Carpenter Valley, CA
Mammalian Wildlife Monitoring Project
June 2017 – June 2018

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Summary

Camera trapping techniques were used from June 2017 to June 2018 to assess the mid-large bodied mammalian composition of Carpenter Valley, CA. We set wildlife cameras at 43 sites across the acquisition and categorized the locations into seven habitat types including the north side forest, south side forest, forested valley floor, meadow, riparian area, rocky scree slope and dirt road. We collected 2,329 independent mammal photographs (excluding humans and domestic dogs) representing 22 species (or species groups for chipmunks and mice). Species diversity in the valley overall was found to be highest during the summer months with multiple species either hibernating or migrating from the valley in winter. Lowest mammalian diversity among the habitat categories was found in the meadow while highest diversity was recorded on the road. We found that larger bodied predators tended to use the road more often while prey species were less likely to be photographed on the road. The greatest number of mammal photographs per camera effort was obtained in the north side forest and we suggest that the untreated forested slopes of Carpenter Valley hold the greatest value for the mammal community. Individual species analyses were conducted for 13 species for which we collected greater than ten photographs. For each of these species we determined seasonal and temporal (daily) activity levels as well as their distributions within Carpenter Valley. The data collected in this project will serve as baseline information allowing us to monitor any spatial or temporal changes in mammalian behavior as human visitation rates to Carpenter Valley increase.

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Introduction:

Carpenter Valley is a biologically diverse montane valley located north of Truckee, CA. The 680 acre property had been privately owned for many decades and was recently acquired by the Truckee Donner Land Trust. In conjunction with the Nature Conservancy the property will henceforth be managed for the protection of its ecological systems as well as for public enjoyment. With little human activity over the last decades the valley and its wildlife have been left to thrive in their natural state. This study set out to determine the current distribution and behaviors of the mammal community in Carpenter Valley prior to the property being opened to the public. These data can then be used to observe if future management decisions have an influence on mammal behaviors.

Remote photography methods have been demonstrated to be an appropriate technique for conducting mammal inventories (Silveira et al. 2003). Camera studies are replicable, minimally invasive, cost effective and provide permanent documentation of photo-captured animals (Cutler and Swann 1999). Camera units can gather data during inclement weather and at night which reduces observer bias and they can be left in the field for lengthy periods of time with minimal human attention providing information on more natural behaviors (O'Connell et al. 2011).

Collecting initial data on mammal communities includes assessing the composition and distribution. In an area where no information on territory boundaries is available it is important to cover a large enough area to incorporate multiple individuals of different species and status groups to lessen habitat and home range boundary effects (Larrucea et al.2006). Camera coverage can be conducted either all at once or with a smaller number of cameras rotated over a longer period of time. Ideally initial surveys also should sample 24 hours/day and during all seasons. With enough captures over time photographs will provide information on species composition, habitat associations, and seasonal and temporal activity patterns. The rate of photo-capture can also be used as an index of relative abundance (O'Brien 2011, Rovero and Marshall 2009).

In this study we used these camera techniques to determine the distribution of the medium to large bodied mammalian community of Carpenter Valley. Sagehen Creek Field Station (SCFS), part of the UC Natural Reserve System, lies just north of Carpenter Valley. SCFS has conducted mammal inventories for many years and we expected to find a similar mammal community at our site. The mammals which we expected to be able to photo-capture included mule deer (*Odocoileus hemionus*), marten (*Martes americana*), porcupine (*Erethizon dorsatum*), beaver (*Castor canadensis*), marmot (*Marmota flaviventris*), California ground

squirrel (*Spermophilus beecheyi*), chipmunks (*Tamias* spp.), golden mantled ground squirrel (*Spermophilus lateralis*), gray squirrel (*Sciurus griseus*), northern flying squirrel (*Glaucomys sabrinus*), Douglas's squirrel (*Tamiasciurus douglassi*), mice (*Permomyscus* spp.), gophers (*Thomomys* spp.), woodrat (*Neotoma cinerea*), mountain cottontail (*Sylvilagus nuttallii*), snowshoe hare (*Lepus americanus*), bobcat (*Lynx rufus*), cougar (*Puma concolor*), coyote (*Canis latrans*), grey fox (*Urocyon cinereoargenteus*), black bear (*Ursus americanus*), ringtail (*Bassariscus astutus*), raccoon (*Procyon lotor*), badger (*Taxidea taxus*), spotted skunk (*Spilogale gracilis*), striped skunk (*Mephitis mephitis*), stoat (*Mustela erminea*), long-tailed weasel (*Mustela frenata*), mountain beaver (*Aplodontia rufa*), Belding's ground squirrel (*Spermophilus beldingi*). Some additional extremely rare species which are present in the region include wolf (*Canis lupus*), Sierra Nevada red fox (*Vulpes vulpes*) and wolverine (*Gulo gulo*).

Objectives:

The purpose of this project was to collect information on the diversity, distribution and behaviors of mid to large sized mammalian wildlife present in Carpenter Valley. The data collected will serve as baseline information for comparison of species composition, distribution and seasonal and temporal activity patterns for future studies.

Study area:

Carpenter valley lies at 39°23'30 N/ 120°15'30W at approximately 1,900 m (6,200 ft) in elevation. The acquisition borders both private lands as well as the Tahoe National Forest. Summers are generally dry with large diurnal temperature variations. Winters are longer and nocturnally cold but midday temperatures are often above 0°C (32°F). The region receives an average of 91cm (36 in) annual precipitation, much of which falls as snow. The average winter snow pack is 284 cm (112 in) at 1,900 m (6,200 ft) elevation (Spencer et al. 1983)

Upper montane forests covered the slopes on the north and south sides of the valley. The south sides (north facing slope) were very steep and were dominated by white fir (*Abies concolor*), red fir (*Abies magnifica*), and Jeffrey pine (*Pinus jeffreyi*) with mixtures of mountain hemlock (*Tsuga mertensiana*) and western white pine (*Pinus monticola*). The north sides (south facing slopes) were dominated by Jeffrey pine with mixtures of lodgepole pine (*P. contorta*) and white fir. The north side of the valley was interspersed with numerous fens (springs) that ran year round. On the hillside the fens were surrounded by lodgepole pine and a dense cover of sedges and forbs. Wet areas in the meadow were dominated by willow shrubs (*Salix* spp.).

Methods:

We used 12 Bushnell™ HD motion triggered cameras for one year within Carpenter Valley and the surrounding slopes. Camera triggers were set at high sensitivity in order to capture mammals as small as chipmunks and mice. We used a camera delay of 30 seconds between subsequent triggers to reduce the number of photographs of single individuals that remained in front of the camera. We programmed units to take two photographs for each trigger incident allowing for easier analysis of photographs. The human eye can catch minor differences between two nearly identical photographs more quickly making a captured mammal in the image easier to locate. Cameras marked each exposure with the date and time of capture. Cameras were active 24 hours/day and were programmed to remain on Daylight Savings Time year-round.

Camera stations were placed near animal sign such as along game trails, bedding sites, scat piles, or at water sources and along dirt roads. Cameras were securely strapped to trees or other vegetation when available or placed on a wooden stake. We placed a small amount of generalist scent lure (Carmen's Canine Call) in the center of the cameras field of view. Cameras were visited every 1-2 months with a longer session in the winter due to difficult access. Data cards were large enough (≥ 8MB) to collect data for the entire session and cameras were able to run unmonitored for this length of time. While camera units were set at various heights during summer months, all cameras were set at a height of 7ft in winter to stay above potential snow levels. Data cards from each camera unit were collected when cameras were visited and traded out for an empty card. All camera locations were recorded using a hand-held GPS unit.

Cameras were moved to new locations within Carpenter Valley throughout the year maintaining a relatively even number of stations in each habitat type during each camera session. Habitat selections included the south side forested slopes (ForestS), dirt roads (Road), forested valley floor (ForestF), open meadow (Meadow), moist areas including creeks and fens (Riparian), north side forested slopes (ForestN), and rocky scree habitat (Rocky) (Figure 1). Representative images and brief descriptions of these habitat types follow.

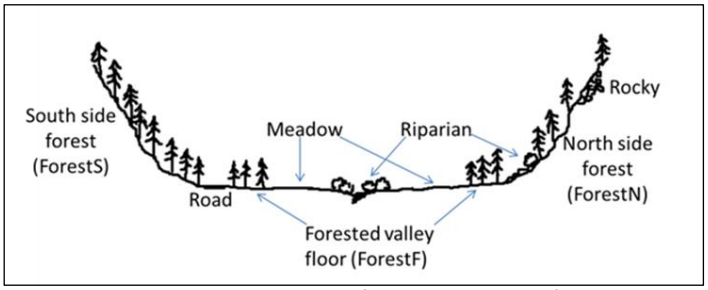
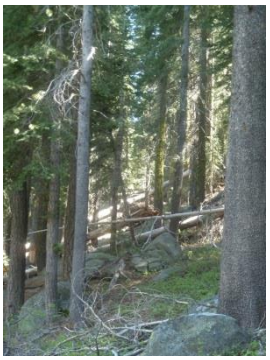


Figure 1. Representation of the locations of sampled habitat types in Carpenter Valley, CA.

ForestS – This category included the steep slopes on the south side of Carpenter Valley. These slopes were heavily forested with large firs and some pine. Much dead wood was located on the ground.


ForestS

Rocky – This habitat category included open scree slopes located at higher elevations on the northern side of Carpenter Valley.


Rocky

Meadow – Open meadow habitat dominated by grasses. Dry upper meadows as well as wet open meadow found along fens were included. Low sagebrush (*Artemisia tridentata*) was also included in this habitat category.


Meadow

Riparian – This category included both willow thickets on the valley floor along the North fork of Prosser creek as well as wet fen habitats found on the north side of the valley. Fens were included in this category when they were associated with significant cover.


Riparian (fen)

ForestN – Forests on the northern side of the valley were drier and generally composed of Jeffrey and lodgepole pine. Slope was generally not as steep as on the south side.

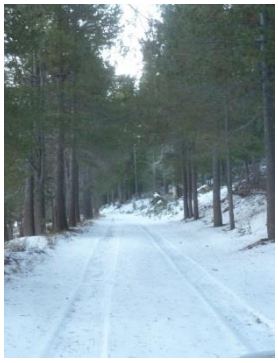

Riparian (willow)


ForestN

ForestF – This habitat category was located on the forested valley floor and was generally composed of loose Jeffrey and lodgepole pine forest.


ForestF

Road - This category included the only dirt road currently in Carpenter Valley. The road ran around the lower perimeter of the valley on the south side, crossed the creek at the end of the acquisition and ran about a quarter of the way along the base of the northern side. The road generally ran through habitat that would have been included in the ForestF category.


Road

Analysis:

All obtained photographs were carefully scanned for mammals and images without mammals were removed prior to analysis. Images with mammals (other than humans and domestic dogs) were sorted by species, camera location, date of capture and time of capture. We next filtered the image records for each mammal species by removing subsequent photographs of a single species at a single camera station within 30 minutes. This was done to ensure that a single individual pausing in front of a camera unit would not be counted as multiple events.

Overall camera trapping success rate was calculated by dividing the number of mammal photographs by the total number of active camera days in the study (also called camera effort). One active camera day was equal to one camera operating for one full day. A species accumulation curve was generated by plotting the number of species captured to date by the number of active camera days to that date. Species richness for each habitat was classified as the number of species photo-captured in each category.

We separately analyzed each species for which we had greater than ten independent photo-capture events and looked at seasonal and temporal (daily) activity levels as well as distribution among habitats. Photo-captures per hour divided by camera effort was used to assess temporal activity patterns. The number of photographs captured per month divided by camera effort was used as an index of activity level. Distribution of photographs among habitat categories was calculated as the number of unique photographs captured per species in each category divided by the camera effort in that habitat category. Habitat graphs were organized as a general cross section of the valley looking upstream (Figure 1). Naïve occupancy was calculated as the number of camera trap stations that captured a specific species over the course of the project divided by the total number of camera stations. Detection rates were calculated as the number of captures at an individual camera unit divided by the number of days the specific unit was active. Detection rates for species not active year-round were calculated only for their active seasons. Detection rate values were plotted on a map of the valley per species to demonstrate relative site occupancy.

We compared the Road and ForestF categories since the road in Carpenter Valley is generally located in forested valley floor habitat. We adjusted for camera effort and used a two sample *t*-test to compare the number of photographs of a specific species captured at each Road and each ForestF camera. If the road had no effect we would hypothesize that species should be photographed at equal rates at these cameras.

Results and Discussion:

Overview:

Camera stations in Carpenter Valley were active for 366 days from June 27, 2017 till June 28, 2018. The study utilized 12 cameras for 4,342 camera days (Mean of 361.8 days) at 43 different camera locations (Figure 2). The majority of camera units functioned correctly for the duration of the survey periods. One camera was disturbed by wildlife (bear) rendering it ineffective for 20 days. One additional camera unit failed to function for one entire survey session and we therefore did not include it as a camera location.

We collected 2,329 identifiable mammal photographs (excluding humans and domestic dogs) representing 22 different species (or species groups as in chipmunks and mice). A list of species recorded by habitat type is reported in Table 1. We achieved an overall camera trapping success rate of 0.54 (total mammal photos captured / active camera days) for the duration of the study. Capture rates for individual species in the study varied widely from 0.023 captures/100 days for species captured only once, to 12 captures/100 days for Douglas's squirrels (Table 1).

