Stemilt-Squilchuck Elk Camera Study

Elk Movements, Calving and Time of Use

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Introduction
Elk are an important economic and cultural resource (WDFW 2003) and have substantial influence on ecosystems in the eastern Cascades of Washington. For example, elk can influence plant community composition (Opperman and Merenlender 2000, Riggs et al. 2000, Alldredge et al. 2001, Rooney 2001, Baker et al. 2005, Beschta 2005, Wisdom et al. 2006), nutrient cycling (Frank 1998, Evens and Belnap 1999, Schoenecker et al. 2004), disturbance regimes (Hobbs 1996, Vavra et al. 2004), and songbird community composition (Berger et al. 2001, Fuller 2001, Bailey and Whitham 2003). Elk populations peaked in Washington in the 1960s and early 1970s due to habitat conditions and forest management practices. Their present distribution occurs widely across the State, occurring in 10 major elk herds totaling an estimated 56,000 to 60,000 animals. Changes in forest management, long-term drought, and increasing human footprint have resulted in reduced carrying capacity for elk in many populations (WDFW 2005).

The impacts of recreational activities on wildlife have also become a growing concern (Larson et al. 2016) prompting research on recreational effects to a growing list of wildlife species (Larson et al. 2016, Wisdom et al. 2018). Increasing recreation on public lands has prompted concerns about effects to wildlife that include shifts in species distribution; increased flight responses, movement rates and energetic costs; reduced foraging times; and reduced carrying capacity from cumulative effects (Larson et al. 2016, Wisdom et al. 2018). Clearly, research into the effects of recreational activities on wildlife is needed to provide managers with information to balance human uses with wildlife conservation.

The elk that use the Stemilt-Squilchuck watershed are a subherd of the larger Colockum Elk Herd (WDFW 2005). Concern has been expressed about the cumulative effects of ongoing and proposed recreational activities (such as hunting, driving, skiing, hiking, snowmobile use) on elk movements and numbers. Thus, the primary objectives of this study are to: (1) understand the location and timing of elk movements through the study area; (2) detect the timing and location of elk cow-calf pairs to refine our understanding location of the elk calving in the study area; (3) use elk location data to assess habitat use patterns and refine elk habitat models; and (4) estimate seasonal elk numbers to provide a baseline of information that can be used to assess future changes in elk numbers and use patterns (Moeller et al. 2018).

Study Area
This study took place in the upper portions of the Stemilt-Squilchuck watersheds in eastern Washington (Fig. 1). This watershed lies in close proximity to the town of Wenatchee and extends from the Columbia River to Mission Peak, a relief of over 6,000 feet. The lower elevations are dominated by private lands and human developments, including houses and orchards. The upper third of the watersheds

are primarily in public ownership including lands managed by Chelan County, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, and U.S. Forest Service (TPL 2008).

Recreational uses are prominent in the upper portions of the watershed on the public lands. Uses include winter recreation such as snowmobiling, backcountry skiing, and the Mission Ridge Ski and Board Resort (TPL 2008). During the non-winter periods, the upper portion of the watershed is heavily used by hunters, hikers, bikers, off-road vehicles, and others (TPL 2008). An extensive road network provides access and is managed through a system of gates and using the Green-Dot system.

The upper portions of the watershed provide habitat for elk until winter snows push elk south where they winter out of the watershed along the banks of the Columbia River. The timing of elk movements, habitat use, and calving are of interest to managers trying to provide recreational opportunities while also protecting a valued resource (TPL 2008).

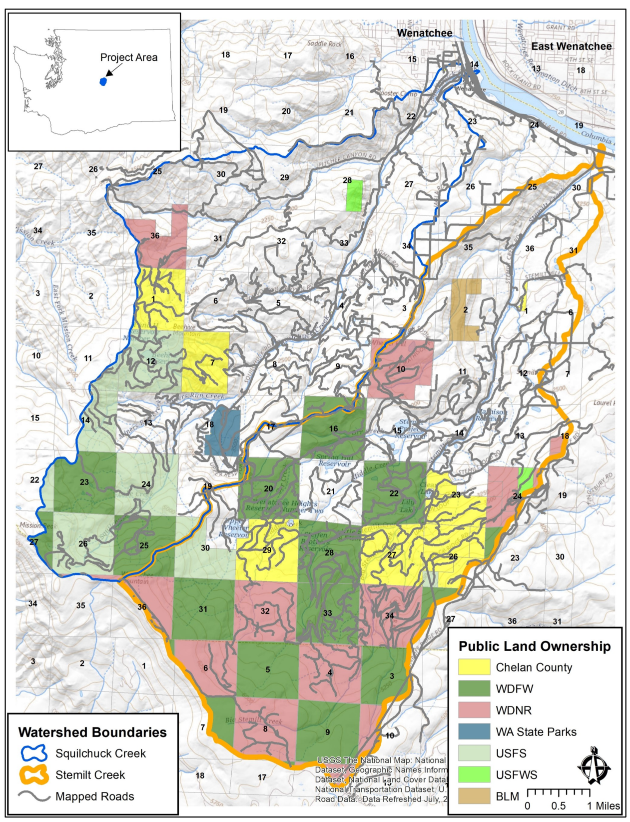


Figure 1. The Stemilt and Squilchuck watersheds showing the land ownership patterns.

