# California Department of Fish & Wildlife

# Inland Deserts Region

# Eastern Sierra Nevada Low Elevation Mesocarnivore Study

# Annual Report 2017


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**Eastern Sierra Nevada Mesocarnivore Study Annual Report**

**Inland Desert Region**

**2017**

This report summarizes work conducted by the eastern Sierra mesocarnivore study crew (formally bobcat study crew), during March 2016 – December 2017. Work on this project was grouped into the following categories:


I. **Bobcat capture-mark-recapture surveys…………………………………………………**
II. **Mesocarnivore occupancy surveys…………………………………………………………...**
III. **Bobcat radio collaring………………………………………………………………………...**
IV. **Animal health and morphology……………………………………………………………...**
V. **Reproductive biology…………………………………………………………………………**
VI. **Spatial Use and Resource Use**
VII. **Prey base…………………………………………………………………………………….....**


**The Bobcat Capture Crew captured and released a female bobcat in Round Valley after fitting her with a GPS collar.**

## Summary

The Inland Desert Region Wildlife Program conducts resource assessment activities necessary to monitor the health and condition of wildlife populations, assess the anthropogenic and environmental impacts to wildlife resources, and to manage wildlife populations. Climate change, disease outbreaks, extreme weather events, and California Department of Fish and Wildlife (Department) policy and regulation changes are a few factors that can affect wildlife populations so it is within our trustee and responsible roles as an agency to monitor wildlife populations. In the fall of 2014, the Eastern Sierra Nevada Bobcat Study (ESNBS) was initiated in response to the proposed statewide ban on bobcat (*Lynx rufus*) trapping in spring of 2014. The main objective of this study was initially to standardize survey techniques for bobcats that would allow the Department to better monitor and manage low elevation (≤9,000 ft) bobcat populations in Inyo and Mono Counties. The ESNBS has conducted population surveys and deployed GPS collars on bobcats to learn more about Eastern Sierra bobcat densities and population characteristics. After three years of focusing mainly on the bobcat population, the focus has shifted to include all lower elevation mesocarnivore species. We have changed the name of the study to the Eastern Sierra Nevada Low Elevation Mesocarnivore Study to reflect the change in our objectives.

This annual report covers work completed since August 2016. Information on prior work can be found on our website and in the 2016 annual report. We set up an interactive website to educate and update the public on the Eastern Sierra Nevada Low Elevation Mesocarnivore Study (www.wildlife.ca.gov/Regions/6/Bobcat). Currently, this website includes information on the general biology and ecology of bobcats as well as project reports regarding work being done on mesocarnivores in Inyo and Mono Counties. This annual report will be made available on the website each year.

A graduate student from Utah State University is collaborating with us to test spatially explicit capture-mark-recapture (CMR) surveys for bobcats using remote cameras. CMR survey data produce abundance estimates via statistical models that take into account the frequency of detection of unique individuals during the survey period. Bobcats can be identified individually through visual comparison of spot patterns and other pelage characteristics seen in remote camera photos. The study area for the CMR survey was located on the west side of U.S. Highway 395 and was between Big Pine, CA and Independence, CA. Analysis of the photo data is currently underway and future publications are expected upon completion.

We completed two occupancy surveys covering four study areas since the 2016 occupancy survey in study area six. Occupancy survey data produces estimates of the percent of the study area that species of interest occur. These surveys also allow for monitoring the distribution of species that occur at low densities. Similar to CMR surveys, occupancy surveys also use remote cameras. However, unique individuals do not need to be identified from photos for the occupancy survey analyses. Only the species needs to be determined from the photos. Therefore, occupancy estimates can be derived for species without unique pelage patterns (e.g., gray fox). CMR surveys need a higher density of survey stations (i.e., remote cameras) compared to occupancy surveys in order to get enough detections of the same individual. A lower density of survey stations frees up the field crew to cover much larger survey areas for occupancy surveys. Percent of a study area occupied by a certain species can be used as an index for relative abundance. Changes in occupancy can be used to influence management decisions. During the

most recent occupancy surveys, we were able to derive occupancy estimates for gray fox, kit fox, coyote, bobcat, and skunk species. Distribution data was derived for raccoons, mink, ringtail, badger, and long-tailed weasels. We believe some of these mesocarnivore species occur at too low of densities to derive occupancy estimates; however, the surveys were designed to obtain occupancy estimates mainly for bobcats, foxes, and coyotes. Future surveys will need to be designed to target certain species like mink and ringtail that primarily use riparian corridors.

In order to collect regionally specific home range and life history data for Eastern Sierra bobcats, we fitted 43 bobcats with GPS radio collars (twenty-six males and seventeen females) from January 2015 to April 2016. Trapping success was highest using multiple traplines and trapping in late winter when prey is scarce. The average weight of males and females was 9.0 kg and 6.7 kg, respectively. None of the captured bobcats showed signs of disease, and only one bobcat exhibited high parasite loads. Body condition was adequate for all captured bobcats except for two bobcats, one of which was thin and the other emaciated. A female bobcat that was collared in January 2015 had three kittens in Horton Creek in April 2015. A second collared female (BC022), had a litter of three kitten in late April in Oak Creek. Shortly after, BC022 was killed near her original den site, the cause of death remains unknown. In both cases, each kitten was briefly examined, pit tagged, measured and photographed while the female was away. Den site characteristics were also documented and researchers are continuing to collect data on den sites for presently collared cats.

The Utah State Master's student we are collaborating with will conduct analyses with the GPS collar data and future publications are expected. Data analyses will include home range estimates, temporal travel patterns, and intraspecies movement patterns. We plan to produce a Habitat Suitability Index using the collar data as well as Resource Selection Functions for bobcats relative to season, home range, and den sites.

It is important to monitor prey levels to better understand population dynamics of mesocarnivores. Lagomorphs (i.e., rabbits and hare), small mammal (i.e., rodents), and upland birds are the primary prey for bobcats and other mesocarnivores. Survey techniques were tested to monitor these prey species. Traditional road and ground surveys were not successful in 2015 and 2016 for counting lagomorph populations. Very few lagomorphs were detected using road transects and a combination of road and walking transects. However, small mammal trapping surveys in 2016 were successful in determining species occurrence. We are still in the process of determining the best methods to monitor all prey species.

## I. Bobcat capture-mark-recapture surveys

A graduate student studying at Utah State University is collaborating with us to conduct spatially explicit capture-recapture (SECR) surveys. The students conducted two SECR surveys annually in 2017 and 2018 for bobcats using camera traps. The goal of this study is to determine effective methods for estimating bobcat densities using non-invasive camera traps, and effectively identify unique individuals from pelage patterns. Furthermore, this study aims to employ spatially analytical methods using camera data to gain insights into the spatial patterns of bobcats. The 2017 survey consisted of 80 camera stations in a grid spaced approximately one mile apart. In 2018, the survey was limited to using 44 of the 2017 camera station locations in an attempt to collect better quality data by placing two cameras at each station. The study area is located on the west side of U.S. Highway 395 and is between Big Pine, CA and Independence, CA (Figure 1). Analysis of the photo data is currently underway and future publications are expected upon completion.