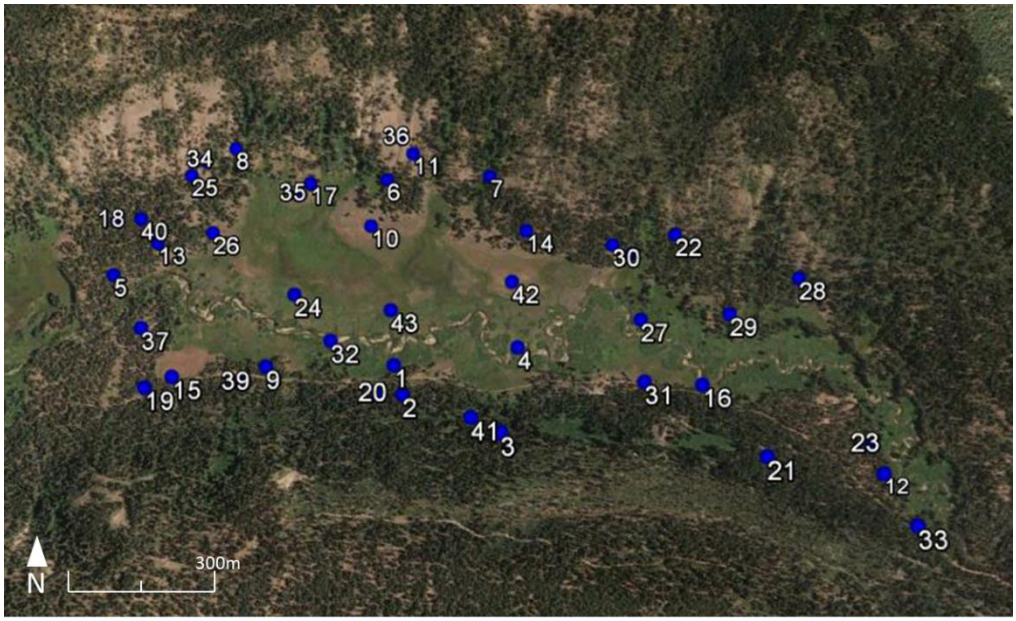


Figure 2. Locations of 43 camera stations in Carpenter Valley, CA. Cameras were active from 6/27/17 – 6/28/18

		Habitat Type										
Common name	**Latin name**	**Forest S**	**Road**	**ForestF**	**Meadow**	**Riparian**	**ForestN**	**Rocky**	**Total captures**	**Successful cameras**	**Naïve occupancy**	**Trapping rate**
Black bear	*Ursus americanus*	10	27	37	0	12	35	2	123	29	0.67	2.8
Bobcat	*Lynx rufus*	7	8	5	0	3	15	5	43	13	0.3	0.99
Coyote	*Canis latrans*	8	37	26	2	11	20	2	106	25	0.58	2.4
Grey Fox	*Urocyon cinereoargenteus*	0	1	0	0	0	0	0	1	1	0.02	0.023
Mountain lion	*Puma concolor*	0	4	0	0	0	0	0	4	1	0.02	0.092
Long-tailed weasel	*Mustela frenata*	0	1	2	0	1	2	0	6	5	0.12	0.14
Mule deer	*Odocoilus hemionus*	176	20	64	3	42	101	15	421	34	0.79	9.7
Snowshoe hare	*Lepus americanus*	12	1	0	0	6	8	0	27	7	0.16	0.62
Mountain cottontail	*Sylvilagus nuttallii*	0	0	1	0	0	0	0	1	1	0.02	0.023
California ground squirrel	*Spermophilus beecheyi*	0	7	38	0	2	183	71	301	21	0.49	6.9
Douglas's squirrel	*Tamiasciurus douglasii*	68	79	202	0	5	182	6	542	28	0.65	12
Western grey squirrel	*Sciurus griseus*	0	5	114	0	1	151	21	292	17	0.4	6.7
Flying squirrel	*Glaucomys sabrinus*	0	0	0	0	0	1	0	1	1	0.02	0.023
Chipmunks	*Tamias spp.*	44	13	61	0	3	108	47	276	19	0.44	6.4
Golden-mantled ground squirrel	*Spermophilus lateralis*	1	2	0	0	1	0	6	10	6	0.14	0.23
Bushy tailed woodrat	*Neotoma cinerea*	1	0	0	0	0	0	25	26	2	0.05	0.6
Mountain beaver	*Aplodontia rufa*	0	0	0	0	0	1	0	1	1	0.02	0.023
Mice	*Peromyscus spp.*	3	3	41	14	10	26	4	101	21	0.49	2.3
Skunk	*Mephitis mephitis*	0	4	8	2	0	16	14	44	14	0.32	1
Spotted skunk	*Spilogale gracilis*	0	0	0	0	1	0	0	1	1	0.02	0.023
Porcupine	*Erethizon dorsatum*	0	1	0	0	0	0	0	1	1	0.02	0.023
Raccoon	*Procyon lotor*	0	1	0	0	0	0	0	1	1	0.02	0.023
									2329			
	Species richness	10	17	12	4	13	14	12	22 total species			
	Photos per habitat	330	214	599	20	99	849	218				
	Camera success rate	13.2	9.73	23.04	10	5.66	26.12	19.82				

Table 1. Numbers of photo-captures of species per habitat type in Carpenter Valley are shown. “Total cameras” showed the total number of images of the species captured. “Successful cameras” showed the number of cameras that captured at least one image of the species. “Naïve occupancy” was the percent of cameras that captured at least one image of the species. The “trapping rate” was calculated as the number of photos divided by the camera effort multiplied by 100 to provide the capture rate per 100 days. “Camera success rate” was calculated as photos divided by the camera effort in each specific habitat type.

Species are captured according to their abundance in an area as well as by chance. Incidents of new species increased relatively quickly at the beginning of the study and then leveled off as most species present were photo-captured. A species accumulation curve for our data showed that 2/3 of species captured in the study had been photographed within 228 camera trap days, representing only 19 days in this study (Figure 3). New species continued to be documented, although at a much lower rate, even at 4,212 camera trap days (grey fox). This demonstrates the need for broad initial surveys to run for significant lengths of time to capture less abundant and more elusive species. The accumulation curve would likely have shown a second pulse of new detections had we started the study in winter corresponding to newly available species waking from hibernation.

While all habitat types were sampled each month throughout the year the effort in each category was not completely equal. To remove bias we divided the number of photographs by the camera effort (the number of days an active camera was placed within each habitat type). Species richness is defined as the number of different species represented in an ecological community. Lowest species richness was found in the meadow areas of Carpenter Valley (Table 1). Animals likely preferred cover either to hide from predators or to stalk their prey. Due to the many fens water was not a limiting source along the forested valley slopes and animals were not required to leave cover and enter the meadow. Greatest species richness was found along the road. Certain mammalian species may have preferred to take the path most easily travelled. However, this may depend on the role of the species as will be discussed later. Lowest camera success rates occurred in riparian habitat, while greatest camera success was obtained in north side forests (Table 1).

Greatest species diversity in Carpenter Valley was photo-captured June through October while lower diversity was documented December through March (Figure 4). This reflects the behavior of mammals that migrate seasonally or hibernate during the winter months. Mammals that remained in Carpenter Valley throughout the winter also demonstrated lower relative activity levels in the cold season. Camera success rates were lower December through March while camera success peaked during the summer months (Figure 5). Camera effort was even throughout all months.

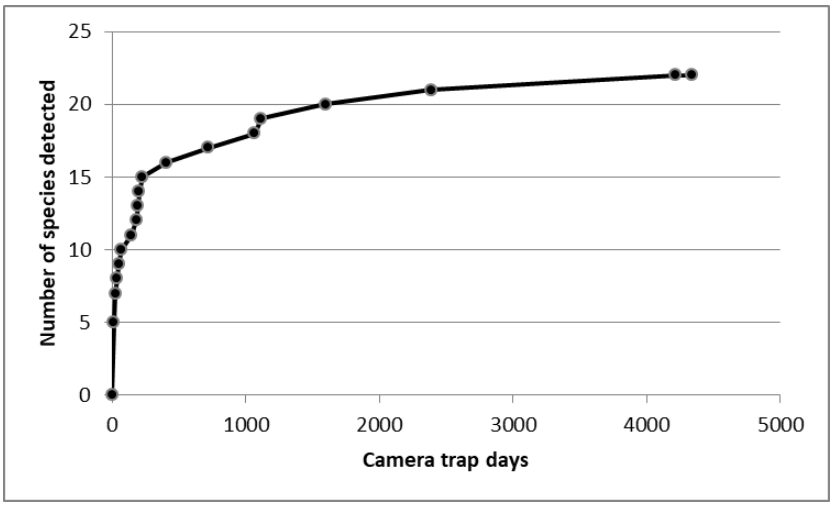


Figure 3. Species accumulation curve for camera trap data collected in Carpenter Valley 6/2017-6/2018

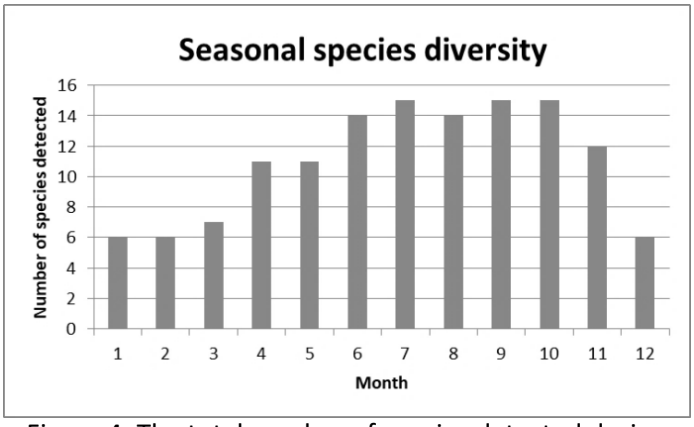


Figure 4. The total number of species detected during each month of the year in Carpenter Valley.

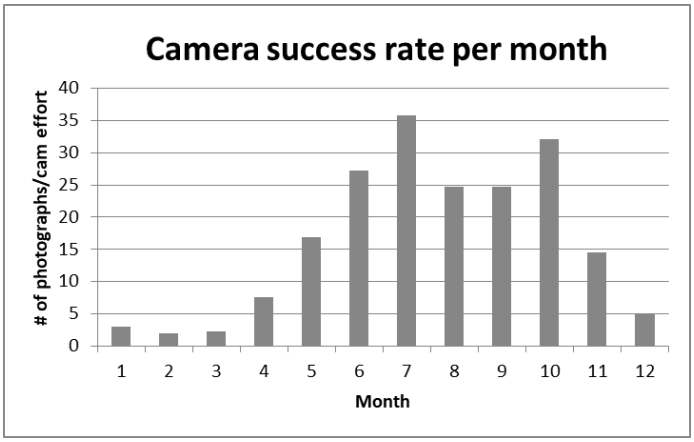


Figure 5. The total number of mammal images divided by the camera effort during each month in Carpenter Valley.

Coyote (*Canis latrans*)

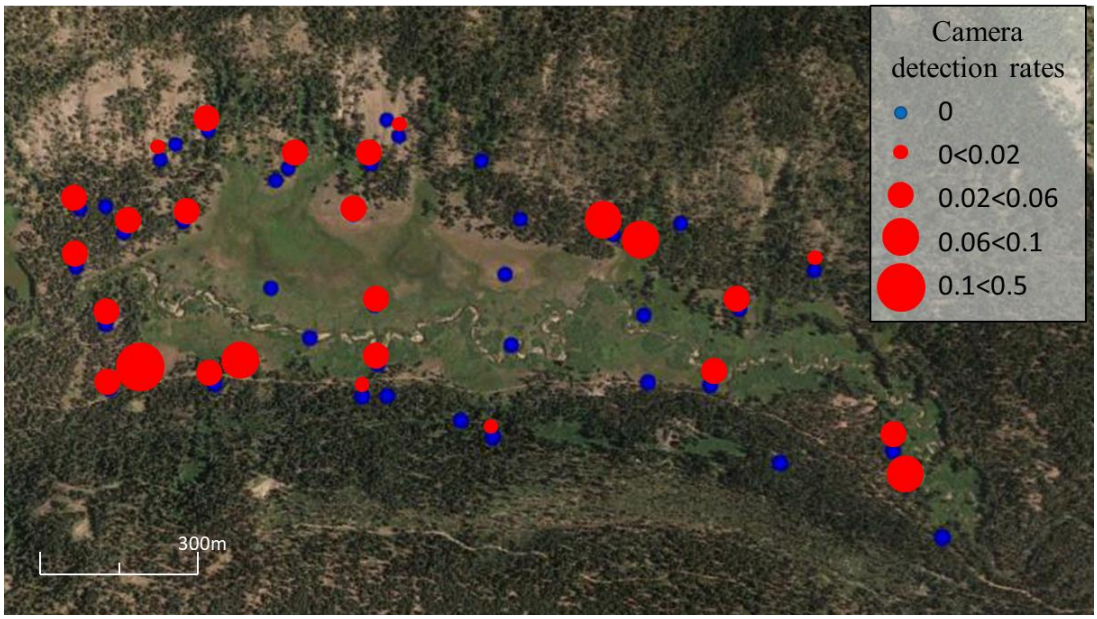


Figure 6. Locations and capture rates of coyotes at individual camera stations in Carpenter Valley, CA 6/2017 – 6/2018.