Methods

Recent advancement in remote camera technology allows considerable information to be obtained on wildlife behavior and population size (Long et al. 2008, Moeller et al. 2018). We used an array of remote cameras to assess the movement patterns, habitat use, and provide seasonal estimates of the number of elk in the Stemilt-Squilchuck study area. Fifty remote cameras were installed in a grid pattern across the study area (Fig. 2). Each camera was oriented to the north to reduce issues with sun and shadows. Cameras were programmed to operate 24 hrs/day and take a series of 3 photos/detection to enhance the identification of elk sex and age. At each station, flagging was installed 50 meters from each camera and within the camera view to aid in the determination of the area sampled, an important variable in estimating abundance. Cameras were installed in the spring of 2020 and remained active until the fall of 2021. The study period encompassed spring and fall migration, and elk calving.

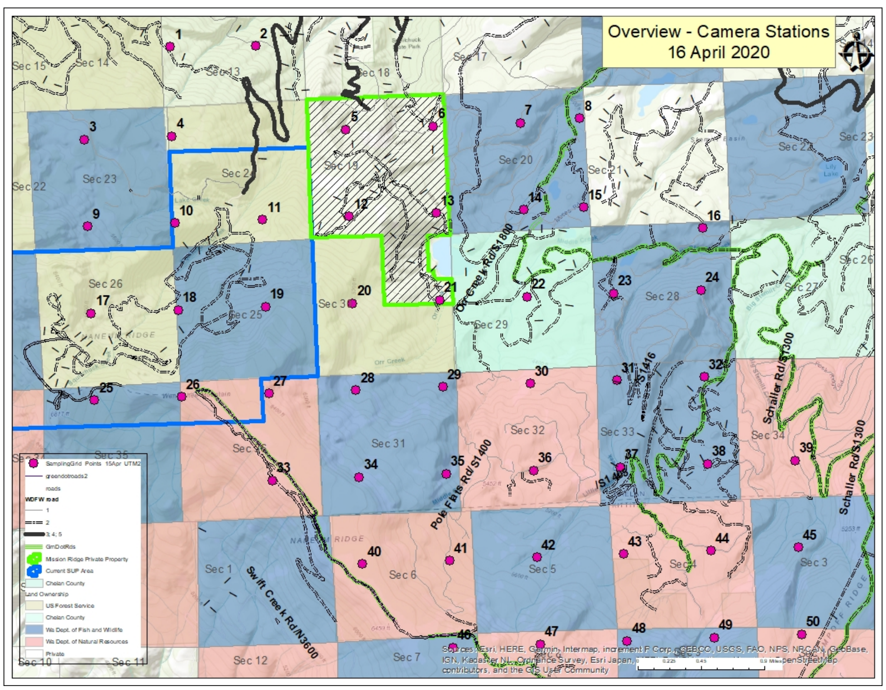


Figure 2. Map showing the location of remote cameras in the Stemilt-Squilchuck study area.

Results

Elk Detections

We detected elk 4,962 times on our array of 50 cameras in the elk survey area (Fig. 2). Of these detections, 68% were of bull elk, 25% of cow elk, and 7% of elk calves (Fig. 3). The total number of detections varied little across years with 2,423 elk detections in 2020 and 2,539 in 2021 (Table 1). Similarly, the proportion of bulls, cows, and calves were very similar across years (Table 1).

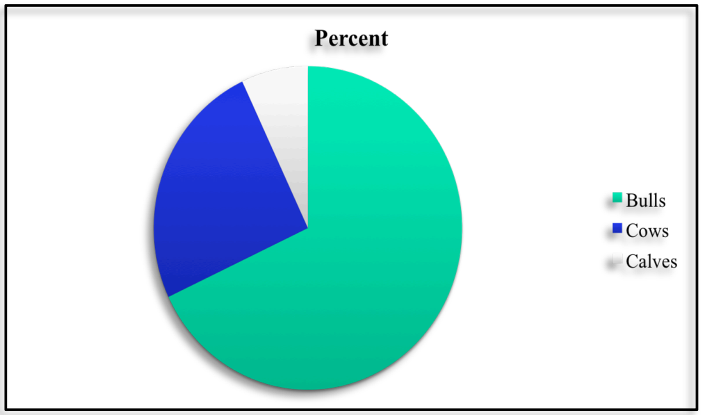


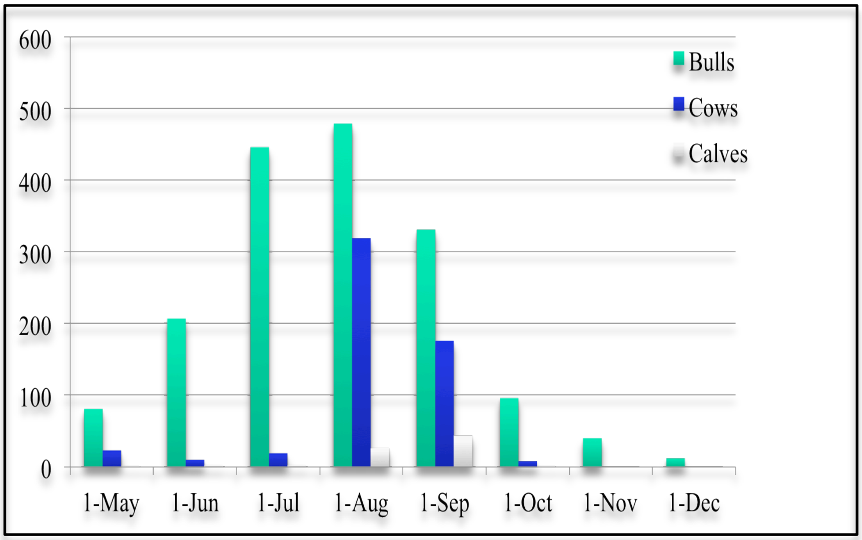
Figure 3. The proportion of the elk detections that were bulls, cows, and calves captured during the 2020-2021 remote camera study.

