on warning signs well away from actual crossings (Gagnon et al., 2019). Movements of animals on trails trigger the cameras which then trigger the lights. Such mitigation would be a much less costly alternative to re-engineering the road bed. Given mountain goats' habitual trails and crossings apparently limited to just two points along the road, a camera-activated warning light system may be worth considering if either traffic or goat movements change in timing or frequency (Fig. 29).

If re-engineering becomes a necessary and feasible option, then, as Singer (1985) points out, any bridges or underpasses must be located on traditional crossing routes and not be confining. What is advantageous is that the two crossing areas are associated with land that extends out into the lake and these areas can therefore accommodate a potential structure. The culvert at Crossing 1 (which stays dry during summer), could be adapted to accommodate an underpass allowing for goat crossings. The wall of rock at Crossing 2 could possibly support an overpass to the below gravel pullout even in a half-arch shape but this sort of structure would be more costly than expanding the height of the existing culvert at Crossing 1 (the more busy of the two crossing areas). Experts such as at Animal Road Crossings (ARC: https://arc-solutions.org/) would need to be consulted.

Since underpasses were installed at Glacier NP (Fig. 27), mountain goats have not been observed on the road; however, they may still use the highway edge if drawn to certain resources (Sumio Harada, pers. comm., 2019; Fig. 28).

What presents a challenge is that the two crossing areas documented alongside Windy Arm are also where people pull over in their vehicles to rest or enjoy the vistas. Coolant/antifreeze thus gets deposited. Yukon authorities might consider asking that people not pull over along this short stretch of road between the Conrad campsite and the B.C. border, or, as has been done in B.C., require that a bittering agent be added to antifreeze to deter consumption (AGCanada, 2009). Otherwise, the areas would need to be cleaned of fluids as using deterrents such as cayenne carries risks including attraction of bears or eventual habituation to and consumption of the deterrent (Newhouse and Kinley, 2001). Signs could also ask that people avoid pulling over unless the coolant/antifreeze in their cars is animal-friendly (propylene glycol-based instead of ethylene glycol-based antifreeze; for more information including on retailers see the BC-SPCA website: https://spca.bc.ca/faqs/antifreeze/).

Where moose visit roadside salt pools in the Laurentides Wildlife Reserve, Quebec, managers have successfully decreased their visitation by 90% through management (LeBlond et al. 2007). The salt pools were drained or filled with rocks to deter moose from drinking the brackish water. Likewise, the two roadside shoulders along this stretch of the

Klondike Highway could be tested for mineral content, possibly cleaned of antifreeze, while also perhaps considering the use of odor deterrents at the outset in consultation with relevant experts.

In addition to highway mitigation methods, additional (precautionary) changes to management might need to be considered. In Alaska, where a proposed all-season highway between Juneau and the Katzehin river flats would intersect mountain goat winter habitat, in addition to highway mitigation, changes to hunting regulations have been recommended to reduce deleterious effects on populations (White et al., 2012). This is also because this particular road would grant unprecedented access to mountain goat range to the large number of hunters from Juneau. It was therefore recommended that hunting be regulated with more restricted limited-entry drawing hunts to avoid overharvest, and that hunt areas be smaller to avoid localized depletion (White et al., 2012). Furthermore, White et al. (2012) recommended that winter migration must be taken into account given that mountain goats overwinter near the road corridor making them especially vulnerable. All this said, traditional harvest access must be respected and maintained.

Figure 27 Mountain goats under one of the underpasses leading to a natural goat lick just outside Glacier National Park, Montana. Photo Credit: U.S. Geological Survey

Any resumption of mining near Pooly must heed note that mining activity should be at least 1 mile away from mountain goat winter habitat (White and Gregovich, 2016) and this recommendation is unlikely to be met here given that mining claims overlap with mountain goat range (Fig. 7) and goats are active in the area throughout the year (pers. comm., Keith Wolfe Smarch, 2018).

One simple way to immediately reduce disturbance to goats in this area is to install signs telling people to avoid hiking in the area during the kidding period (mid-May to mid-June or later) including along old mining roads midway between Crossings 1 and 2 (local residents are supportive of such signage). Websites advertising hiking and mountain biking trails, and the Conrad campsite, could include explicit mention of this rule.

Decisions about next steps (Fig. 29) must be made in consultation with CTFN, YTG, and others.

Figure 28 Mountain goats on highway edge near Walton Goat Lick.
Photo Credit: Sumio Harada