Coyote photo-captures were obtained across the sampled area of Carpenter Valley (Figure 6) in all habitat types (Figure 7). The greatest photo-capture frequencies occurred on roads and coyotes were more often captured on roads than in surrounding flat forest habitat (P = 0.05). Roads are likely used by coyotes for longer distance movement and not while they are actively foraging. It is also possible that coyotes become used to human scent along roads and therefore not be as wary of new objects (i.e. cameras) placed along roads. This could increase their photo-capture rate along roads in comparison to more remote locations (Larrucea et al. 2006).

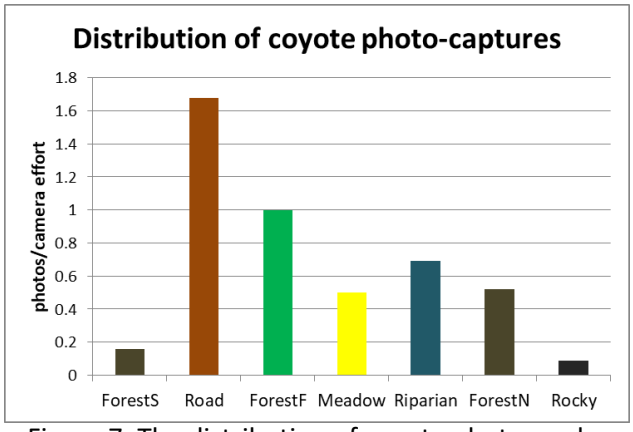


Figure 7. The distribution of coyote photographs among habitat types in Carpenter Valley.

Coyotes were photographed during every month in Carpenter Valley (Figure 8). Greatest seasonal activity was recorded in the fall which corresponds to dispersal season for coyotes. During this season juveniles become independent and begin to look for territories of their own (Shivik et al. 1997). Lowest seasonal activity was seen during the coldest winter months (in 2018 this was Feb-March) which may indicate the need to preserve energy during a season with low numbers of prey and harsh weather (Shivik et al. 1997).

Coyotes were observed to be active at any time of day (Figure 9) which is typical coyote behavior in areas where they are not harassed (Kitchen et al. 2000). Coyotes can be wary of human activity and are able to shift their temporal activity more nocturnally in response to increased human activity (Kitchen et al. 2000). It will be of interest to observe any potential behavioral changes once the property is more heavily visited.

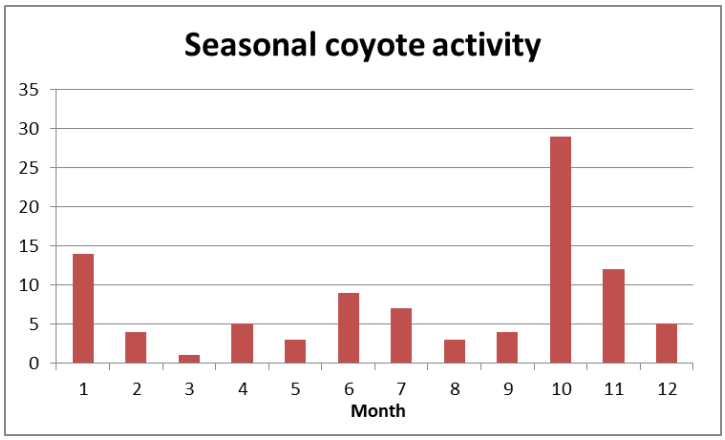


Figure 8. Number of coyote photo-captures per month.

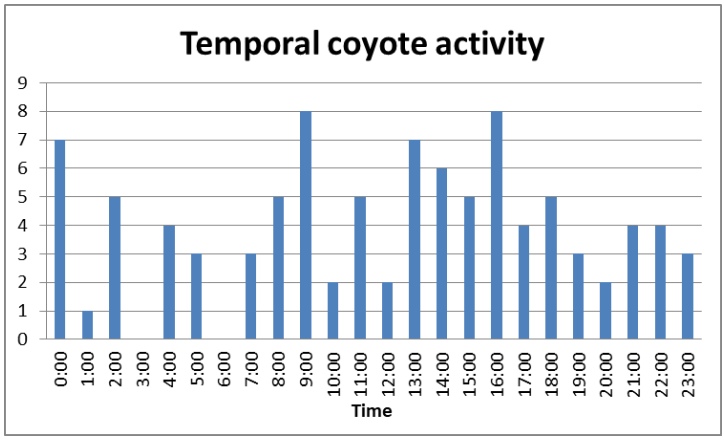


Figure 9. Number of coyote photos captured per hour.

Black bear (*Ursus americanus*)

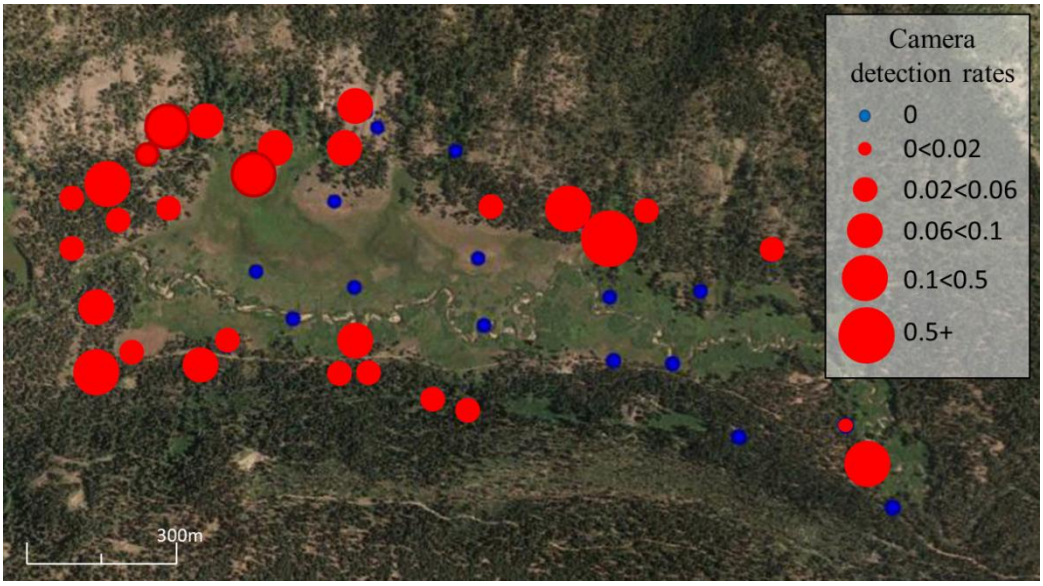


Figure 10. Locations and capture rates of black bears at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

Camera capture rates for bears were computed using data from April to November corresponding to their active season in Carpenter Valley (Figure 10). The first bear photograph of the season was photographed on April 22 while the last photo-capture occurred on November 25. Bears were detected in all habitats other than meadows (Figure 11). Since bears have been observed using meadows this result may be an effect of cameras being more obvious and easily avoidable in meadow habitat. Greatest capture rates occurred in forested areas of the valley floor and north side forests. Bear use of flat forest and roads was similar (P = 0.4). Differences in pelage coloration (black, cinnamon, and blond), size as well as two different ear-tagged bears allowed us to determine that there were multiple individuals in the area.

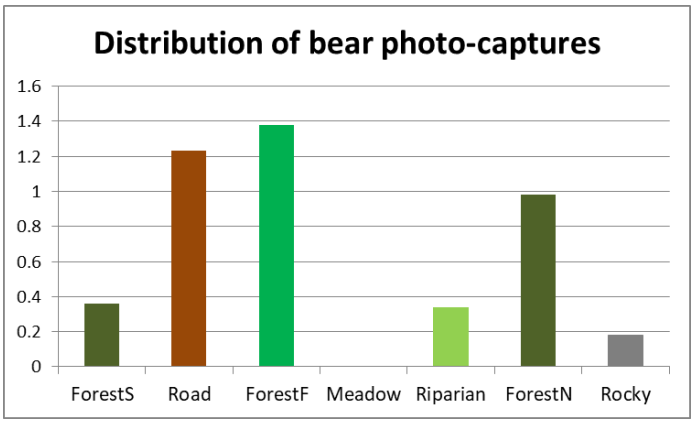


Figure 11. The distribution of coyote photographs among habitat types in Carpenter Valley.

Seasonal activity analysis showed a spike of activity in June (Figure 12). This result could either be due to greater individual bear activity or a greater number of individuals in the area. Bears may show greater foraging activity when they first emerge from hibernation. Alternatively, since the study was conducted from June 27, 2017 till June 28, 2018 the June data could represent a new group of bears in the study area. We observed a minimum of eight distinguishable individuals in June 2018 establishing that there were many bears. We also saw increased seasonal activity in September/October which corresponds to when bears are foraging at higher rates to prepare for hibernation. Bears were determined to be active during any time of day with temporal activity peaking in the evening hours (Figure 13).

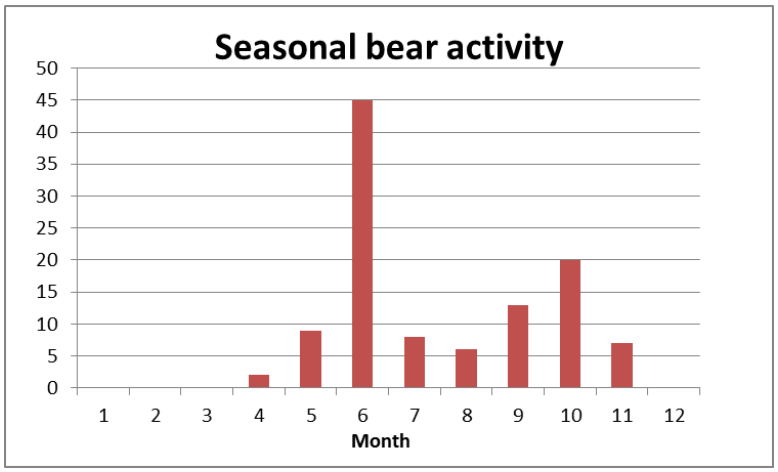


Figure 12. Number of bear photos captured per month.

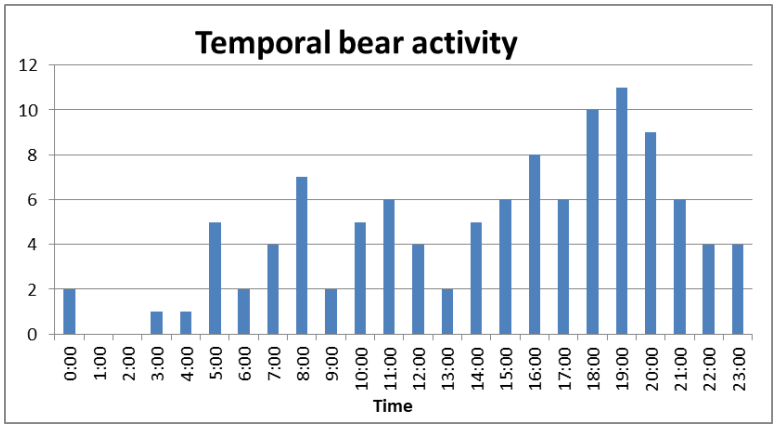


Figure 13. Number of bear photos captured per hour.

Mule Deer (*Odocoileus hemionus*)

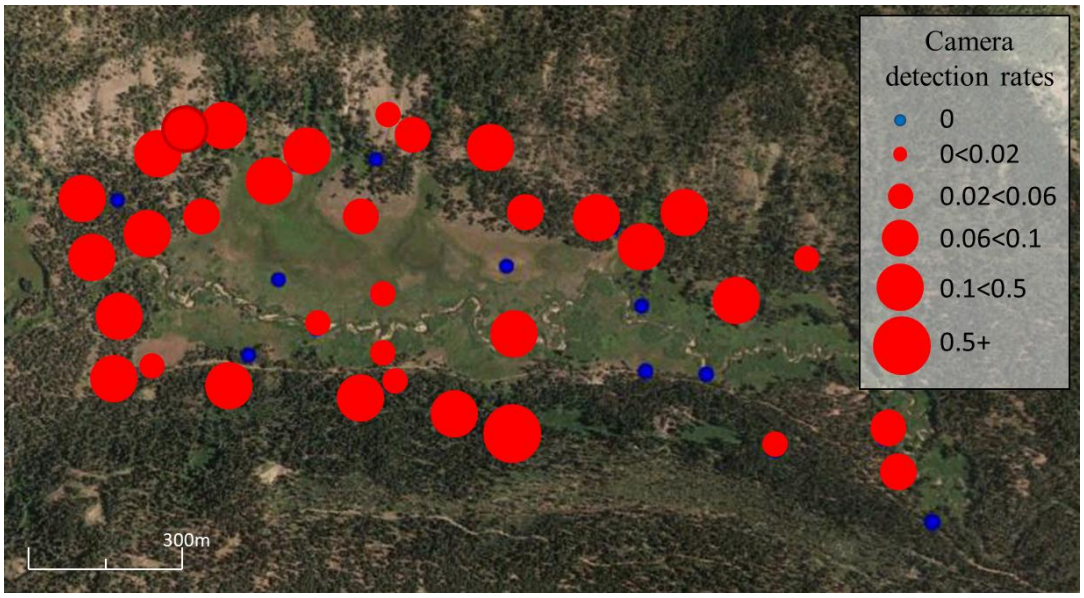


Figure 14. Locations and capture rates of mule deer at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

Deer in Carpenter Valley belong to the Loyalton-Truckee migratory deer herd. Photographic data showed the deer herd arriving in Carpenter Valley in May (first photo-capture date of May 9) and leaving the valley in November (last photo-capture date of November 6) (Figure 15). During the summer months deer had the highest photo-capture rate of any species in Carpenter Valley (Figure 14). Deer were detected in all sampled habitat categories with greatest number of photo-captures occurring on the steep, forested south side slopes (Figure 16). They also were more likely to be photographed in the flat forest terrain than on the road (P = 0.04). Mule deer require cover and are sensitive to open areas likely making them avoid roads in favor for more cover.