Table 1. The number of elk detections for each year and month in the Stemilt-Squilchuck study area.

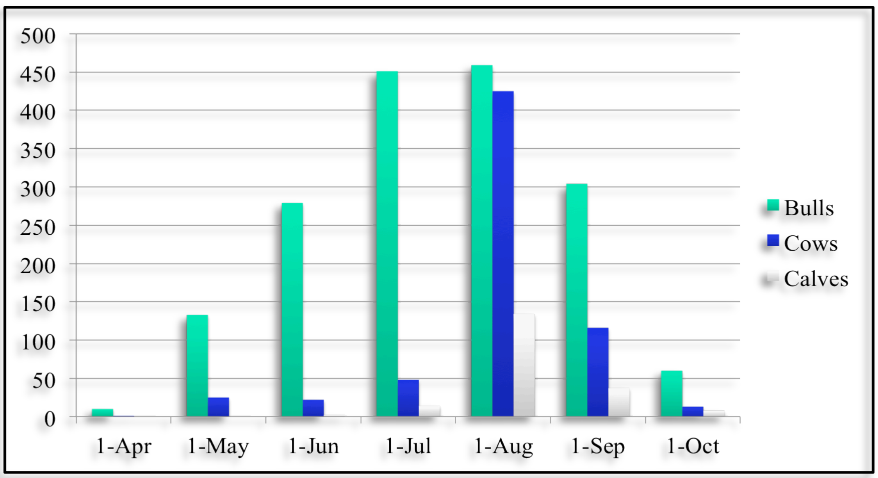
Month	2020			2021		
	Bulls	**Cows**	**Calves**	**Bulls**	**Cows**	**Calves**
April				10	1	0
May	81	23	1	133	25	0
June	207	10	2	279	22	0
July	446	19	2	451	48	14
August	479	319	126	459	425	134
September	331	176	44	304	116	37
October	96	8	1	60	13	8
November	40	0	0			
December	12	0	0			
TOTALS	1692	555	176	1696	650	193

Movements

Elk were first detected in April with bulls arriving first followed by cows. Calves were not detected until May, and then in small numbers (Table 2). The peak months for elk detections were July and August for bulls across both years (Fig. 4a,b). The peak months for detections of cows were August and September across both years (Fig. 4a,b). Calves were detected most often in September in 2020 and August in 2021. Bulls stayed in the study area later than cows or calves. The latest detection of a bull occurred in December, while few cow and calf detections occurred in October.



4a. 2020



4b. 2021

Figure 4 a,b. The number of elk detections each month during the 2020 (4a) and 2021 (4b) field seasons in the Stemilt-Squilchuck camera study area.

Elk were not equally distributed across the camera survey area and their distribution varied by sex and age. Bull elk detections in April were highly concentrated on only five cameras in the northeast portion of the survey area and all in the Stemilt subwatershed (Fig. 5). During May and June bulls were still concentrated in the northeastern portion of the survey area though we also detected some bull elk at cameras located in the higher elevations in the eastern portion of the Stemilt. July, August, and September saw the broadest distribution of detections of bulls across the survey area (Fig. 5). Nearly all cameras in the Stemilt and at all elevations had bull elk detections. However, only 3-5 cameras/month detected bull elk in the Squilchuck portion of the survey area. October showed a considerable drop in the number of elk detections though bull elk were still broadly distributed across all the elevations but where highly concentrated in the Stemilt. In November and December a few bull elk were detected on a few cameras in the northeastern portion of the survey area in the Stemilt.