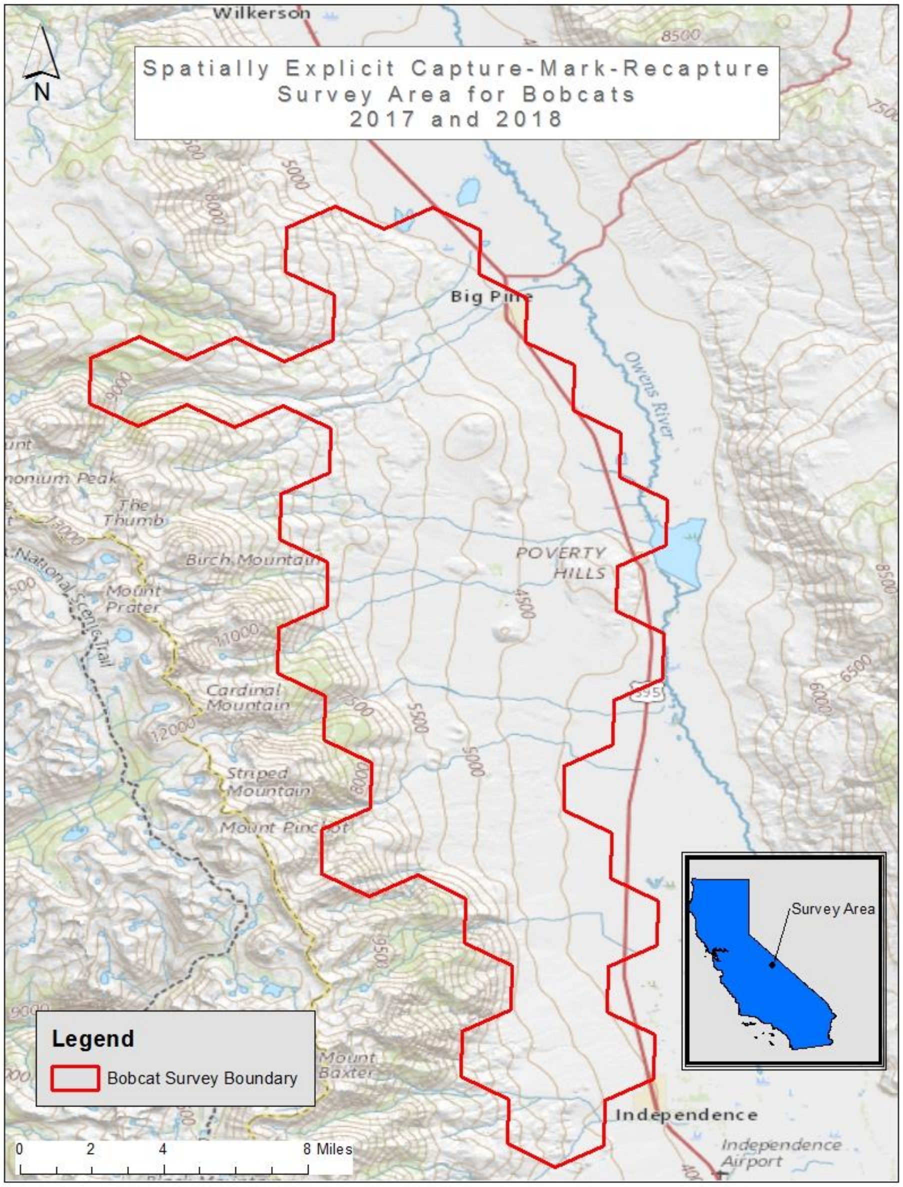


**Figure 1.** Boundary map of the 2017 and 2018 spatially explicit bobcat capture-mark-recapture survey.

## II. Mesocarnivore Occupancy Survey

We completed two occupancy surveys covering four study areas since the 2016 survey in study area six (Appendix B). Results from the 2016 survey can be found in the 2016 annual report (Ellsworth et al. 2016). Simulation models described in the 2016 annual report suggested we increase the number of survey stations per survey in order to have at least 80% power to detect a change in occupancy of $\leq$25%; assuming detection rate (p) continued to be $\geq$43% for each species. Furthermore, the simulations supported doing only three sampling occasions per survey. In 2017, we surveyed study areas five and seven January through February (hereafter winter survey) and study areas three and four November through December (hereafter fall survey). One hundred twenty, 10.4 $km^2$ (4 $mi^2$) grid cells were randomly chosen for both the winter and fall survey areas. Of the randomly chosen grid cells, 94 and 81 grid cells were chosen for the winter and fall surveys, respectively, based on accessibility. One remote camera (Reconyx PC900) was deployed in each grid cell. The field crew chose the exact locations for the cameras based on mesocarnivore travel corridors and sign (e.g., scat, tracks, game trails). Cameras were placed at least 2.5 km apart while staying in their respective grid cell. Commercially available mesocarnivore lures (e.g., Marsyada's Beaver Castor mixed with Minnesota Brand Catnip Oil and O'Gorman's Cat Passion) were systematically rotated at each survey station over the survey period. Each survey period lasted six weeks and survey stations were visited once every 14 days, pending accessibility, to replenish the lure. A major snow event rendered roads inaccessible to replenish the lure during the second occasion of the winter survey.

All occupancy models were run with three sampling occasions in Program MARK. A null model and a time varying model were run for each species that had a sufficient amount of detection data. The time varying model takes into account changes in detection rates over time. Model-averaging was used when models were within at least 2 $\Delta AIC_c$ units from the top model and model weight was $\geq$5% (Appendix D). We collected a sufficient amount of detection data from bobcats, coyotes, and gray foxes during the fall survey (Table 1A). We did not collect a sufficient amount of detection data for gray fox during the winter survey; however, we did collect a sufficient amount of detection data for bobcats, coyotes, kit foxes, raccoons, and skunk species (spotted and striped; Table 1B). We decided to combine detection data from both skunk species because detection rates were too low to run occupancy models for each species separately. Refer to Appendix B for a map of where the two different skunk species were detected.

A

**Study Areas 3 and 4**

| Species | Sessions | Detection Rate (p) | SE of p | 95% confidence interval of p Lower | 95% confidence interval of p Upper | Occupancy (psi) | SE of psi | 95% confidence interval of psi Lower | 95% confidence interval of psi Upper |
|---|---|---|---|---|---|---|---|---|---|
| **Bobcat** | 1 | 0.3757 | 0.0811 | 0.2146 | 0.5699 | 0.3729 | 0.0741 | 0.2421 | 0.5254 |
| | 2 | 0.4345 | 0.0871 | 0.2588 | 0.6282 | | | | |
| | 3 | 0.4149 | 0.0854 | 0.2590 | 0.5898 | | | | |
| **Coyote** | 1 | 0.4079 | 0.0622 | 0.2778 | 0.5523 | 0.8051 | 0.0573 | 0.6686 | 0.8942 |
| | 2 | 0.6391 | 0.0649 | 0.4969 | 0.7604 | | | | |
| | 3 | 0.6246 | 0.0650 | 0.4856 | 0.7457 | | | | |
| **Gray Fox** | 1 | 0.3412 | 0.0878 | 0.1940 | 0.5270 | 0.3980 | 0.0630 | 0.2831 | 0.5254 |
| | 2 | 0.4032 | 0.0922 | 0.2417 | 0.5888 | | | | |
| | 3 | 0.7444 | 0.0972 | 0.5169 | 0.8880 | | | | |

B

Study Areas 5 and 7

| Species | Sessions | Detection Rate (p) | SE of p | 95% confidence interval of p Lower | 95% confidence interval of p Upper | Occupancy (psi) | SE of psi | 95% confidence interval of psi Lower | 95% confidence interval of psi Upper |
|---|---|---|---|---|---|---|---|---|---|
| **Bobcat** | 3 | 0.3647 | 0.0799 | 0.2260 | 0.5302 | 0.5022 | 0.0898 | 0.3328 | 0.6711 |
| | | 0.3170 | 0.0792 | 0.1848 | 0.4873 | | | | |
| | | 0.3587 | 0.0763 | 0.2259 | 0.5173 | | | | |
| **Coyote** | 3 | 0.4978 | 0.0641 | 0.3416 | 0.6545 | 0.6075 | 0.0554 | 0.4953 | 0.7093 |
| | | 0.6412 | 0.6618 | 0.5042 | 0.7585 | | | | |
| | | 0.6944 | 0.0754 | 0.5312 | 0.8201 | | | | |
| **Kit Fox** | 3 | 0.5866 | 0.0765 | 0.4333 | 0.7247 | 0.2176 | 0.0455 | 0.1414 | 0.3197 |
| **Racoon** | 3 | 0.6560 | 0.0709 | 0.5075 | 0.7792 | 0.2109 | 0.0436 | 0.1379 | 0.3087 |
| **Skunk spp.** | 3 | 0.0984 | 0.6662 | 0.2444 | 0.3223 | 0.2162 | 0.0464 | 0.1389 | 0.3205 |
| | | 0.3936 | 0.1136 | 0.2035 | 0.6226 | | | | |
| | | 0.8915 | 0.1022 | 0.5089 | 0.9849 | | | | |

**Table 1.** Occupancy model results for the fall 2017 survey in study areas 3 and 4 (A) and winter in study areas 5 and 7 (B). The null model and a time varying model for detection rate (p) were run. Model averaging was performed when the two models were within 2 $AIC_c$ values of each other and model weight was ≥5%.