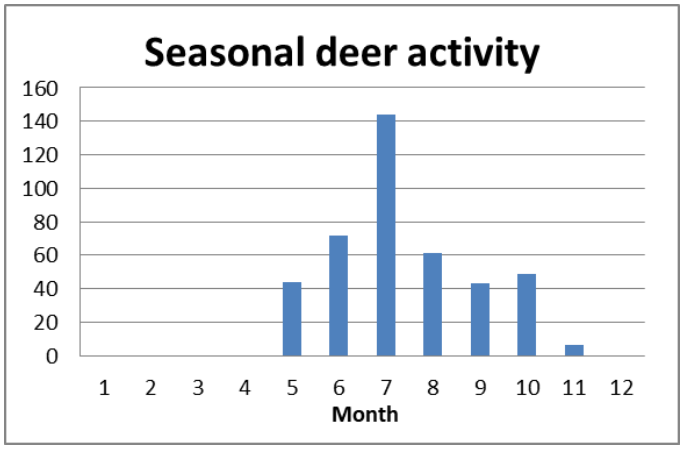


Figure 15. Number of deer photo-captures per month

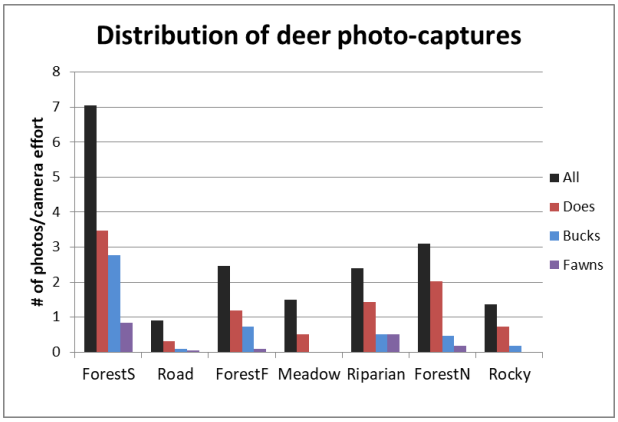


Figure 16. Distribution of deer photo-captures among habitat types.

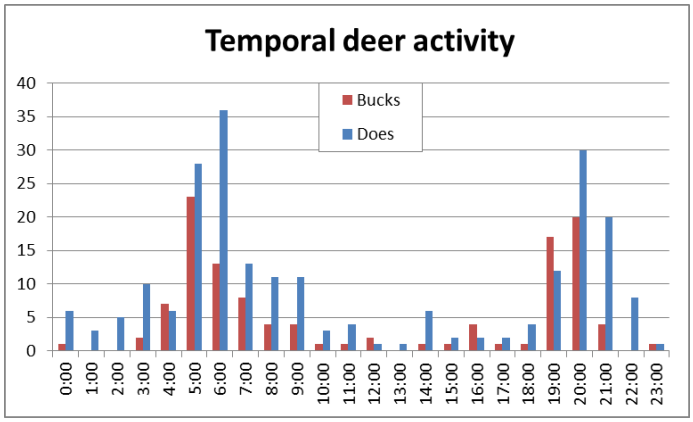


Figure 17. Distribution of identifiable buck and doe photographs by hour.

Deer were active at all times of day but showed distinct peaks in activity at dawn and at dusk (Figure 17). This finding is similar to other studies conducted on mule deer (Dorrance 1967). Bucks and Does showed similar temporal activity patterns.

Greatest photo-capture rates for fawns occurred on the south side forests (Figure 18) which is also where the youngest fawns were recorded. The south side forests are unmanaged with many downed trees that may act as refugia. We collected 39 images of fawns with the first fawn photo-capture of the season taken on June 19. Fawning dates tend to occur over a short period of about 30 days (Dorrance 1967) indicating that the deer herd migrates to Carpenter Valley just prior to fawning. The Loyalton-Truckee deer population is currently listed as "stable to declining" indicating the importance of preserving these important fawning areas (CDFW).

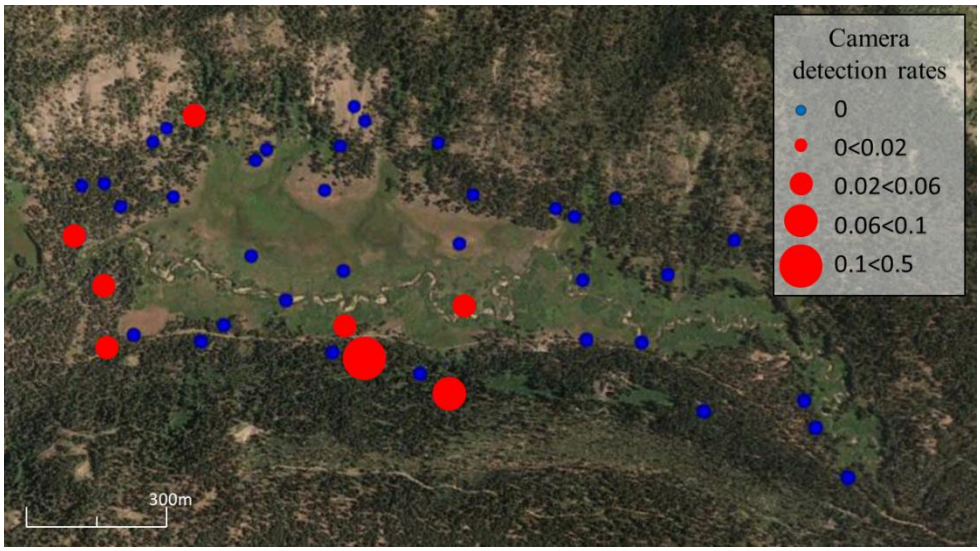


Figure 18. Locations and capture rates of mule deer fawns at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

Bobcat (*Lynx rufus*)

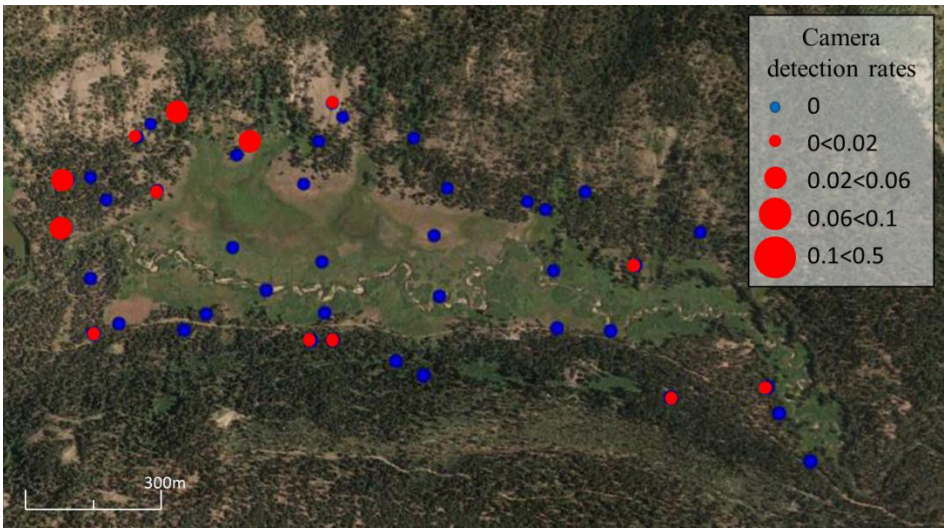


Figure 19. Locations and capture rates of bobcats at individual camera stations in Carpenter Valley, CA, 6/2017 – 6/2018

Bobcats were photographed throughout the study area in most of the habitat categories with greatest detection rates occurring at cameras placed on the northwest side of Carpenter Valley (Figure 19). We captured more photographs of bobcats on roads (Figure 20), but adjusting for camera effort bobcats were not statistically more likely to be captured on roads than in flat forest habitat (P = 0.16).

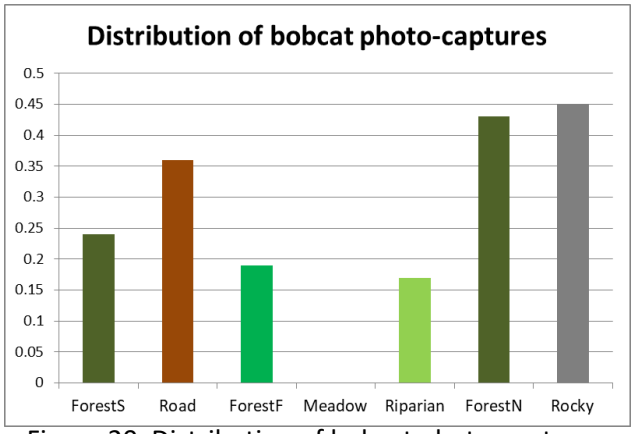


Figure 20. Distribution of bobcat photo-captures by habitat

Bobcats were photographed during every month in Carpenter Valley but cameras detected a lower level of activity during the warmest summer months (Figure 21). We observed bobcats to be active at any time of day (Figure 22). In the future this wary species may shift to more nocturnal activity in areas of greater human activity (Gaynor et al. 2018).

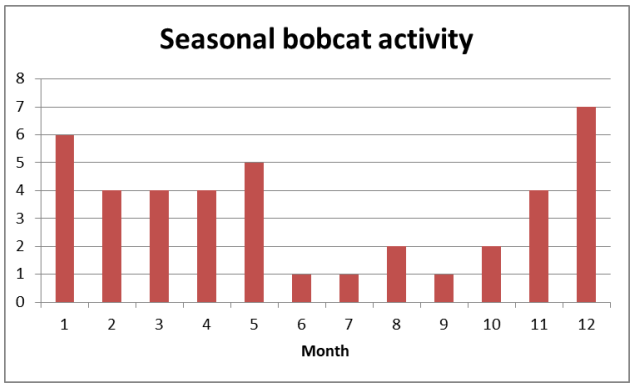


Figure 21. Number of bobcat photos captured by month.

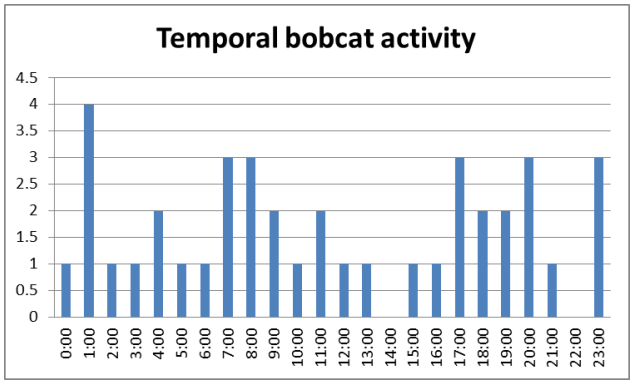


Figure 22. Number of bobcat photos captured by hour.

Western grey squirrel (*Sciurus griseus*)

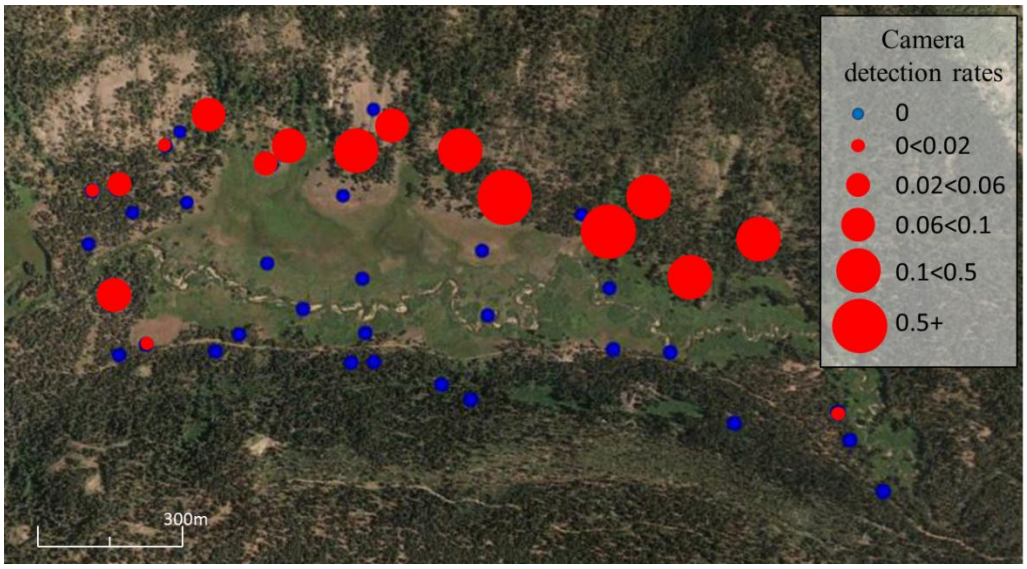


Figure 23. Locations and capture rates of Western grey squirrel at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

Western grey squirrels were photo-captured at high rates on the north side forested valley floor and on the north side of the valley (Figure 23). We captured no grey squirrels in the south side forests (Figure 24). Grey squirrels are most likely to occur in areas with mature trees with a high degree of canopy closure (Foster 1992). They are closely associated with pines (*Pinus* sp.), and especially Ponderosa pine, which provide them with cover and food (Verts and Carraway 1998). Pines are predominantly found on the valley floor and the northern side of Carpenter Valley and this is reflected in the distribution of Western grey squirrel. Grey squirrels were captured more often in flat forest habitats than on the road (P = 0.04). This result may be due to their preference to forage in areas with ground litter or it could be an artifact related to most of the road occurring on the south side of the valley.