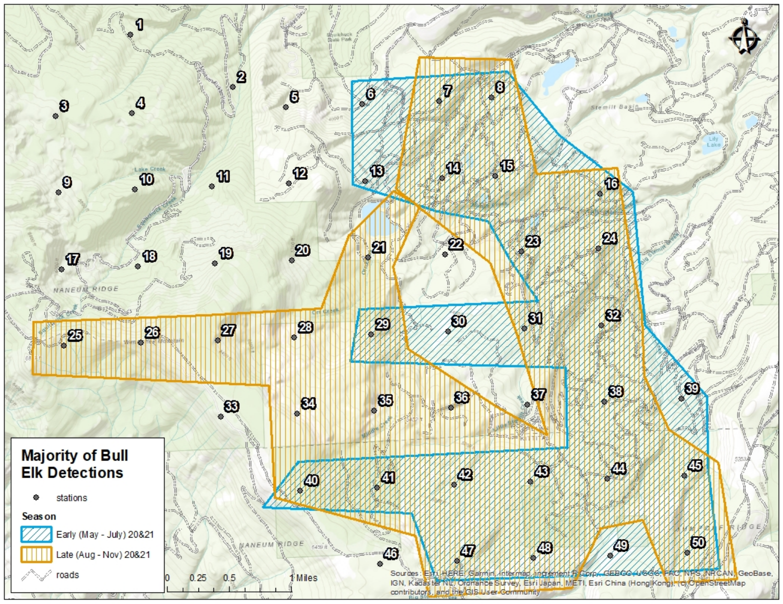


Figure 5. Map showing the majority of the bull locations during the early (April-July 2020, 2021) and late (August-November 2020, 2021) survey periods during the Stemilt-Squilchuck camera survey.

Cow elk were highly concentrated in the southeast portion of the survey area in the Stemilt during June-August (Fig. 6). The number of cow detections was low until they peaked in August when they were at their highest levels during both years (Fig. 4a,b). In September, detections of cows were lower than in August but occurred more broadly across the survey area in the Stemilt. We only detected cow elk at two cameras in the Squilchuck, both at high elevations on the summit of Naneum Ridge. By October the number of cow elk detections was few but remained broadly distributed across the Stemilt portion of the survey area. No cow elk were detected in November.

Table 2. Earliest and latest detections of elk in the Stemilt-Squilchuck study area, 2020-2021.

Elk	**Early Detection (No. Elk-Month)**	**Late Detection (No. Elk-Month)**
Bulls	10-April	12-December
Cows	1-April	8-October
Calves	1-May	1-October

Calving

One of the primary objectives of the camera survey was to document the timing and location of elk calving. We found the majority of the detections of elk calves occurring during the months of June through September (Fig. 4a,b) and were concentrated primarily in the very southeastern portion of our survey area in the Stemilt (Fig. 6). Only 1 calf was detected in May (2020) and in June we detected two calves in each year and in nearly the very same locations on the very southeastern edge of the survey area. By July the number of calf detections increased but still occurred primarily in the same area. August and September had the highest number of elk calf detections across both years and calves were more broadly distributed by moving to the higher elevations along Naneum Ridge. By October the number of detections of elk calves were few and located at cameras that were on or near Naneum Ridge.

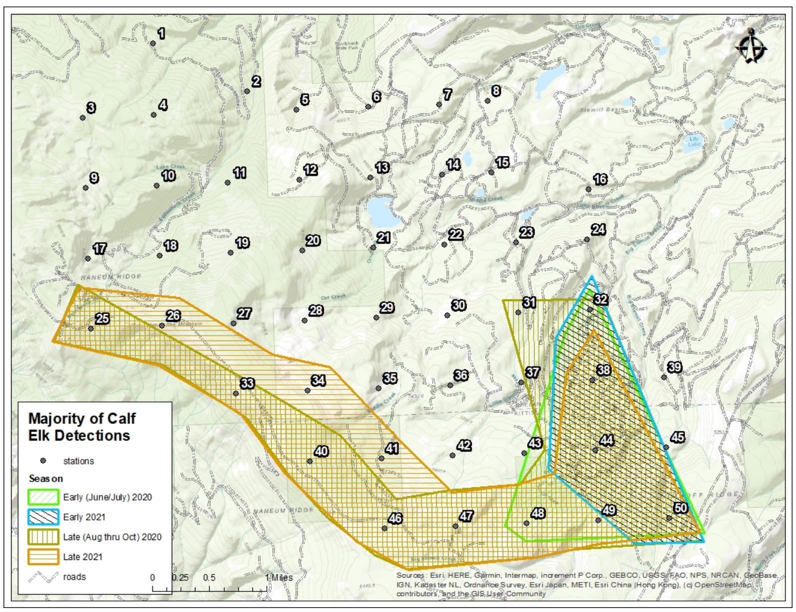


Figure 6. Map showing the location of elk calves (and cows) during the early (May-July) and late (August-November) periods for each of the survey years in the Stemilt-Squilchuck remote camera survey.

Habitat Use

We used the elk detections to evaluate the interim elk habitat model that was developed for the Stemilt-Squilchuck Landscape Evaluation (WCSI and CCNRD 2019). First, we updated the model to reflect updated information on the status of roads (Appendix A, see also roads survey report WCSI and CCNRD 2021). We then used a generalized linear mixed effects statistical model to test the assumption that the number of elk detections would be positively correlated to the elk habitat quality rating. We found a statistically significant ($P<0.05$) relationship between the number of elk detection and the habitat quality ratings (Fig. 7). We also assessed each independent variable used in the elk habitat quality model (Fig. 8a,b) and found that the terrain (slope steepness) and elk nutrition variables were statistically significant (*P<0.05*). These variables indicated that elk were selecting for areas with gentle slopes and those identified as having the highest forage resources. We also found that some of the cameras were "outliers" in that the number of elk detections was high but the habitat values were moderate. We suspect that these cameras were located in areas that are key movement routes used by elk.