Detection rates (p) for bobcats were similar for both the winter and fall surveys in 2017. However, study areas five and seven had 13% more area occupied by bobcats compared to study areas three and four (Table 1A and 1B). Furthermore, study area six surveyed in 2016 had 25% higher occupancy and slightly higher detection rates of bobcats compared to study areas five and seven. Gray fox had similar occupancy levels as bobcats in study areas three and four. An inadequate amount of detection data was collected for gray fox in study areas five and seven suggesting gray fox habitat is limited in those study areas. Kit fox were only detected in study areas five and seven. Gray fox were not detected at grid cells where kit fox were detected. The majority of kit fox detections occurred in the southern region of study area 7; however, one grid cell detected a kit fox once approximately 10 km east of the town of Bishop, CA. The farthest south a gray fox was detect east of U.S. Highway 395 was approximately 26 km southeast of the town of Lone Pine, CA. Two gray fox were present in the photos taken at the southeast location. The map in Appendix B shows an obvious north to south spatial segregation between gray and kit fox though there is some overlap in distribution. Kit fox can be difficult to detect when densities are low. It is recommended to use scat surveys during the breeding season to adequately survey low density kit fox populations (Dempsey et al. 2014). Kit fox range may be limited due to lack of adequate soil types for making burrows (Arjo et al. 2003) and the Owens River may also act as a barrier for western movement.

It is well known that mesocarnivores are difficult to detect during the spring and summer because prey is abundant and therefore lures are not as effective (Thompson 2004, Long et al. 2008). However, black bear surveys are effective during the spring and summer. We conduct black bear surveys during the spring and summer using hair collection devices. DNA can be extracted from the hair samples and analyzed to determine individuals and sex. The genetic data is used in capture-mark-recapture models to estimate abundance and density of black bears. In the near future, you can visit a CDFW Region 6 webpage to learn more about the Eastern Sierra Nevada Black Bear Project. In 2016, we started deploying remote cameras at all the bear hair collection stations and added mesocarnivore lures. We surveyed study area two in northwest Mono County (Appendix A). Detection rates were low for mesocarnivores as we anticipated. However, the photo data was helpful for determining relative distribution of mesocarnivores. Appendix B and C contains maps that depict the survey cells where all the occupancy modeled species was detected and where less detected species like badger, pine marten, ring-tailed cat, mink, and long-tailed weasel were also detected. In regard to the fall and winter survey, the low detection rates for some species are likely a result of the study design being tailored for bobcats, coyotes, and fox species. The low detections are not necessarily an indication of low abundance. In order to derive robust occupancy estimates for the species with low detection rates, surveys must be designed specifically to detect that species. For example, to properly survey mink, survey stations should be concentrated along riparian corridors and mink specific lures should be used. In addition, sign surveys (scat and tracks) can also be used effectively to monitor relative abundance of mink (Bonesi and Macdonald 2004).

Large scale distribution studies of mesocarnivores have not been completed in the eastern Sierra since Grinnell's work in the 1930's (Grinnell et al. 1937*a*, *b*). One of our main goals for this mesocarnivore study is to reevaluate the distribution and occupancy levels of all low elevation mesocarnivores in the eastern Sierra. To improve our distribution data, we plan to create a database where all observations of mesocarnivores can be recorded from the public and CDFW biologists. These opportunistic observations will be helpful for monitoring distribution of mesocarnivores during years we do not survey and where we have not been able to survey yet. For example, the distribution map that includes badger (Appendix C) shows no detections of badgers in study area four. Project manager, Jonathan Fusaro, has documented badger tracks off the Horton Creek trail during his personal time. In addition to our Low Elevation Mesocarnivore Study, there is also a High Elevation Red Fox Study conducted in the eastern Sierra Nevada. The High Elevation study is primarily focused on searching for Sierra Nevada Red Fox above 9,000 feet elevation; however, the study is also compiling ancillary data on all mesocarnivores. Summary reports from that study will be available soon. The high elevation study also uses remote cameras. Species like pine martin are commonly photographed at the high elevation cameras whereas we have only detected pine marten once on our low elevation cameras. The one detection we had was near Lake Sabrina at 9012 feet elevation. The High Elevation study detects many of the same species we detect during our low elevation surveys.

## III. Bobcat Radio Collaring

*Summary*

Trapping with the intent to radio collar bobcats commenced in early 2015 and occurred every winter through 2018. Trapping efforts would start as early as December and end in early April at the latest. These efforts were determined to avoid overlapping the lower elevation mesocarnivore camera survey period and reproductive events such as rearing kittens. Short trapping periods occurred in July 2016 and

July 2017 in attempts to re-collar bobcats whose collars had stopped transmitting GPS locations or where the collar drop off mechanisms failed. Trapping was not successful during those periods.

Three different collar brands were used: ATS, Vectronics and Lotek. The ATS collar weighed 380 g, Vectronics weighed 352 g, and Lotek was the lightest at 217 g. All collars were programmed to take seven locations per night (every two hours 6pm – 6am) and one location at noon each day. All collars were programmed to drop off after being on the animal for 52 weeks (ATS), 80 weeks (Lotek), and 86 weeks (Vectronics).

A total of 12 collars have been retrieved from the field resulting from bobcat-vehicle collisions, recapture, programmed collar drop-off and the animal unexpectedly dropping the collar. From January 2015 through February 2018, six collared bobcats (five males and one female) were removed from the study as a result of road mortalities. Of the remaining six collars retrieved, two were ATS collars that successfully dropped off on schedule, two were ATS collars obtained via recapture of an individual, one was a Vectronics collar from a harvested bobcat that was returned by the hunter, one Lotek was collected as the result of the bobcat escaping the collar one month after capture, and one Vectronics collar was collected from private property where the cause of death of the bobcat is unknown.

In January 2016, two ATS collars were programmed to drop but were not retrieved due to GPS and radio telemetry signal failure. Four ATS collars, scheduled to drop off in winter of 2017 were not retrieved, this is likely due to GPS and telemetry failure as well as failure of the drop off mechanism built into the collars. Further capture efforts involving traps, cable-restraints and/or dogs will be used next year to remove these collars and check animal welfare. Any failed collars collected will be sent back to the manufacturer for evaluation of the failure and data retrieval.

For the analysis of home range, space use and social organization, this study aimed to obtain a minimum sample size of 30 bobcats fitted with GPS collars. From January 2015 through April 2018, 43 GPS collars were deployed from the Volcanic Tablelands north of Bishop CA, to approximately 50 miles south of Lone Pine, CA (Appendix 1a). Two ATS, two refurbished Vectronics, and one Lotek collar did not get deployed due to low trapping success towards the end of our trapping window timeframe. These collars will potentially be deployed in the future on bobcats or another species in this area.