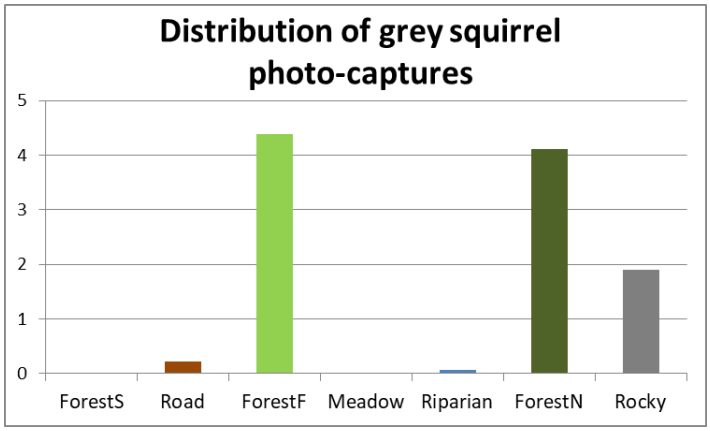


Figure 24. Distribution of grey squirrel photo-captures by habitat

Grey squirrels were active year round in Carpenter Valley emerging even in winter on warmer days, however, peak seasonal activity occurred from August through November (Figure 25). It is important to note that trail cameras in this study focused on ground activity and not activity that was occurring in the trees. In fall grey squirrels cache food for winter which may have increased the amount of time spent on the ground and therefore the number of photographs captured. Temporal activity of grey squirrels was strictly diurnal with peak activity in the late morning (Figure 26). This is similar to what has been described by other studies (Foster 1992, Reid 2006). An interesting occurrence in this study was the photo-capture of an adult albino grey squirrel.

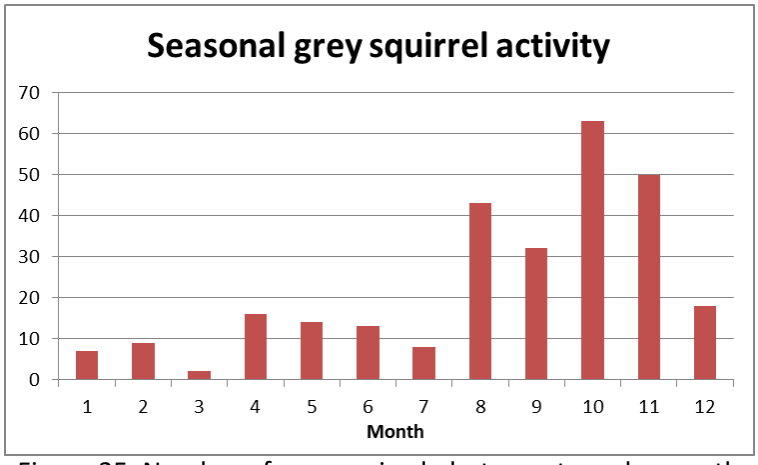


Figure 25. Number of grey squirrel photo-captures by month

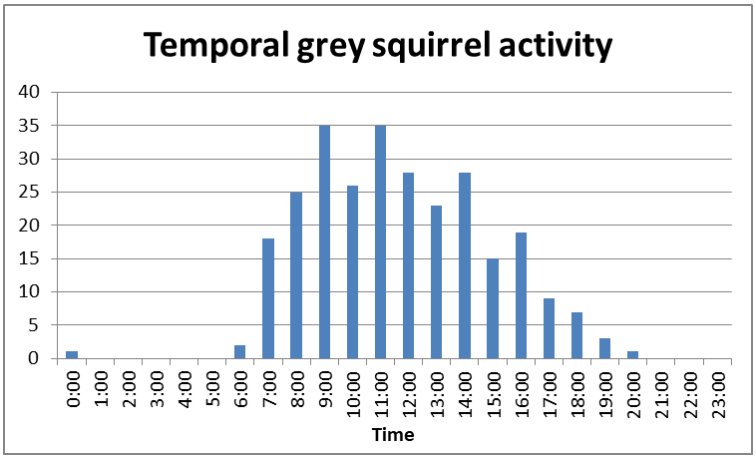


Figure 26. Number of grey squirrel photo-captures by hour

Douglas's Squirrel (*Tamiasciurus douglasii*)

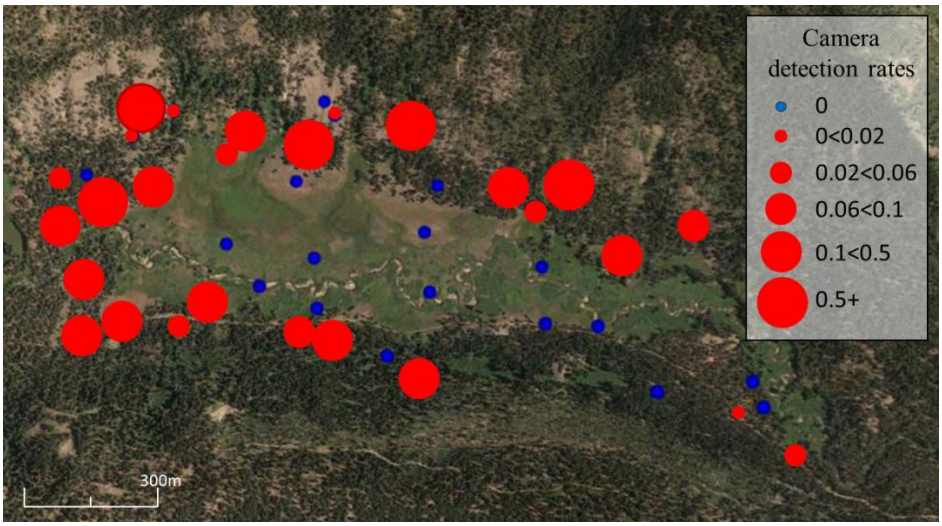


Figure 27. Locations and capture rates of Douglas's squirrel at individual camera stations in Carpenter Valley, CA 6/2017 -

Douglas's squirrels were photo-captured at relatively high rates in all coniferous areas of Carpenter Valley (Figure 27). They were not detected in meadow habitat (Figure 28). While we photo-captured more Douglas's squirrels in the forested valley floor than on the roads the difference was not significant once we adjusted for camera effort (P = 0.11).

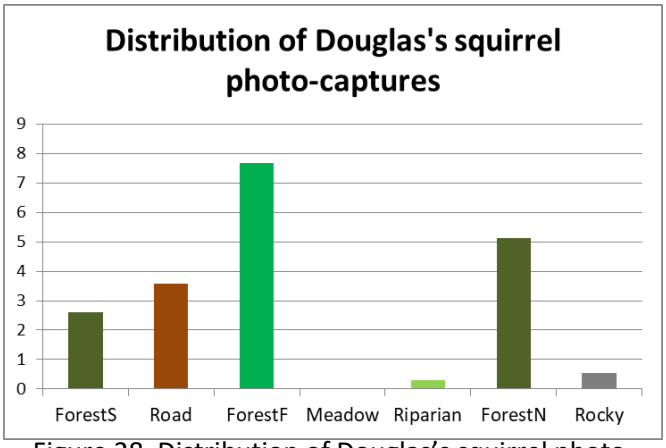


Figure 28. Distribution of Douglas's squirrel photo-captures by habitat

While Douglas's squirrels were photo-captured throughout the year they were most active from May till December (Figure 29). Douglas's squirrels were found to be strictly diurnal. Peak activity occurred during the morning with a second lower activity peak in the evening (Figure 30).

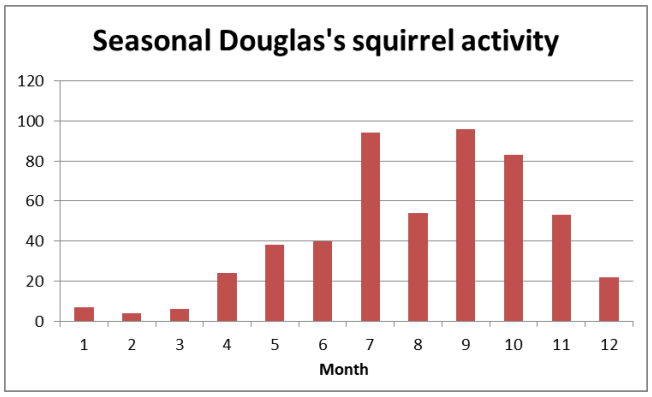


Figure 29. Number of Douglas's squirrel photo-captures by month

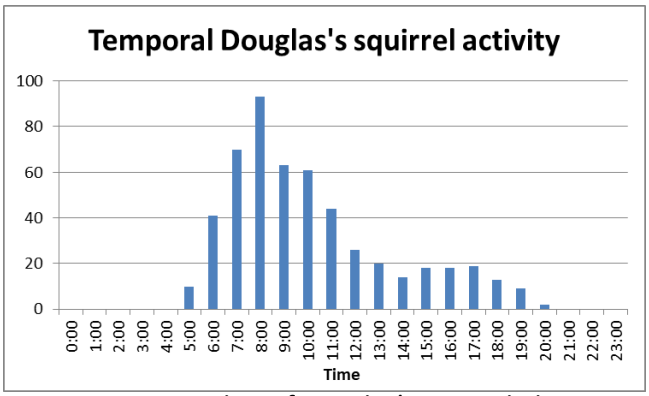


Figure 30. Number of Douglas's squirrel photo-captures by hour

California ground squirrel (*Spermophilus beecheyi*)

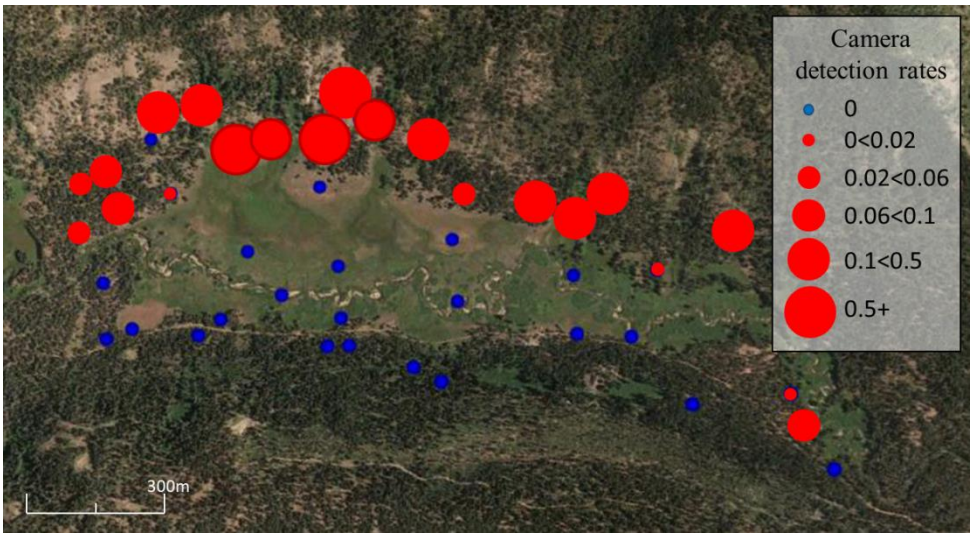


Figure 31. Locations and capture rates of California ground squirrel at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

California ground squirrels (CGS) prefer more open and disturbed habitats (White et al. 1980) and this was reflected in their capture locations in Carpenter valley. CGS were nearly exclusively captured on the northern side of the valley where forests were drier and more open (Figure 31). Highest camera capture rates occurred in the rocky higher-elevation areas. Since CGS hibernate during the winter we used only data from active months to calculate photo-capture rates. CGS were captured in flat forest habitat more often than they were captured on the road (Figure 32, P = 0.03).We determined the active period of CGS in Carpenter Valley to be from April till November (Figure 33). Earliest detection of the season was April 14 and last was November 8. We did not detect any emergence even on warmer winter days. CGS were strictly diurnal and active throughout the day (Figure 34).

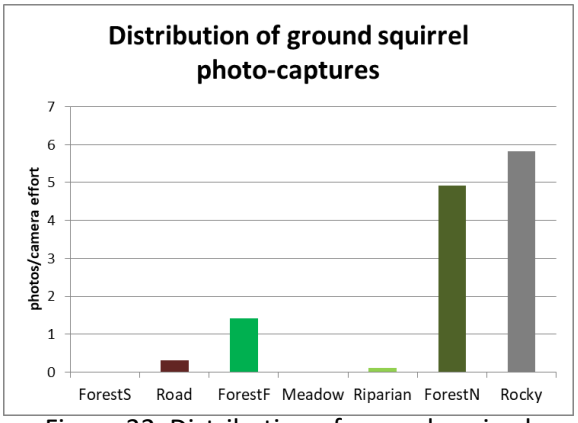


Figure 32. Distribution of ground squirrel photo-captures by habitat

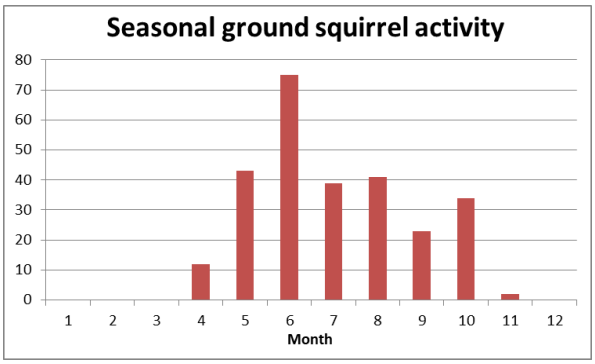


Figure 33. Number of ground squirrel photo-captures by month

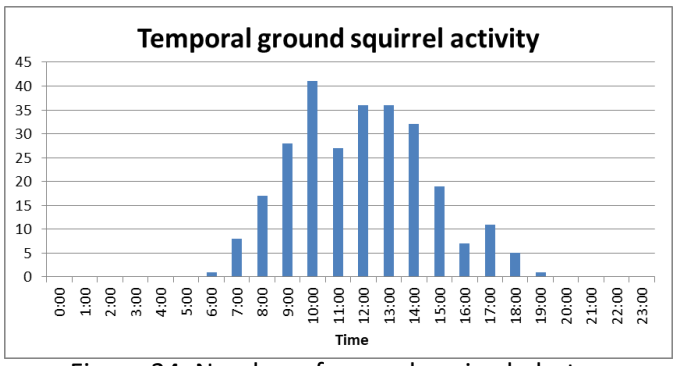


Figure 34. Number of ground squirrel photo-captures by hour

Chipmunks (*Tamias* spp.)