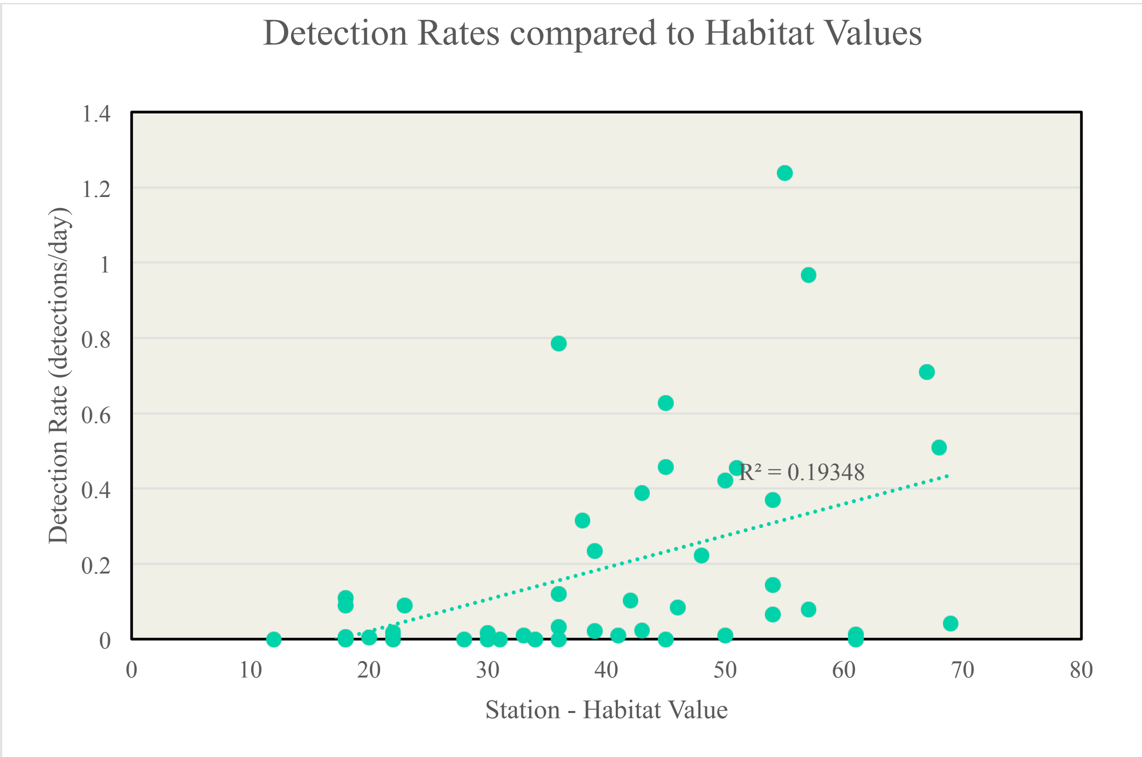
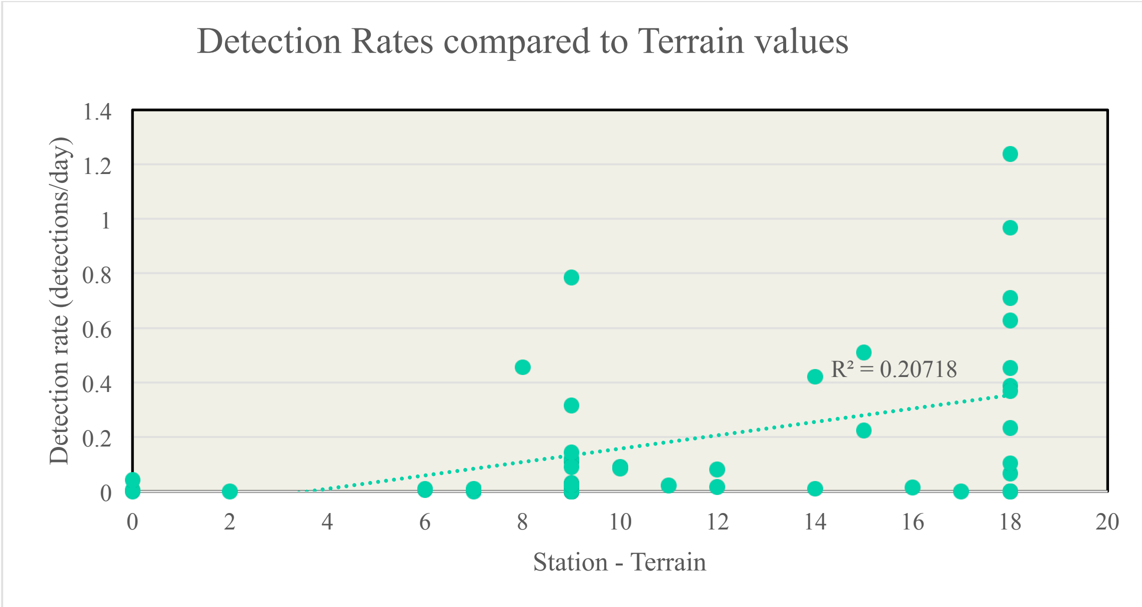
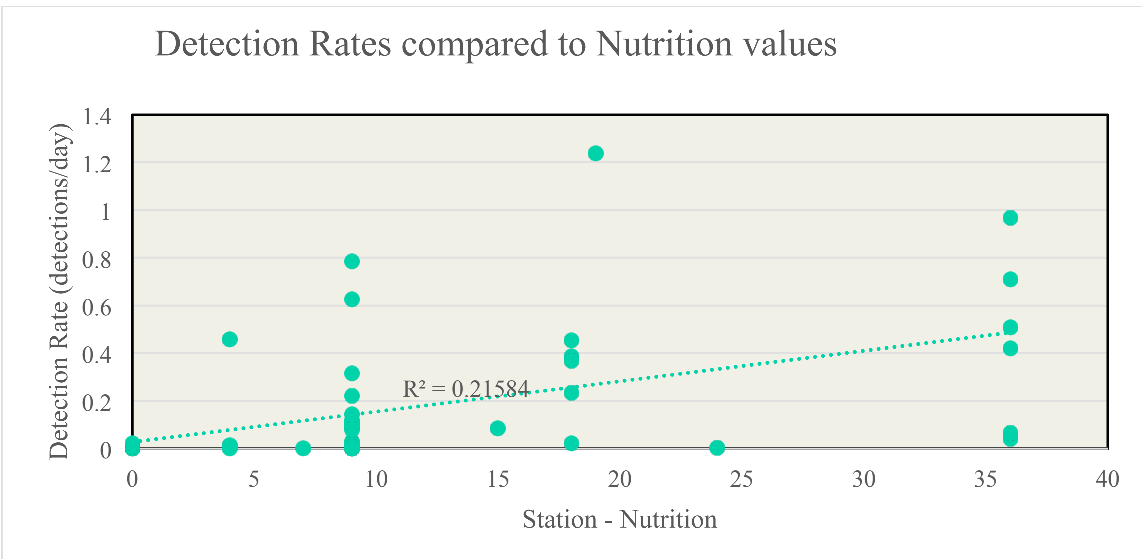