Total trap nights were calculated as the total number of traps activated, multiplied by the total number of nights they were out. When summarized across all the trap-lines, the average number of trap nights to catch a bobcat in 2015/2016 was 103.27, in 2017 the average dropped to 93 trap nights per bobcat and in 2018 the average dropped again to 49.7 trap nights (Figure 2).

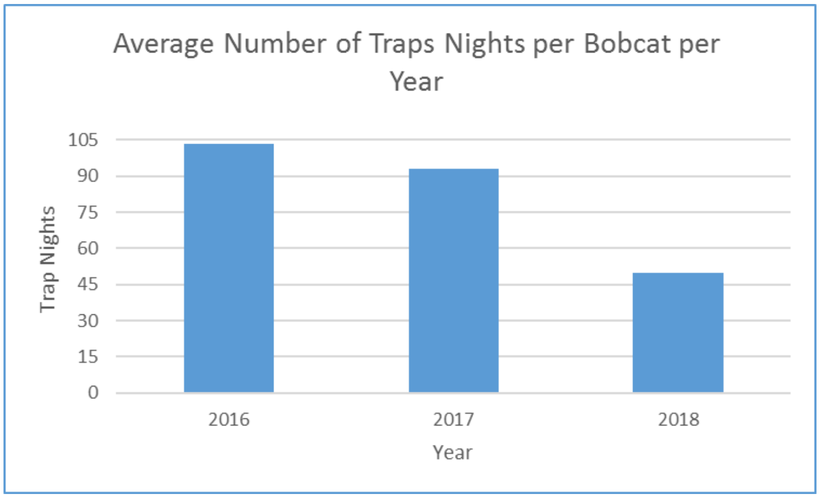


**Figure 2.** Average number of traps nights per bobcat for every trapping year.

Bobcats were trapped using cage traps with a single dropdown style door in 2016 and 2017. In 2018, all but one bobcat were trapped using cage traps. One bobcat was caught incidentally by a houndsmen while the contracted houndsmen was attempting capture and GPS-collar mountain lions. We attempted for one month to capture bobcats using Select-A-Catch LLC. cable-restraints to increase our capture success. However, we were unsuccessful. All traps and cable-restraints were checked twice a day with a maximum time duration of 16 hours between checks. Most bobcats were caught after dark and found during morning checks; however, evening checks are still recommended if traps are left open during the day. Approximately, 7.0% of bobcats were captured during the day and found in traps during the evening check. Non-target species were released immediately. The most common non-target species were stripped skunks, grey foxes, and ringtails. Not a single animal caught in a bobcat trap was injured with more than a few minor abrasions, except for the one bobcat that broke a canine in 2016. We ceased trapping immediately after detecting the broken canine and trap doors were modified by reducing the gaps in between the bars to <1 inch. The door modification prevented further damage bobcat teeth, although four other bobcats had old or previously broken canines.

The majority of bobcats were captured using waterfowl or rabbit carcasses as bait (provided by local hunters or roadkill) and a combination of bobcat urine, visual attractants and commercially available lures. Trapping success significantly improved with experience. Figure two shows how the average number of trap nights to catch a bobcat decreased every year, with a decrease of 53.57 nights, from 2016 to 2018. Trapping also greatly improved when experienced trappers, Vicki and Jeff Davis, ran trap-lines. Combined, their experience exceeds 50 years. We would like to develop a peer-reviewed manuscript with more detailed bobcat trapping protocols and techniques in the near future. Trapping is extremely challenging. Based on remote camera photos and bobcat sign, more bobcats were missed than were captured during a given trapping period.

## IV. Animal Health and Morphology

*Age Structure and Sex Ratios*

Age structure and sex ratio estimates are key components for monitoring the health of a population (Johnson et al. 1981). A canine tooth from a dead bobcat can be used to derive exact age of the individual

(Crowe 1972). In a laboratory, the tooth is cross-sectioned and cementum annuli, or rings like those in trees, can be counted on the tooth to determine age. We were able to obtain 32 tooth samples from bobcats trapped by trappers prior to the prohibition of bobcat trapping in 2015 (Fish and Game Code §478). Trappers volunteered to provide us the lower jaw of bobcats they harvested. We used these data, described in the 2016 annual report, to determine age structure. Since we were unable to obtain teeth from trappers after 2016, we were only able to determine age class (Juvenile 0-12 months, subadult 12-24 months, and adult >24 months) from GPS-collared bobcats. Age-class can be determined from tooth replacement and wear (TRW; Heffelfinger 1997). It is relatively straight forward to determine juveniles and subadults from TRW. However, we were unable to accurately estimate specific ages of adults. A bobcat's teeth should become more warn and stained as they age. We discovered from the cementum annuli analyses that tooth wear and staining can vary significantly for adults regardless of age. We trapped a total of 34 adult bobcats (14 females and 20 males), eight subadults (3 females and 5 males), and 8 juveniles (3 females and 5 males) during three year GPS-collaring effort. Since we have decided to cease the bobcat GPS-collaring effort, age structure and sex ratio data will be limited to opportunistic collection of bobcat mortalities (e.g., road kill). We recommend collecting lower jaws of bobcats from sport hunters. Sport hunting is still legal and nine bobcats were harvested in Inyo County during the 2016/2017 hunting season. One bobcat was harvested by a hunter in Mono County in 2016/2017.

All trappers were required to report the sex of the bobcats that they harvested. During the 2015/2016 trapping season, California harvest records report a total of 263 bobcats harvested statewide, 131 males and 125 females for a statewide sex ratio of approximately 1:1 (Meshriy and Andersen 2016). The 2016/2017 California bobcat harvest report reveals a total of 265 bobcats were harvested, 120 males and 139 females with 6 reported as unknown for a statewide sex ratio 9:10 (males per females; Meshriy and Andersen 2017). We derived a sex ratio for Inyo County of 13:10 (males per females), or 43% females from the 32 bobcats trapped for fur in 2014/2015. Based on other harvested populations we expected a 1:1 ratio (Johnson et al. 1981). Our data is potentially biased against females, due to trapper's preference for males. Trappers reported releasing females in hopes to maintain a health population size in their area. The higher percentage of males could also be due to our small sample size and more samples would likely shift the sex ratio closer to 1:1. However, the estimate from harvested bobcats may be accurate because the sex ratio for the 53 bobcats captured over three years was 15:10, similar to the 32 harvested bobcats in 2014/2015. It is also important to note that male bobcats may have a higher likelihood of being caught because they have larger home ranges and are pursuing mates during this time of year. Having larger home ranges means they have a higher chance of encountering more traps.

*Capture Data*

Of the 53 bobcats captured between January 2015 and April 2018, there were 20 females and 33 males. This includes 6 kittens (4 males and 2 females), 43 adults and 4 yearlings/juveniles approximately 9 - 12 months. The average weight for all adult bobcats was 8.26 kg. Adult males had a higher average than females (Table 2, Figure 3). During each capture, we measured neck circumference and found males averaged 22.36 cm and females averaged 19.74 cm (Table 3, Figure 4). This is consistent with other bobcat populations (Lembeck 1978). Both weight and neck circumference are important, not only for comparing morphological data by region but also for GPS collaring. To date, two bobcats, BC047 and BC014, pulled off a GPS collar. It is unknown how the bobcat removed the collar, the collar fit followed collaring protocol. BC047 pulled off a Lotek collar approximately 5 weeks after deployment. Tracks where the collar was found suggest a fight may have occurred between the collared bobcat and another bobcat. During the altercation, the foam layer that encircles the collar band may have completely compressed and allowed the collar to slip off. BC014 was first collared in 2016 and was refitted with a Vectronics collar in 2017 which it pulled off 17 months after deployment in 2018. Radio collars should be no more than five percent of an individual's body weight and with smaller animals like bobcats, a goal of two to three percent of the body weight is ideal. In 2016, one juvenile was fitted with a radio collar that was approximately five percent of the animal's body weight. In 2017, four juveniles were captured and released because they didn't weigh enough to safely fit a GPS collar. In 2018, Lotek collars were purchased weighing about 150 g less than the other GPS collars (ATS and Vectronics models). Due to having a lighter collar, all bobcats captured in 2018 were safely fitted with a GPS collar within the targeted percent of the individual's body weight.