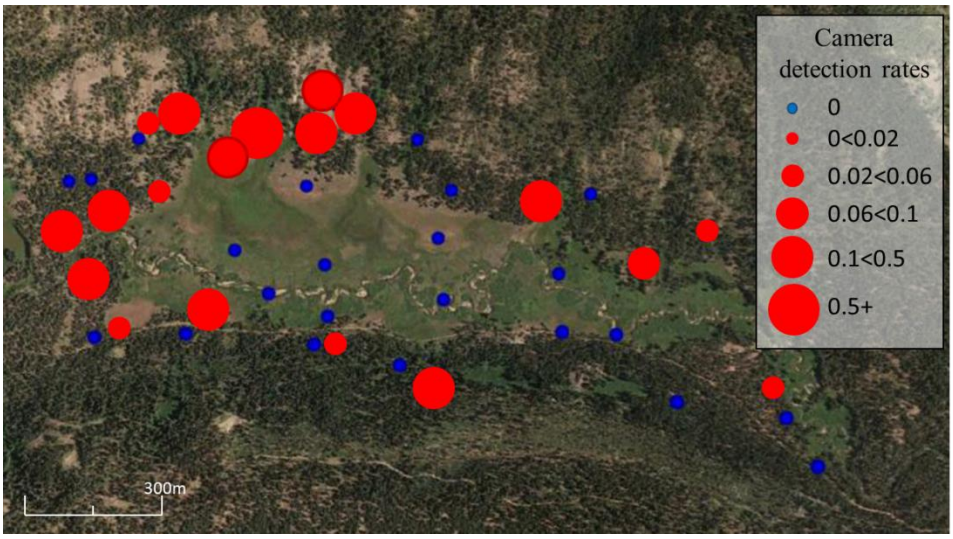


Figure 35. Locations and capture rates of chipmunks at individual camera stations in Carpenter Valley, CA 6/2017 -

A number of species of chipmunks may be found in Carpenter Valley including yellow pine chipmunks (T. *amoenus*), lodgepole chipmunks (T. *speciosus*), Allen's chipmunk (T. *senex*), and long-eared chipmunk (T. *quadrimaculatus*). The different species of chipmunks could not reliably be distinguished from photographs and so we grouped them for analysis.

Chipmunks were photo-captured in all habitat categories other than the meadow (Figure 36). They were only infrequently captured in riparian areas. While chipmunks were captured on both sides of Carpenter Valley the greatest capture rates were recorded in drier regions such as the forest floor and the northern slopes (Figure 35). Chipmunks were more likely to be captured on forested valley floor than on the roads running through that habitat type (P = 0.02).

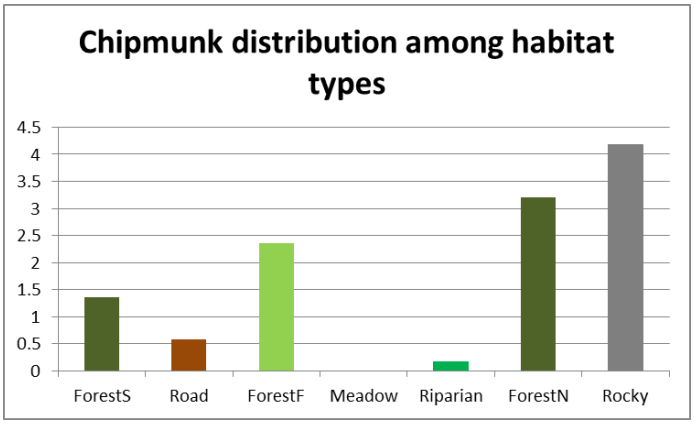


Figure 36. Distribution of chipmunk photo-captures by habitat

Chipmunks were active from April till November and hibernated during the winter (Figure 37). No winter emergence was detected. The first photo-capture of the season occurred April 1 and the last capture was on November 25. Increased activity was observed in October when foraging increases to prepare for winter hibernation. Chipmunks were strictly diurnal with peak daily activity occurring in the morning (Figure 38).

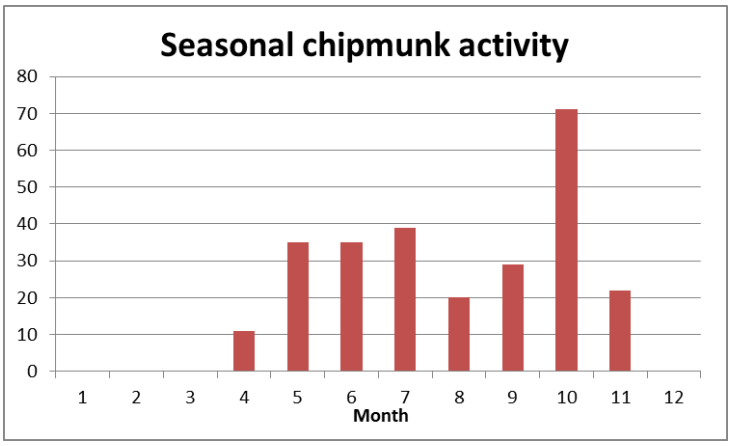


Figure 37. Number of chipmunk photo-captures by month

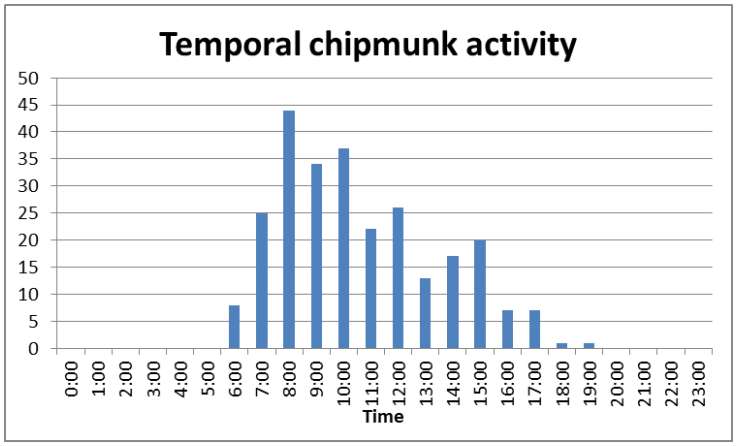


Figure 38. Number of chipmunk photo-captures by hour

Snowshoe hare (*Lepus americanus*)

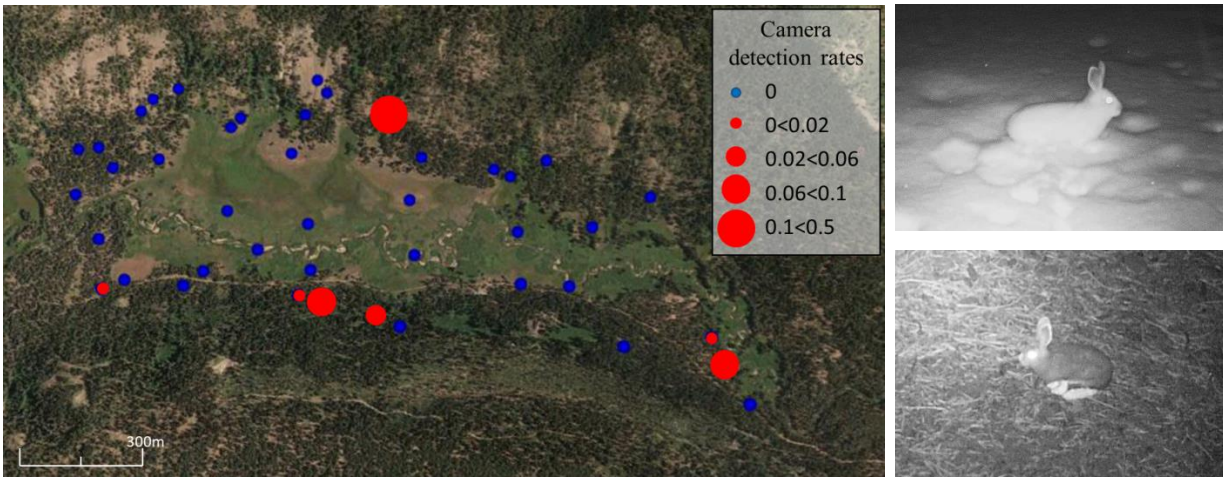


Figure 39. Locations and capture rates of snowshoe hares at individual camera stations in Carpenter Valley, CA.

Snowshoe hares rely on cover for protection and are therefore generally found in densely vegetated areas (White et al. 1980). We collected 27 independent images of snowshoe hare and found this to be reflected in the sites at which hares were photo-captured. Photo-captures occurred in densely vegetated areas on the South and North slopes of Carpenter Valley (Figure 39). No images were captured in the meadow, loose forest floor or in rocky habitats (Figure 40).

Snowshoe hares were active year round with photo-captures peaking in July (Figure 41). We were able to detect the change in pelage coloration from photographs and observed that pelage coloration was white from December through March. Hares began to morph into brown pelage in April with full brown coloration observed in June. Hares with varying degrees of patchy coloration were observed in April and May. Temporal activity of snowshoe hares was observed to be entirely nocturnal with peak activity occurring before dawn (Figure 42).

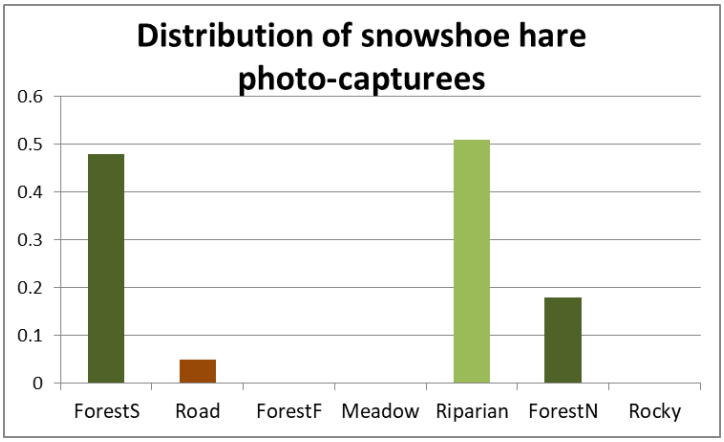


Figure 40. Distribution of snowshoe hare photo-captures by habitat

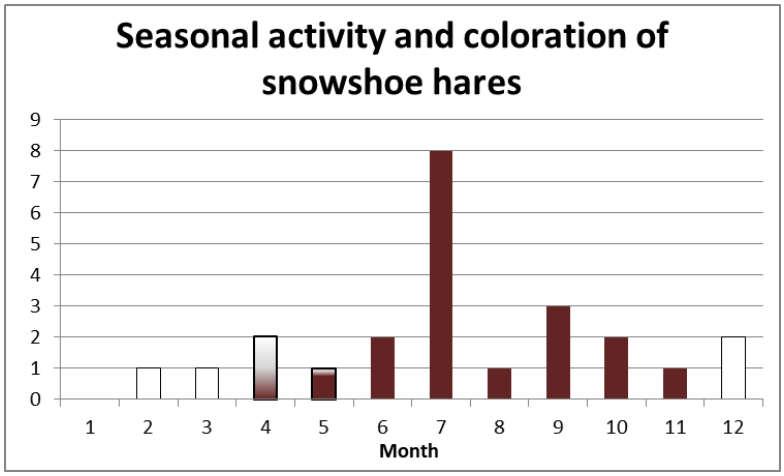


Figure 41. Distribution of snowshoe hare photo-captures by month. Column color represents the pelage coloration of hares in photographs captured during that month.