Figure 7. Elk detection rates are positively correlated (R^2=0.19348, *P<0.05*) with the habitat quality values around each camera station in the Stemilt-Squilchuck camera study area.



8a. Terrain



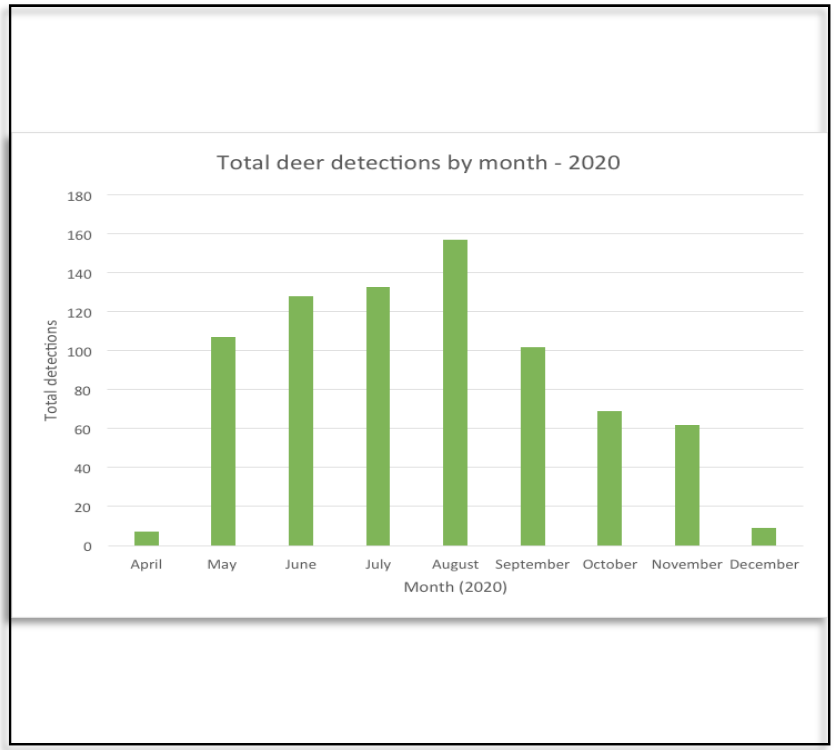
8b. Nutrition Value

Figure 8 a,b. Elk detection rates are positively correlated with gentle terrain (R^2=0.20718, *P<0.05*) and higher nutritional values (R^2=0.021584, *P<0.05*) in the Stemilt-Squilchuck camera study area.