Each bobcat was examined for overall health including assessment of ectoparasite burden, dental condition, body condition and presence or absence of other signs of disease or injury. Body condition was classified as emaciated, thin, adequate or obese by assessing musculature, presence of subcutaneous fat over the ribs, and prominence of spinous processes and hips. Forty bobcats were classified as being in adequate body condition and four were categorized as thin. Eighteen bobcats had parasites, most having fleas. However, there were two cases of ear mites, BC027 and BC044, and two cases of worms, BC031 and BC053. Although, 35% of captured bobcats had some form of parasites, 78% of the bobcats with parasites only had one or two fleas. None of the captured cats were classified as having a high parasite load and no ticks were found on any of the bobcats. Therefore, overall parasite load was low. Lack of parasites is likely due to the time of year, since ectoparasites, especially ticks, tend to be less active in winter and more active in spring and summer. No other signs of disease were detected during processing; however, whole blood, serum, and swabs (rectal, soft pallet, orbital, and nasal) samples were also taken and lab results are pending.

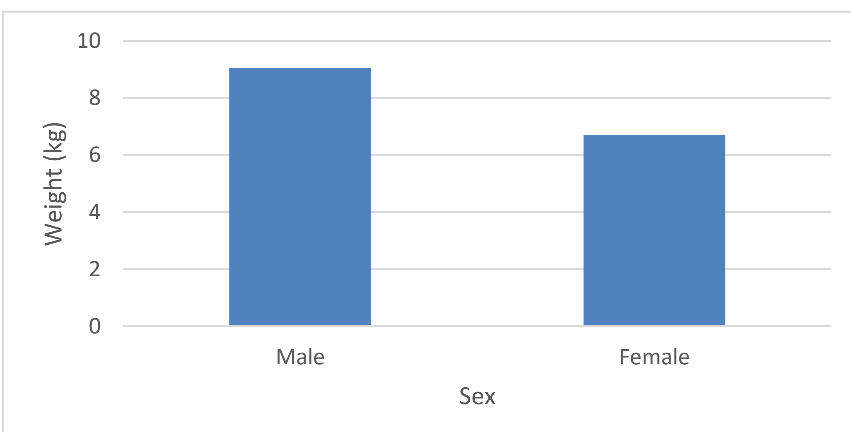


**Figure 3.** Average weight (kg), based on sex, of the 47 bobcats (kittens excluded) captured during the Eastern Sierra Nevada Bobcat Study from 2015 to 2018.

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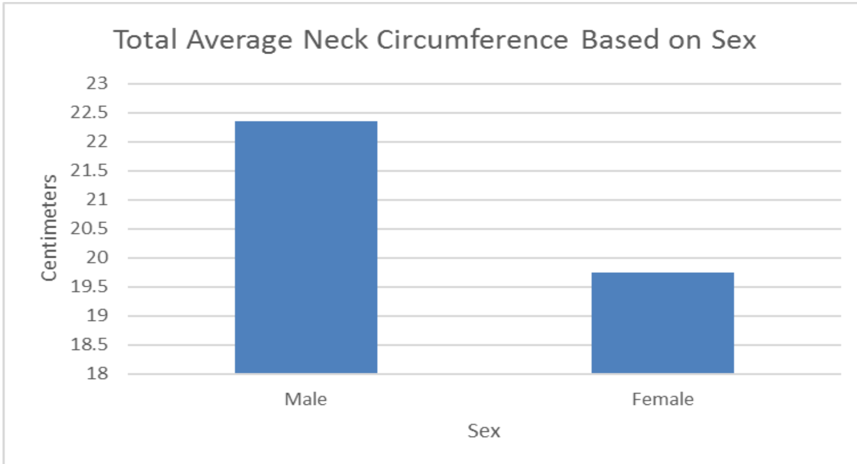


**Figure 4**: Average neck circumference (cm), based on sex, of the 47 bobcats (kittens excluded) captured during the Eastern Sierra Nevada Bobcat Study from 2015 to 2018.

| Sex | Average | Maximum | Minimum |
|---|---|---|---|
| Male | 9.06 | 11.20 | 5.20 |
| Female | 6.70 | 9.00 | 4.80 |

**Table 2.** Average, maximum and minimum weight (kg), based on sex, of the 47 bobcats (kittens excluded) captured during the Eastern Sierra Nevada Bobcat Study from 2015 to 2018.

| Sex | Average | Maximum | Minimum |
|---|---|---|---|
| Male | 22.36 | 29.00 | 19.00 |
| Female | 19.74 | 24.50 | 17.00 |

**Table 3.** Average, maximum and minimum neck circumference (cm)**,** based on sex, of the 47 bobcats (kittens excluded) captured during the Eastern Sierra Nevada Bobcat Study from 2015

*Mortality*

Mortality data was collected for both collared and un-collared bobcats when possible. From 2014 to 2018, we collected data from nine bobcat mortalities including seven collared bobcats, one kitten and one un-collared bobcat (Table 4). One bobcat kitten from the female known as BC001 died due to abandonment. A remote camera was placed outside of BC001's den site and remote camera photos recorded BC001 moving her two other kittens to a new den site, abandoning the third. BC001 was seen in remote camera photos in February 2016. None BC001's kittens have ever been captured with BC001 on camera traps. However, it appears BC001 was pregnant again based on photos taken from a remote camera in April 2016.

A total of 6 of the bobcat mortalities appear to be the result of vehicle collisions and occurred on or close to U.S. Highway 395 (Table 4). Vehicle related trauma was visible on each bobcat that was assumed hit by vehicles (Figure 5). Five of the bobcat carcasses were sent to CDFW Investigations Lab, three were male (two adults and one yearling) and two were female (both adults). Five were collared and one was un-collared. One bobcat, BC015, was legally harvested and retained by the hunter, and another bobcat, BC026, was found on a private residence for which the cause of death remains unknown.

| Date | Previously Captured | Sex | Age Estimate | Cause of Death | Location |
|---|---|---|---|---|---|
| 5/7/2015 | Yes; BC001 kitten | Unknown - | Juvenile (Kitten) | Abandon | Horton Creek den site |
| 5/11/2015 | No | Male | Adult 2 | Road Kill | 395 South of Big Pine |
| 10/12/2015 | Yes; BC003 | Male | Adult 2 | Road Kill | Round Valley Rd |
| 2/18/2016 | Yes; BC007 | Male | Juvenile | Road Kill | 395 South of Gorge Rd |
| 2/20/2017 | Yes, BC018 | Female | Adult 2 | Road Kill | 395 by Division Creek |
| 1/6/2018 | Yes, BC015 | Male | Adult 2 | Harvest | Lone Pine, exact location retained by hunter |
| 7/18/2017 | Yes, BC026 | Female | Adult 2 | Unknown | Oak Creek, East of 395 |
| 2/7/2018 | Yes, BC039 | Female | Adult 1 | Roadkill | US HWY 395, Mile marker 124 |

**Table 4.** Data for known bobcat mortalities, including: date collected, cat ID if known, sex, age class estimate (Juvenile, Adult 1, or Adult 2), cause of death (harvest, road kill, public safety, or other) and general location

**Figure 5.** Road mortality was the highest cause of mortality of bobcats studied during the Eastern Sierra Nevada Bobcat Study. This photo depicts a female bobcat hit on U.S. Highway 395 approximately 5 miles north of Bishop, CA in 2017.