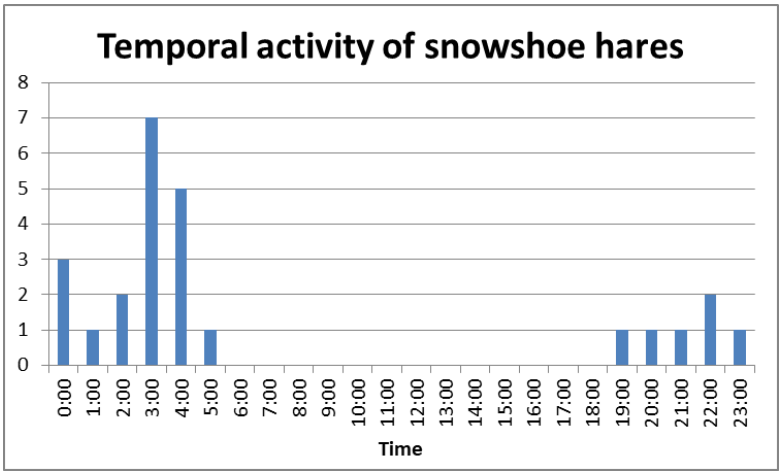


Figure 42. Number of snowshoe hare photo-captures by hour

Striped skunk (*Mephitis mephitis*)

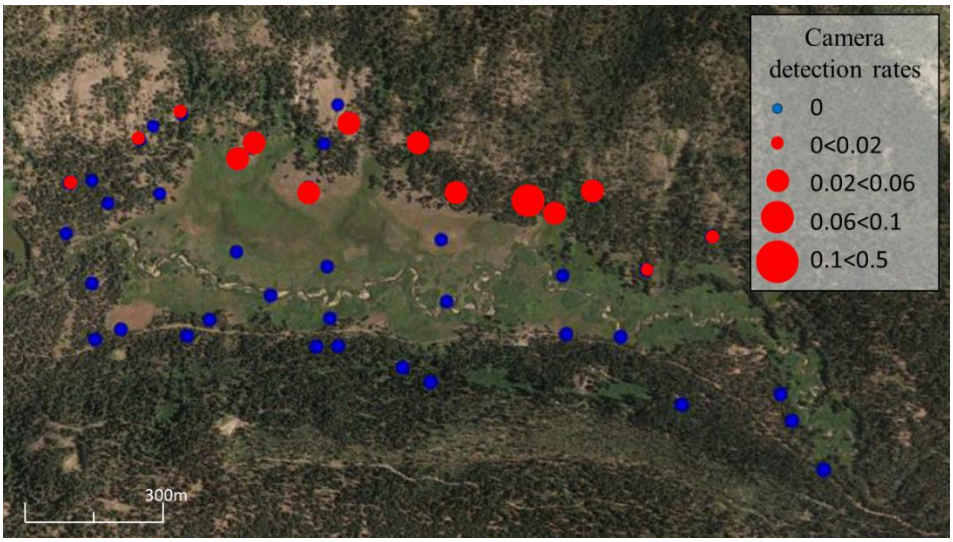


Figure 43. Locations and capture rates of skunks at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

We collected 44 independent images of striped skunks during the study. While skunks were captured in a variety of habitats all captures occurred on the northern side of the valley (Figure 43). Differences in the number of photo-captures on roads and in flat forest were not significant (P = 0.35). Skunks were active for most of the year but no activity was recorded in December or January (Figure 45). Peak seasonal activity occurred in spring and fall which corresponded to the breeding and the dispersal seasons (Reid 2006). Skunks were generally observed to be nocturnal but were occasionally photo-captured during the day as well (Figure 46). This behavior is similar to that reported by Reid 2006.

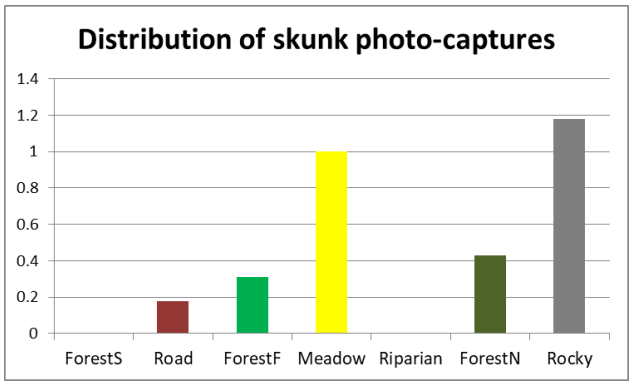


Figure 44. Distribution of skunk photo-captures by habitat

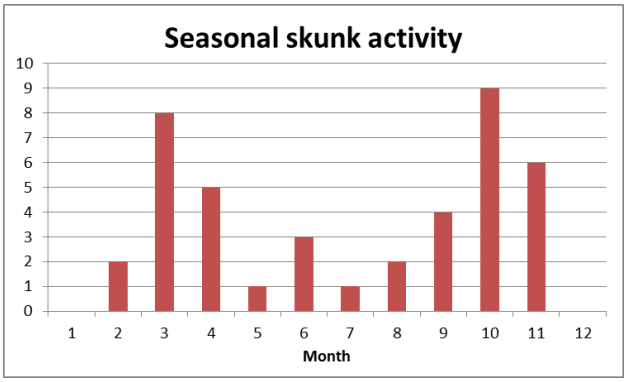


Figure 45. Number of skunk photos captured per month.

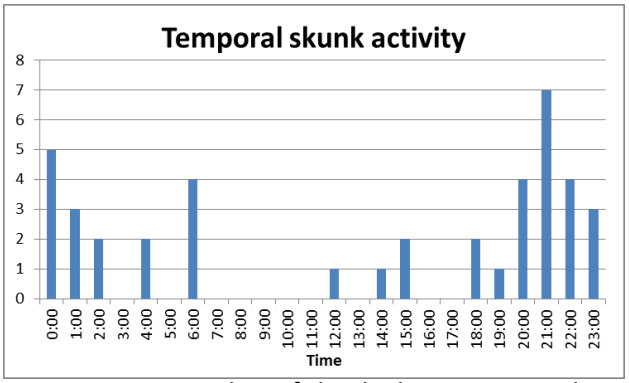


Figure 46. Number of skunk photos captured per hour.

Mice (*Peromyscus* spp.)

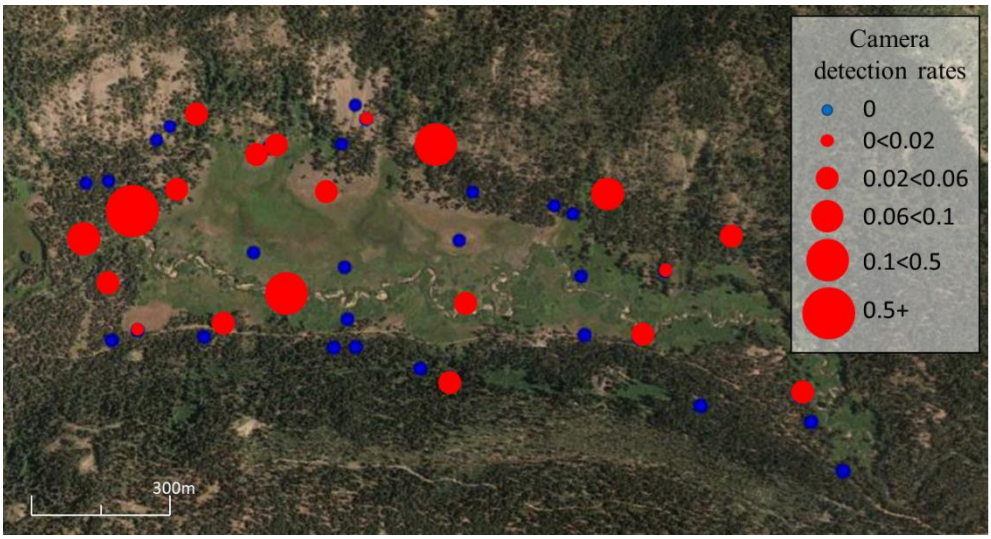


Figure 47. Locations and capture rates of *Peromyscus* spp. at individual camera stations in Carpenter Valley, CA.

Small mammals could not reliably be identified from photographs so we grouped them as one. This grouping likely included *Peromyscus* and *Microtus* genera and possibly also *Thomomys*, *Perognathus*, and *Zapus*.

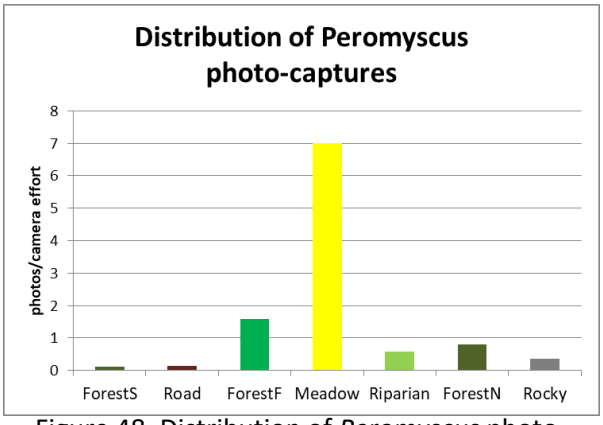


Figure 48. Distribution of *Peromyscus* photo-captures by habitat

Mice were photo-captured in all habitat categories throughout Carpenter Valley with greatest detections occurring in meadow habitat (Figure 48). The meadows provide them with food and cover and possibly less mammalian predation pressure.

Mice were predominantly active from July till November but some activity was detected year round (Figure 49). Only one image was captured when snow was present. Mice were completely nocturnal with the majority of activity occurring in the early morning hours (Fig. 50).

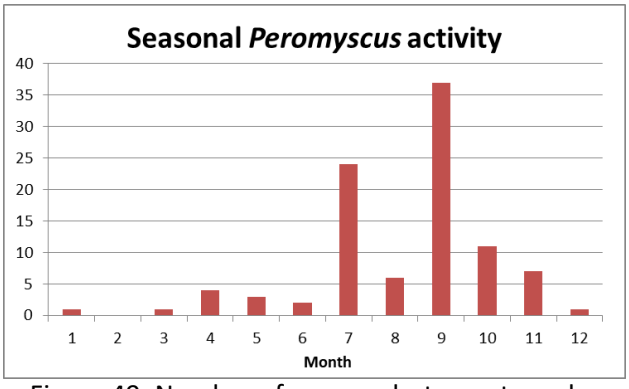


Figure 49. Number of mouse photo-captures by month

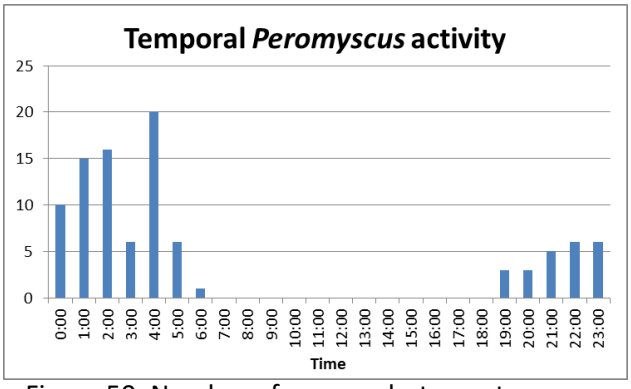


Figure 50. Number of mouse photo-captures per hour

Bushy-tailed Woodrat (*Neotoma cinerea*)

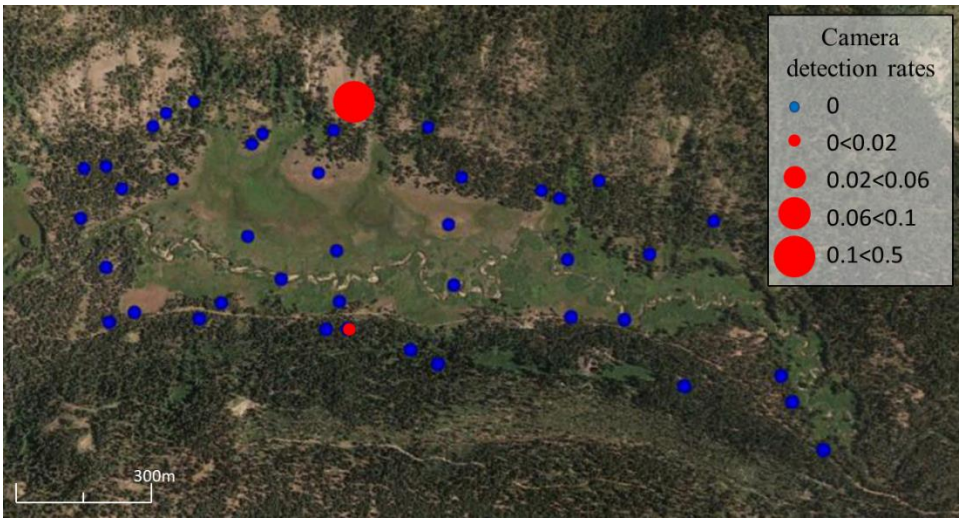
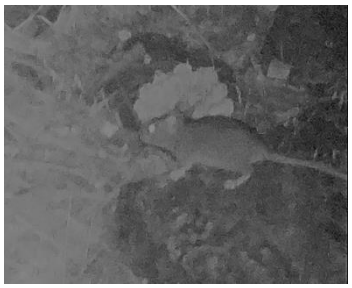


Figure 51. Locations and capture rates of bushy-tailed woodrat at individual camera stations in Carpenter Valley, CA.



We collected 26 independent images of woodrats. All but one photograph were collected in rocky habitat (Figure 52). Capture rates were calculated using only camera data from May to November. The limited data indicated that woodrats were only active during warmer seasons (Figure 53) which is what other studies have indicated as well (White et al.1980). Woodrats were shown to be nocturnal (Figure 54).