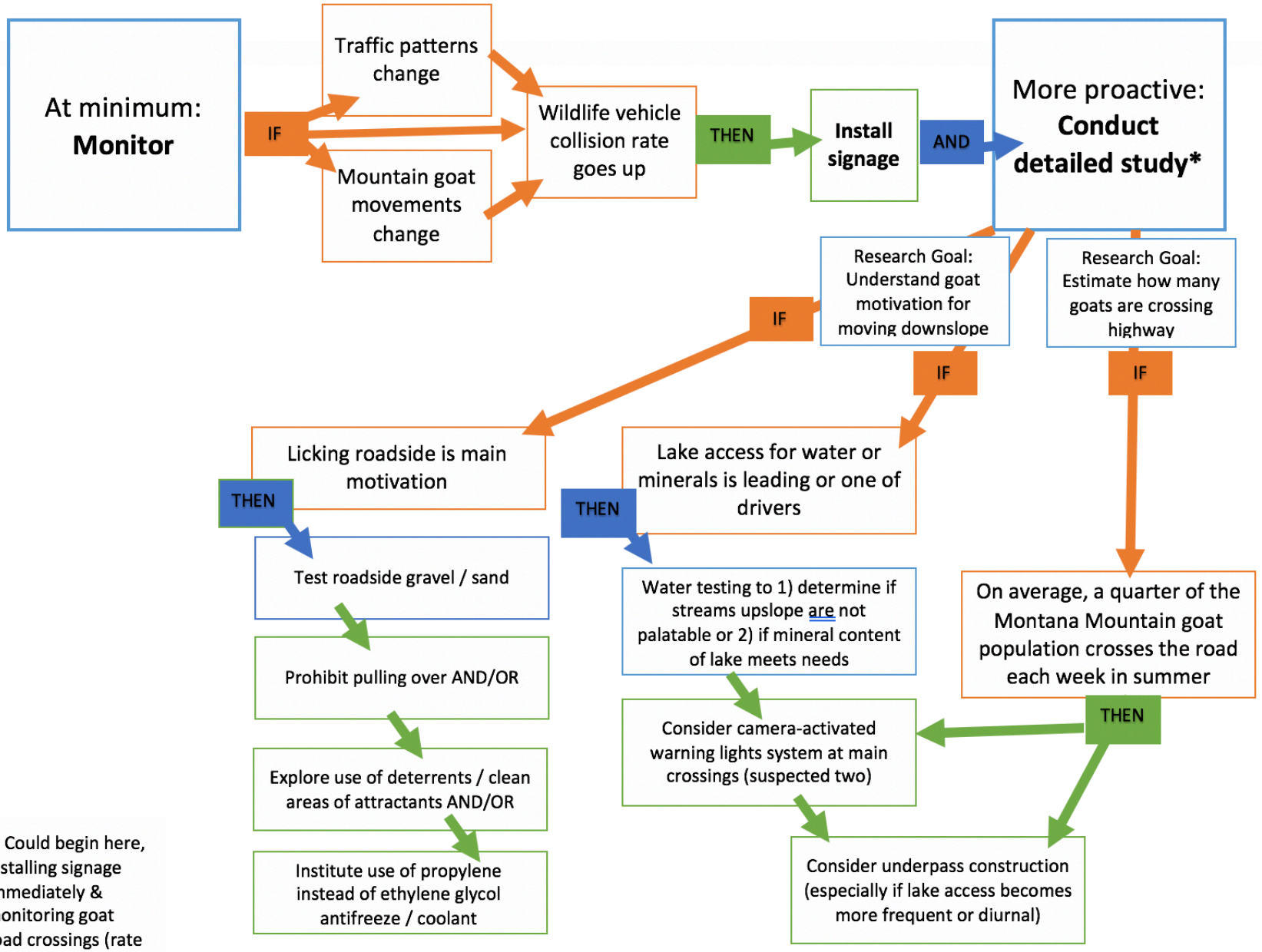


Figure 29 Flowchart for decision-making about mountain goat highway crossings.

SUMMARY

Mountain goats from the Montana Mountain population in the southern Yukon cross the Klondike Highway at two points less than 3.5 km apart between Pooly Creek and a wide roadside pullout near the B.C. border. Evidence of crossings included trails leading to the highway, shed hair along these trails and along the roadside, mountain goat tracks along the road shoulder, evidence of browsing and shed hair deposited on plants, images from camera traps of mountain goats including from just above the highway and on the lake side of the highway, and observations of mountain goats on the highway itself. Mountain goats and also Dall sheep have been observed by a local resident to cross the road to access water in the Windy Arm of Tagish Lake. We found evidence of them browsing on plants along the roadside, and observed a nanny with kid to use her hooves to dig and lick minerals in gravel or coolant/antifreeze deposited on the side of the highway where there is a wide shoulder and vehicle pullout. Water access could be motivated by excess summer heat, unpalatability of streams on the slopes, or mineral (e.g. Calcium) content of lake water, and is deserving of further investigation. A focal study of these highway crossings would ideally be carried out to better understand the factors motivating mountain goats to descend the steep slopes at night and early morning to this stretch of the Klondike Highway at least between late spring and early autumn. Monitoring of the risks to wildlife and motorists along this stretch of road is highly recommended especially as increasing summer temperatures may raise mountain goats' water and mineral needs, and/or mountain goat movements or highway traffic patterns may change.

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APPENDICES

Appendix I Camera Trap Effort and Photographic Rates. The camera trapping rates at Crossing 1 and 2 are at least partly indicatory of highway crossing rates in particular the lower cameras stationed near to or above the highway (indicated with an asterisk "*").

Crossing	CT Location name	Start	End	Trap nights	Total trap nights	Captures	Photo capture rate (N captures/N trap nights)
1	Pooly creek*	6/19/18 14:54	6/24/18 16:55	5	5	1	0.20
	Pooly creek path*	6/23/18 17:08	7/23/18 15:22	29	29	7	0.24
	High above road	6/19/18 11:52	7/24/18 16:21	35	35	3	0.09
	Highway barrier*	6/23/18 20:30	6/24/18 9:35	0	0	5	NA
	Low above road*	6/18/18 19:52	6/28/18 10:52	9	40	114	2.85
		7/23/18 17:21	8/23/18 17:24	31			
2	Above road & second crossing point*	7/24/18 19:09	7/25/18 5:47	0	0	3	NA
	High above second crossing	7/24/18 14:12	8/23/18 15:31	30	30	10	0.33
	Junction above second crossing*	7/24/18 15:00	8/23/18 15:04	30	30	37	1.23
	Raspberry plants near junction*	7/29/18 16:38	8/23/18 14:55	24	24	23	0.96
Mid	Bluebells (high slopes)	5/20/18 13:11	6/18/18 12:52	28	28	23	0.82
	Ledge	5/20/18 11:42	6/18/18 12:13	29	29	19	0.66
	Mid-slopes	5/20/18 14:06	6/18/18 12:45	28	28	2	0.07
TOTAL					**278**	**247**	**0.89**