## V. Spatial and Resource Use

One of the chapters the Utah State graduate student will be writing for his thesis will include spatial analyses of the bobcat collar data. He will evaluate home range size of bobcats relative to sex. In addition, he will analyze habitat use patterns. We anticipate these data will be summarized in 2019.

## VI. Reproductive Biology

Bobcats are primarily solitary predators with a polygamous mating system. Social interactions are suggested to be predominantly influenced by reproduction and survival  (Neilson and Woolf 2001, Ferguson et al. 2009). It is suggested that females are more influenced by prey abundance and resource accessibility whereas males are influenced primarily by access to females (Lynch et al. 2008, Ferguson et al. 2009, Donovan et al. 2011). From observations of the collar data obtained to date, all females are overlapped by at least one collared male, except BC053 who is sole bobcat collared in Fish Slough area. However, we did detect sign and obtained photos of an un-collared bobcat in the Fish Slough area. We investigated two more den sites in 2017. We were not able to find kittens at one of the sites. Yet, we did find a bed and predict the female moved her kitten(s) before we found them. We identified three healthy kittens at the second den site (Figure 6). One of the den sites found in 2017 was located in extremely think riparian vegetation in an irrigated pasture. The second den site found in 2017 was located near a creek but in a large pile of dead woody debris.

**Figure 6.** Three male bobcat kittens found at BC026's den site in the spring of 2017.

## VII. Prey Base

Monitoring prey species is critical for determining what may be driving population demographics of bobcats or other mesocarnivores. Our objective within the timeframe of this report was to develop techniques for surveying small mammals and lagomorph species. We are still in the process of determining the best methods to monitor prey species.

**Figure 7.** A bobcat carrying its prey, California ground squirrel (*Otospermophilus beecheyi*). The photo was taken with a remote camera during a bobcat survey.

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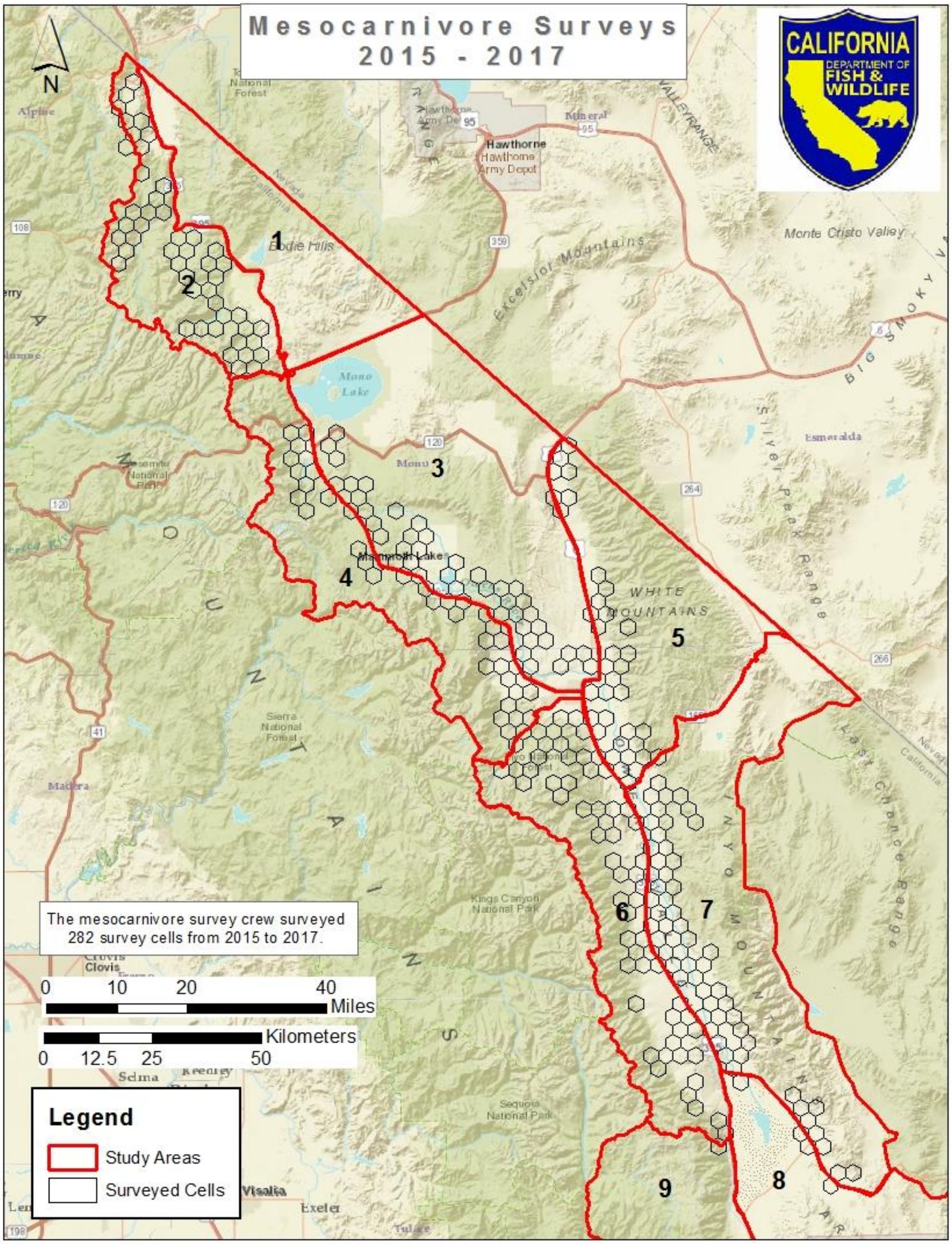
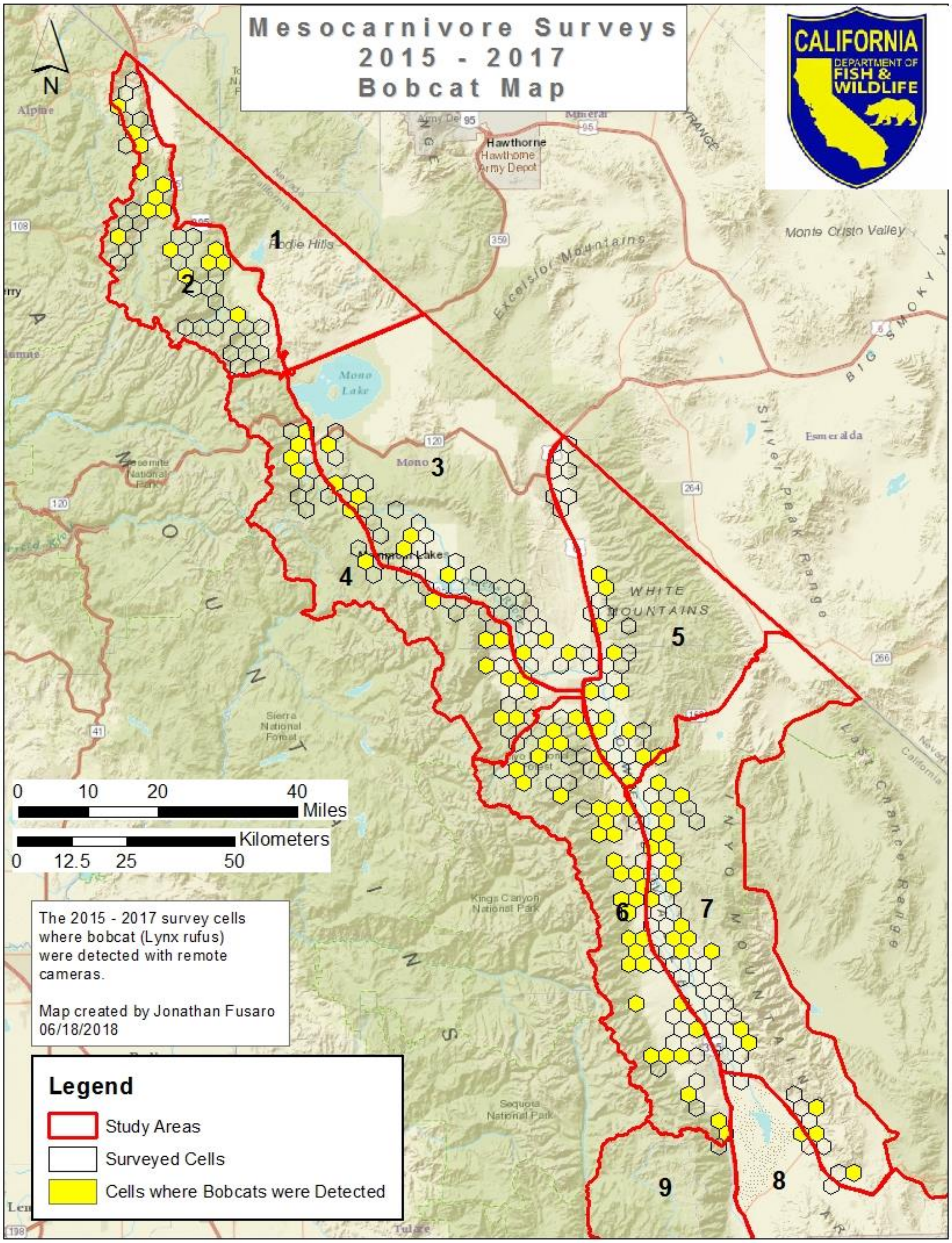
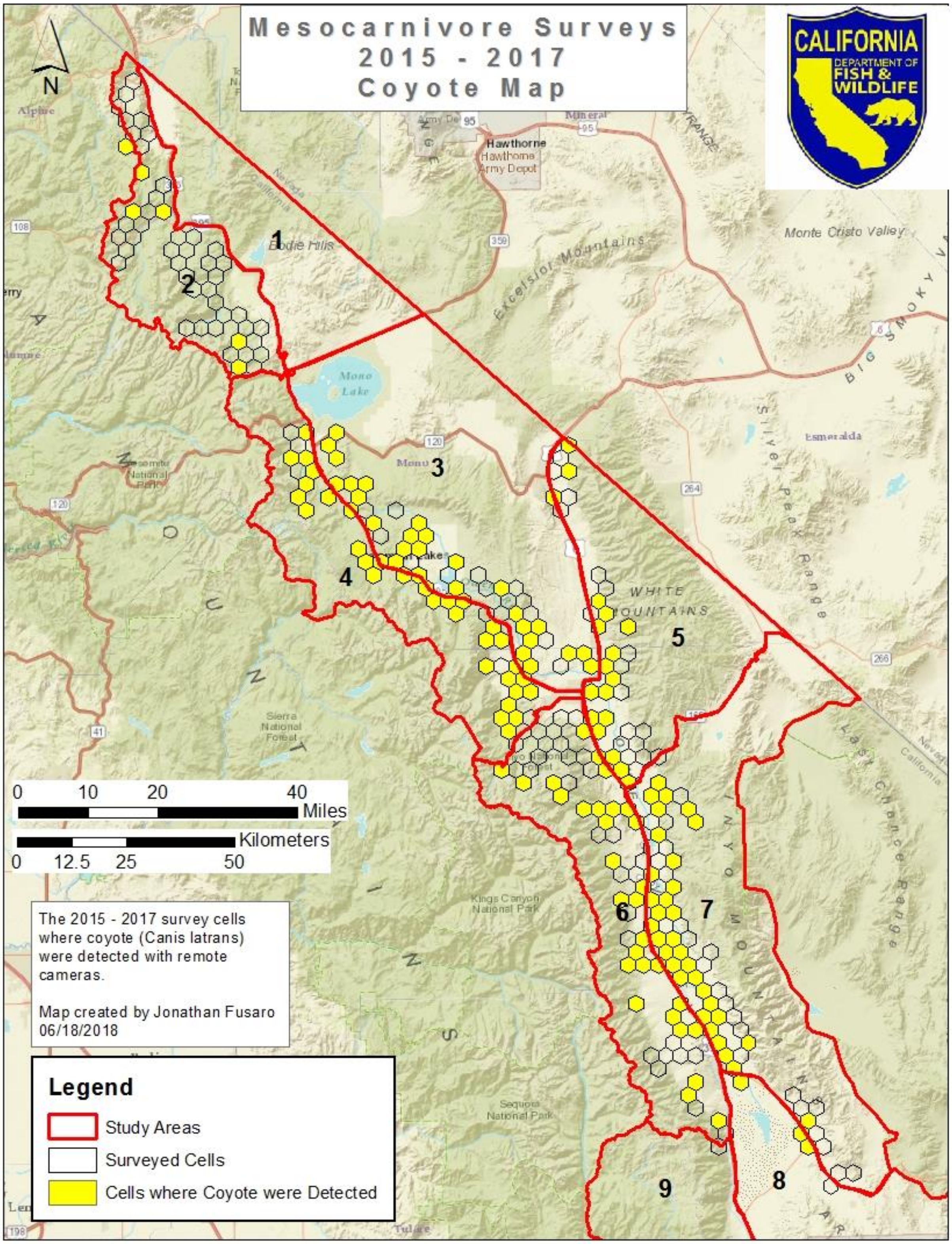
**Appendix**