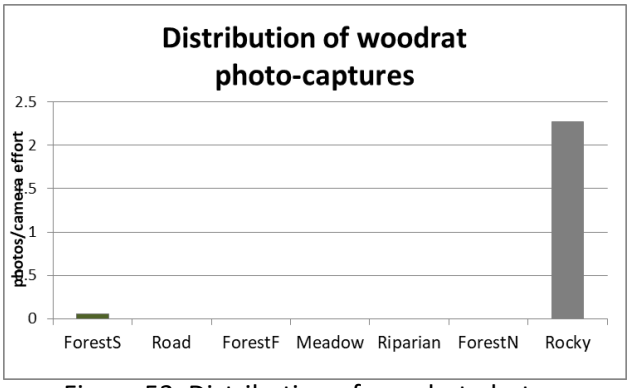


Figure 52. Distribution of woodrat photo-captures by habitat

Figure 53. Number of woodrat photo-captures by month

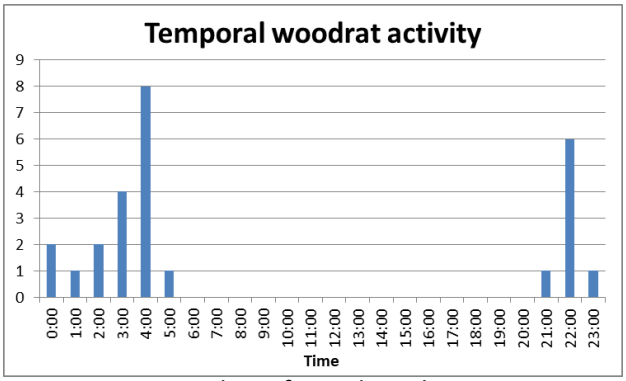


Figure 54. Number of woodrat photo-captures by hour

Golden-mantled ground squirrel (*Spermophilus lateralis*)

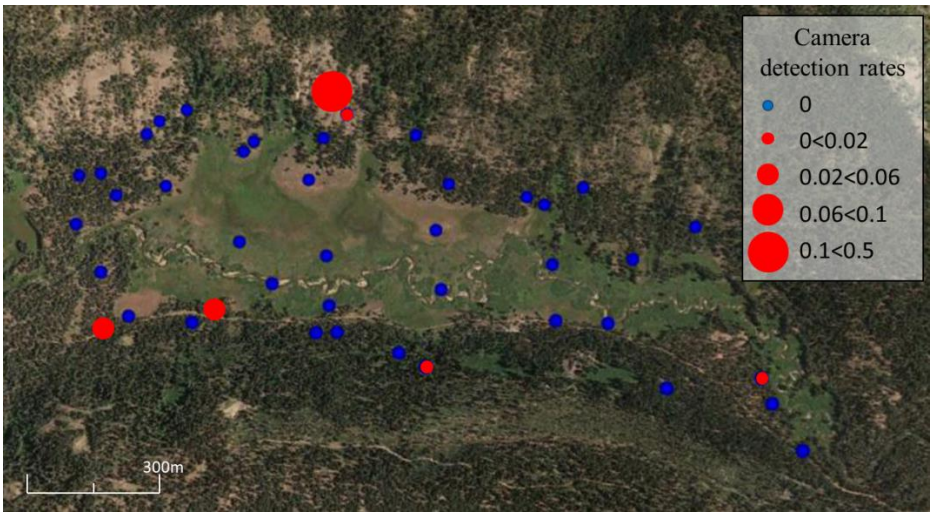


Figure 55. Locations and capture rates of golden-mantled ground squirrel at individual camera stations in Carpenter Valley, CA 6/2017 - 6/2018.

These analyses are based on only 11 unique capture events and are therefore not a robust analysis of behavior. We observed initial indications that golden-mantled ground squirrels (GMGS) are diurnal and active in the summer and fall with no activity in the winter. It is possible that the images captured in the rocky habitat are all of one or two individuals, although captured on different days. The repeated presence of these individuals may have skewed the results toward favoring rocky, open habitat. However, GMGS are known to hibernate and are described to favor open rocky terrain (White et al. 1980, Reid 2006) which supports the limited data that we collected.

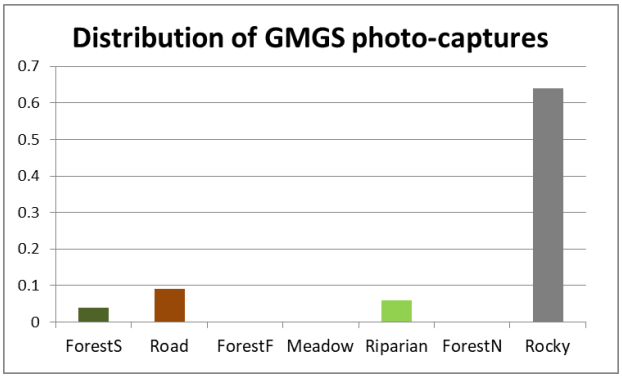


Figure 56. Distribution of GMGS photo-captures by habitat

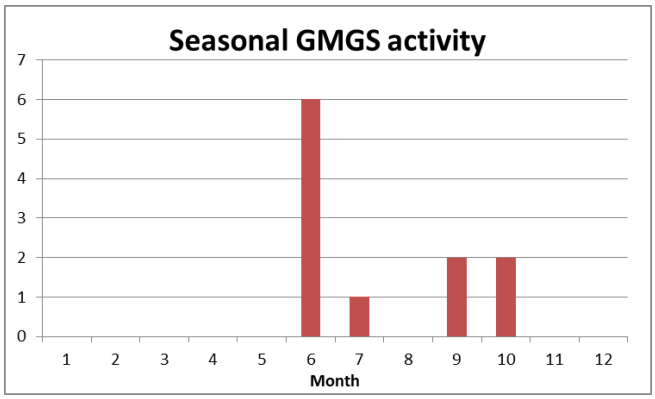


Figure 57. Number of GMGS photo-captures per month

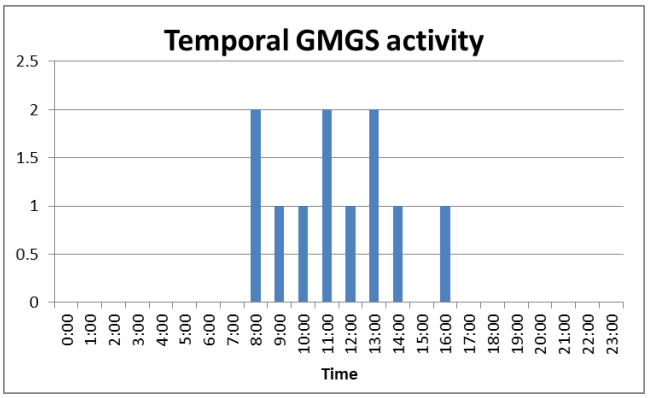
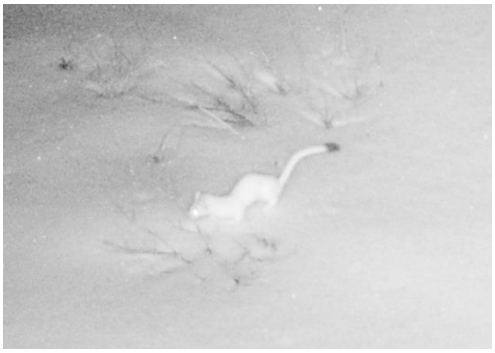


Figure 58. Number of GMGS photo-captures by hour





Other species:

Other species we photo-captured but for which we did not collect enough data to analyze individually included: long tailed weasel, cougar, mountain beaver, Mountain cottontail, spotted skunk, northern flying squirrel, raccoon, grey fox, and porcupine.

Camera surveys were effective for detecting both broadly distributed species as well as more rare and cryptic species. Species that were more abundant and wide spread were detected more quickly as can be seen in the species accumulation curve (Figure 3). The rate of new species detections slowed over time but it was important to run broad surveys long enough to detect more elusive species. Even after a year of camera surveys the detection can be incomplete. For example, the cameras did not detect marten although one was observed in the study area in May 2018 while checking camera units. However camera stations also provided surprises such as a flying squirrel which are mostly arboreal and not as likely to be detected in terrestrial camera studies.

Since this survey sought to assess the entire mid to large mammal community of Carpenter Valley cameras were placed generally and individual species capture rates therefore varied widely (Table 1). Capture rates of individual species could be increased by setting cameras more specifically into habitat preferred by the target species. This survey also used a high trigger sensitivity setting on camera units allowing us to survey for mammals as small as mice and chipmunks. A more restricted study would use a sensitivity setting in relation to the target species reducing the number of false triggers to sort through.

General discussion:

This study provided information on the distributions and habitat associations of mammals found in Carpenter Valley. The lowest species diversity among the sampled habitat categories was found in the meadows of Carpenter Valley. The uniformity of the meadow habitat meant that cameras were more difficult to camouflage and specific game trails were more difficult to find. It is therefore plausible that the meadow habitat was underrepresented in photo-capture rates. However the lack of cover in the meadow makes the habitat a much more vulnerable location. Since water is readily available on the surrounding slopes at the many springs mammals do not need to access the creek and cross the meadow. Incidental evidence of tracks and scat observed while setting up camera stations supported that the meadow did not have as high a level of large mammal activity as the surrounding forested areas.

The greatest species diversity was found on the dirt road that runs along the edge of Carpenter Valley. Species that were captured in greater numbers on the road versus the surrounding forested valley floor included coyotes and bobcats. Additionally all four cougar photographs and the one grey fox photograph were captured on the road. The reverse was observed for mule deer, grey squirrels, Douglas's squirrels, ground squirrels, chipmunks and mice in that they were photographed more often in flat forest habitat compared to on the road. The open terrain of the road may make prey species more vulnerable and cause them to avoid it. Foraging herbivores also would find the road of less interest due to the lack of understory. Conversely large bodied predators may prefer the road as an easier method of travel.

Three species, Western grey squirrel, California ground squirrel, and striped skunks, were only captured on the northern side of the valley. Forest type, understory vegetation, and downed wood are key elements explaining differences in small mammal distribution (Coppeto et al. 2006). Ground squirrels and skunks have both been shown to prefer younger successional stages in forests (White et al. 1980). The northern slopes of Carpenter Valley have more open forests which ground squirrels prefer while the south side is more densely forested.

The mature south side forests are structurally diverse with much downed wood and snags, and therefore ideal for animals such as marten and fisher. Marten are old growth dependent species and they prefer forests that retain old, dead trees and logs that can serve as refuge for both martens and their prey (Meslow et al. 1981, Moriarty et al. 2011). Mature forests are also preferred by northern flying squirrels that use snags and old trees for their nests (Meyer et al. 2005). Flying squirrels prefer to nest close to perennial creeks making Carpenter Valley ideal

habitat. The south side forests were also the region where we documented the highest rate of does with young fawns. Logging practices often remove downed wood and snags that are naturally found in old-growth forests making the relatively unmanaged forests of Carpenter valley a rare resource. Generalist species such as golden-mantled ground squirrels, chipmunks and mice increase in more open and disturbed stands. The low number of these species detected on the south side speaks to the relatively undisturbed nature of these slopes.

Due to this we suggest that the forested slopes provide higher conservation value to the mammal community of Carpenter Valley than does the valley floor. The great amount of water available on the north slopes mean that animals do not necessarily need to access the creek which would otherwise be a draw to the meadow. Much of the water on the north slopes remained open throughout the winter of 2017-2018. While the valley floor clearly holds high conservation value for many species of birds, plants, amphibians and fish we would suggest that the untreated forested slopes of Carpenter Valley hold the greatest value for the mammal community.

Recommendations:

This study provides information on the distribution as well as seasonal and temporal activity patterns of mammals currently found in Carpenter Valley. The property is scheduled to be opened to the public and it has been demonstrated that species can shift their temporal activity in response to greater human activity (Gaynor et al. 2018). A shift in activity can potentially alter foraging behavior, increase competition, or increase vulnerability to predators (Gaynor et al. 2018). Increased activity due to visitation or forestry management practices also can affect species distribution. Here we provide some suggested precautions that can be taken when Carpenter Valley is opened to the public to help preserve the current composition and behaviors of the native mammalian community.

We recommend limiting domestic dog access to the valley. Domestic dogs can act as predators reducing prey for native predators and also can harass mule deer adding stress to does as they fawn (Lowry and McArthur 1978). Even leashed dogs leave the scent of a predator or can introduce pathogens (Cleaveland et al. 2000). Scent left by dogs can make prey species more wary while intriguing native predators such as coyotes and wolves that may view a dog as a potential competitor (Vanak et al. 2009).

We recommend conducting any required forestry work until after the fawning period. Photographic data indicated that the Loyalton-Truckee deer herd arrived in Carpenter Valley in May. Since most fawns are generally born in herds within 30 days of each other (Dorrance 1967)

fawns in Carpenter Valley are likely all born in May to early June. Any necessary forestry practices, especially on the south slopes, may need to be conducted later in the season to avoid this critical period.

The winter season could be used as a peaceful retreat for visitors as long as hibernating animals are not disturbed by too much activity. Relatively low levels of mammalian activity were detected in Carpenter Valley during the coldest winter months. Some species such as deer migrated to other areas while others species such as bears, golden-mantled ground squirrels, woodrats, chipmunks and California ground squirrels hibernate.

A trail will need to be established so that the public can enjoy the splendor of Carpenter Valley. Since few generalist species were found on the south slope of Carpenter Valley we would recommend against putting in a trail that risks opening up this area. A trail on the south slope would likely promote travel by predators into a region that also was shown to harbor many deer fawns. However, a trail along the edge of the valley floor similar to the existing road would likely not have a great impact on current mammal distribution as predators already regularly travel the forested valley floor. A difficulty in building a trail along the north side of the valley would be crossing the many fens and associated wet meadows without damaging them.

Carpenter Valley is a beautiful montane valley with a diverse mammalian community that the public will soon be able to enjoy. The data collected in this project will serve as baseline information allowing us to monitor any spatial or temporal changes in mammalian behavior as human visitation rates to Carpenter Valley increase.

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