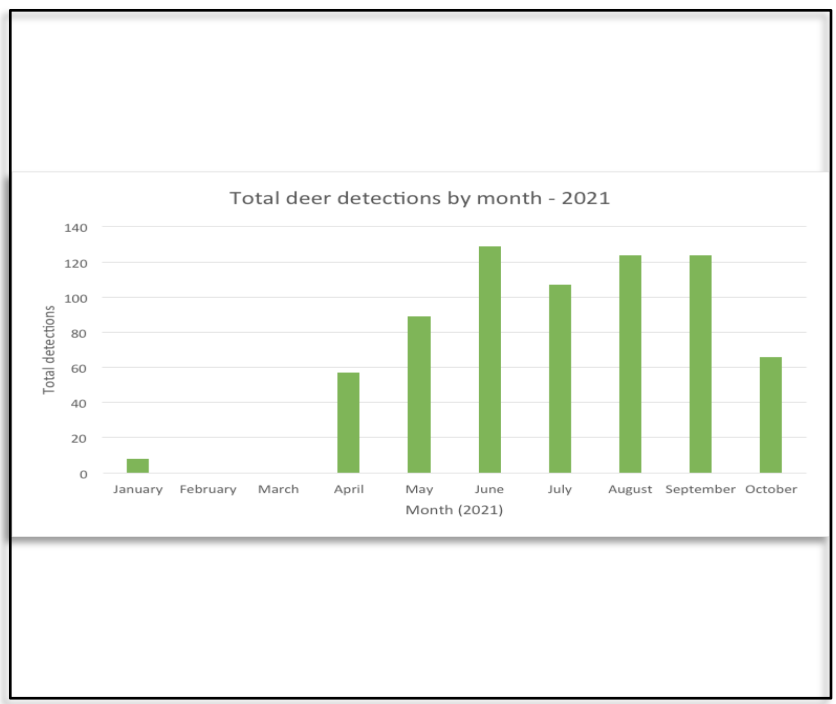
Elk Numbers
We are working closely with the Washington Department of Fish and Wildlife to assess the best approach to estimate elk numbers using camera data. To date we have calculated initial latency to detection values and estimated the area surveyed by each camera. These are key variables used in the estimation of elk numbers when animals are not marked (Moehler et al. 2018). Our sample sizes suggest that we can estimate the total number of elk (bulls, cows, calves combined) and the total number of bulls only.

Other Species
We gathered a variety of information about other wildlife species of interest and human use across the survey area.

Mule Deer
Mule deer were detected broadly across the survey area, 71% of cameras in 2020 and 2021 (Fig. 9a,b). However, the highest number of detections of mule deer occurred in only two clusters within the survey area. One was in the Squilchuck portion of the survey area, primarily to the north of the Mission Ridge ski area. The other cluster was in the lower elevations of the survey area in the Stemilt portion. It also appeared that there was some segregation between deer and elk as the number of detections of deer was negatively correlated with the number of elk detections ($P=0.001$).



9a. 2020



9b. 2021

Figure 9 a,b. Detections of deer captured on remote cameras for the 2020 (9a) and 2021 (9b) survey years in the Stemilt-Squilchuck camera study area.

Carnivores

We detected five carnivore species on our cameras. The most common species was black bear (147 detections) and coyote (84 detections). Other carnivores included cougar (18 detections), bobcat (18 detections), and gray wolf (3 detections).

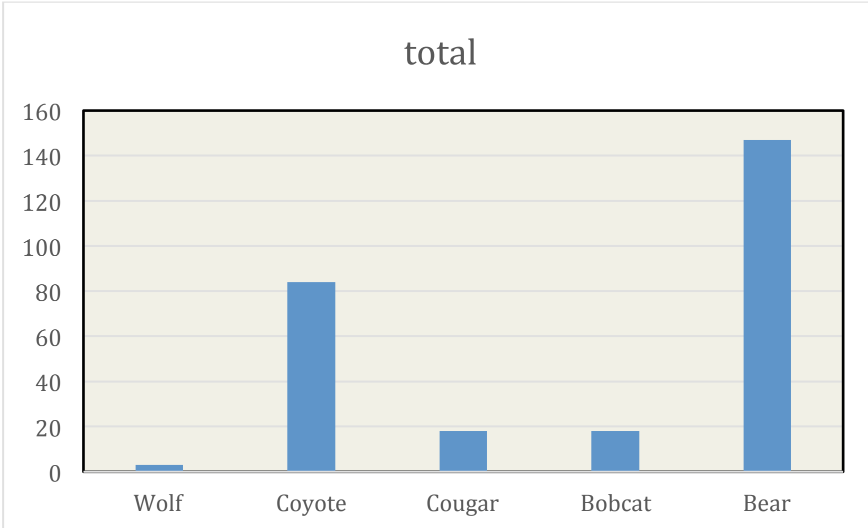


Figure 10. Detections of carnivore species captured on cameras during the 2020-21 Stemilt-Squilchuck camera survey.

Human Use

Human use occurred broadly across the study area, with detections of people at 48% and 49% of the cameras in 2020 and 2021, respectively (Fig. 11). Areas with the highest levels of human detections were near the Clara and Marion Lakes and along the Orr Creek road. We also found a negative relationship between the number of human detections at cameras and the number of elk detections (*P=0.001*).

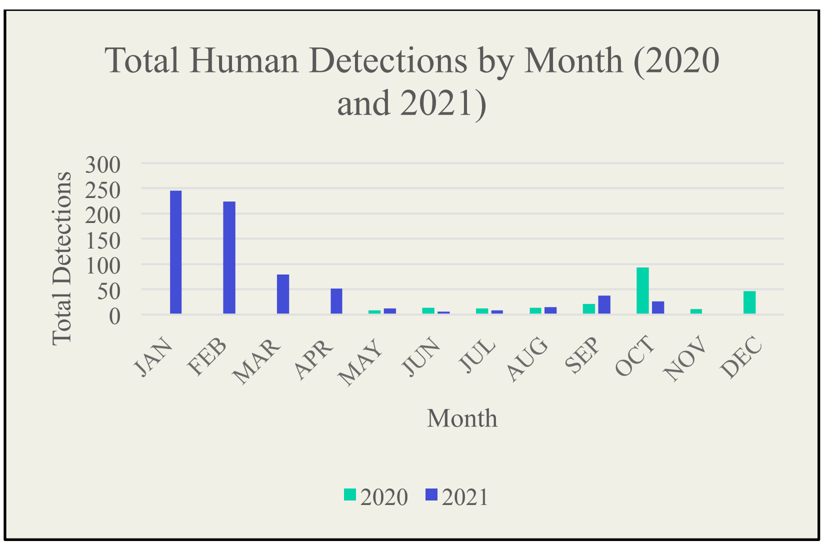


Figure 11. Human activity by month captured on remote cameras in the Stemilt-Squilchuck camera study area.

Discussion and Management Implications

Elk Calving

Phillips and Alldredge (2000) evaluated the effects of human-induced disturbance on elk reproductive success by using a control-treatment study. They collected data during 1 pretreatment year and two treatment years. Treatment elk were repeatedly approached and displaced by study personnel during a 3-4 week period of peak calving during both years. Elk reproductive success was lower (annual population growth was 7% without treatment and dropped to zero with treatment) in elk exposed to disturbance when there were an average of 10 disturbances/cow during the 3-4 week period (Phillips and Alldredge 2000).

From the information collected from the camera survey, we have identified the portion of the Stemilt that is most heavily used by elk during calving (Fig. 6). Typically, elk calves are most vulnerable to human disturbance from the time they are born until the end of June. Timing restrictions on some roads and trails during April-June in areas of high calving concentration could reduce the potential for human disturbance during a vulnerable time of the year for elk.

Elk Movement and Stopover Sites

Many elk populations in the western US, including the Colockum herd, migrate seasonally between high elevation summer ranges and low elevation winter range (Fryxell and Sinclair 1988, Sawyer et al. 2009). A downhill migration in fall to their winter range is a response to weather conditions and a strategy to find wintering areas with shallow snow depth to find adequate forage (Boyce 1991, White et al. 2010). In the spring, elk migrate from their winter ranges to track the growth of highly nutritious emergent vegetation as they move up in elevation to their summer ranges (Sawyer and Kauffman 2011, Sawyer et al. 2012, Barker et al. 2019).

Important components of successful ungulate migration consists of the actual movement routes, and places along the route in which animals can obtain quality forage and security, referred to as “stopover sites”. For migrating ungulates, stopovers play a critical role in the altitudinal migrations as a place where they can maximize energy intake (Sawyer and Kauffman 2011).

Human activities associated with recreation and vegetation management can influence elk movements, such as the rate of movement, and also migration patterns, especially for elk that migrate between summer and winter ranges (Barker et al. 2019, Paton 2012, Paton et al. 2017, McClure et al. 2016). Human developments can present impermeable barriers (e.g., fences, freeways) or may result in semi-permeable barriers (e.g., low-use roads or road networks)(Sawyer et al. 2012). Generally, ungulates are able to move through low to moderate levels of human use or development, but high levels of human use or development may alter movement patterns (Sawyer et al. 2012).

There is an opportunity to incorporate the concept of stopover sites into the management of elk in the Stemilt. Providing high quality forage and security at stopover sites (e.g., 1 per 10 km) along movement routes is important to maintaining ungulate migration (Sawyer and Kauffman 2011, Sawyer et al. 2012). Based on this, identifying and managing for 2-3 stopover sites across the upper portion of the Stemilt using the combination of camera data and habitat quality mapping could be a management strategy that would help secure continued elk use. Based on our information, enhanced security of stopover sites would benefit the greatest number of elk from July-September with seasonal restrictions on roads and trails. Selecting areas with high nutritional values and that currently have low levels of human use may provide a starting point for the selection of stop over sites. These areas could then be managed to continue to provide high quality forage resources (see Vegetation Management below) and to maintain low levels of human use.

Vegetation Management

Elk achieve peak body condition in the late summer and fall and their winter survival and productivity depend on their ability to develop fat reserves from the forage they consume during the summer (Cook et al. 2005). The application of thinning and prescribed fire to restore forest structure and composition can alter elk forage and cover. Fire suppression and exclusion has allowed forests to become denser, reducing the abundance and diversity of understory plants that provide elk forage (see Cook et al. 2005 for a review). The application of thinning and prescribed fire can dramatically increase understory plant diversity and productivity, and restore forage availability for elk (Lehmkuhl et al. 2013, Barker et al. 2019, Hull et al. 2020). For example, removal of tree canopy (to <40% canopy closure) in dry forests using thinning and prescribed fire treatments can increase the availability of forage for elk by 2-3 times compared to closed-canopy forest conditions (Lehmkuhl et al. 2013). Elk also rely on dense forests for cover for security and in some cases dense forest canopy reduces snow depths elk to access forage during the winter (Cook et al. 2005). Ideally, forest management includes a combination of open-canopied forests that provide foraging opportunities interspersed with cover patches of varying sizes that reduce sight distances, provide hiding and security cover, and in some cases provide thermal cover. This type of cover:forage arrangement would be particularly important in elk calving areas and in areas being managed as stopover sites.

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Appendix A.

Revised elk habitat quality map