*A. Survey areas*


Mesocarnivore Surveys
2015 - 2017
CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE
The mesocarnivore survey crew surveyed
282 survey cells from 2015 to 2017.
0 10 20 40
Miles
Kilometers
0 12.5 25 50
Legend
Study Areas
Surveyed Cells
1
2
3
4
5
6
7
8
9
Mono Lake
Hawthorne
Bodie Hills
Excelsior Mountains
Monte Cristo Valley
White Mountains
Mammoth Lake
Sierra National Forest
Kings Canyon National Park
Sequoia National Park
Esmeralda
Clovis
Selma
Visalia
Exeter
Madera

*B. Occupancy Maps*




Mesocarnivore Surveys
2015 - 2017
Coyote Map
CALIFORNIA
DEPARTMENT OF
FISH & WILDLIFE
N
1
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3
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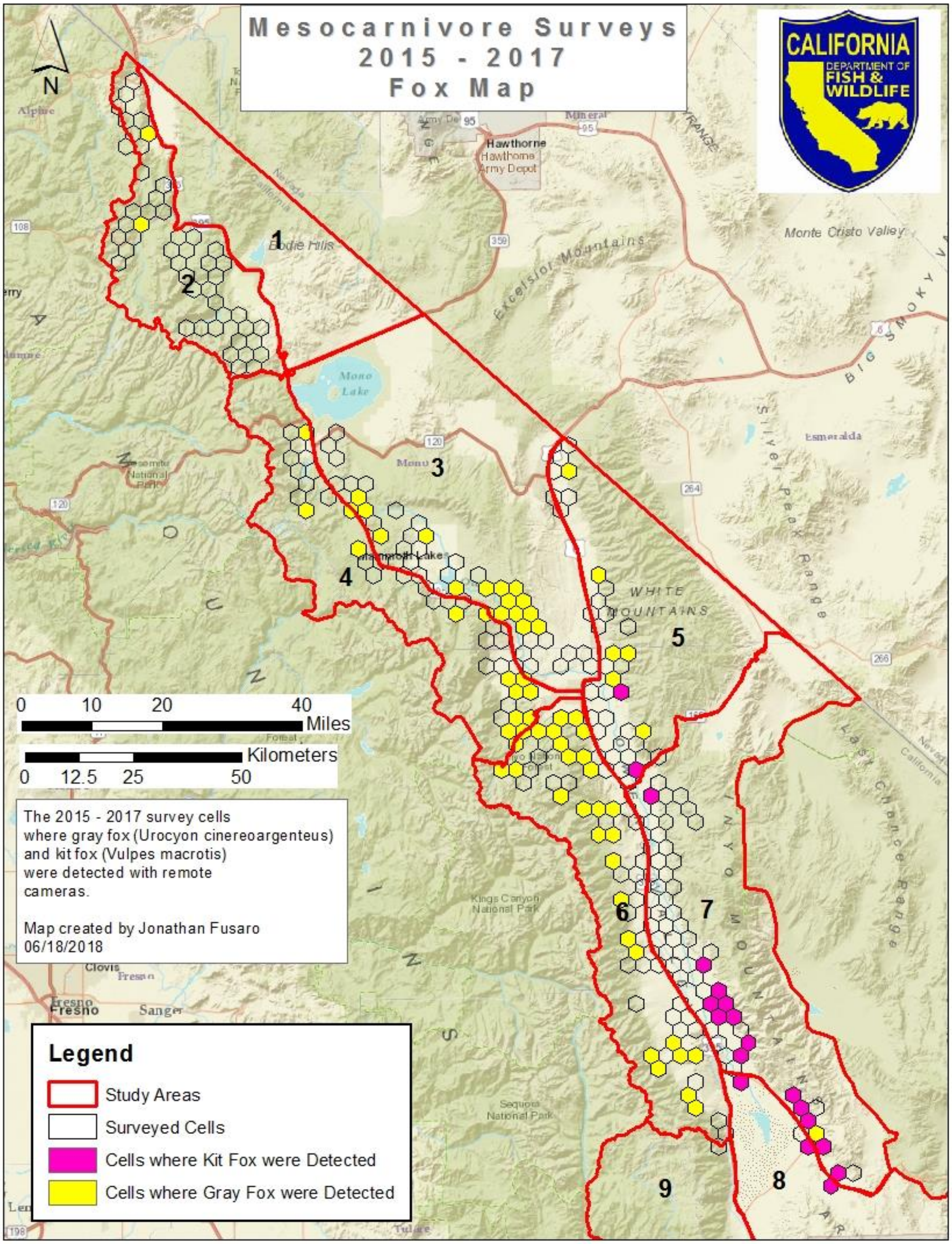
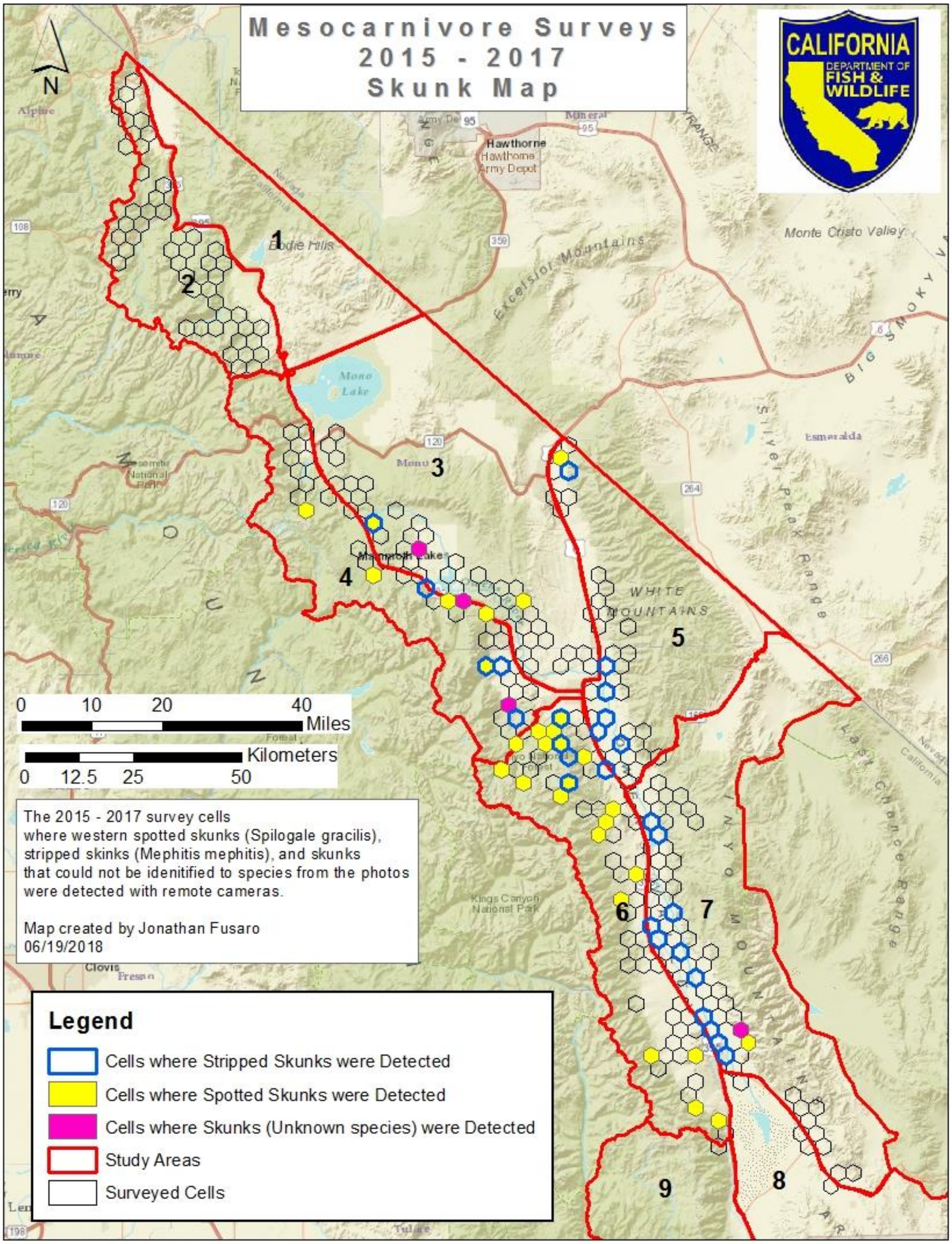
5
6
7
8
9
Bodie Hills
Mono Lake
Hawthorne
Hawthorne Army Depot
Excelsior Mountains
Monte Cristo Valley
Esmeralda
WHITE MOUNTAINS
Sierra National Forest
Kings Canyon National Park
Sequoia National Park
0 10 20 40 Miles
0 12.5 25 50 Kilometers
The 2015 - 2017 survey cells where coyote (Canis latrans) were detected with remote cameras.
Map created by Jonathan Fusaro 06/18/2018
Legend
Study Areas
Surveyed Cells
Cells where Coyote were Detected



Mesocarnivore Surveys
2015 - 2017
Fox Map
CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE
N
0 10 20 40
Miles
Kilometers
0 12.5 25 50
The 2015 - 2017 survey cells
where gray fox (Urocyon cinereoargenteus)
and kit fox (Vulpes macrotis)
were detected with remote
cameras.
Map created by Jonathan Fusaro
06/18/2018
Legend
Study Areas
Surveyed Cells
Cells where Kit Fox were Detected
Cells where Gray Fox were Detected
1
2
3
4
5
6
7
8
9
Hawthorne
Bodie Hills
Excelsior Mountains
Monte Cristo Valley
Mono Lake
WHITE MOUNTAINS
Esmeralda
Kings Canyon National Park
Sequoia National Park
Fresno
Clovis
Sanger


Mesocarnivore Surveys
2015 - 2017
Skunk Map
CALIFORNIA
DEPARTMENT OF
FISH & WILDLIFE
N
1
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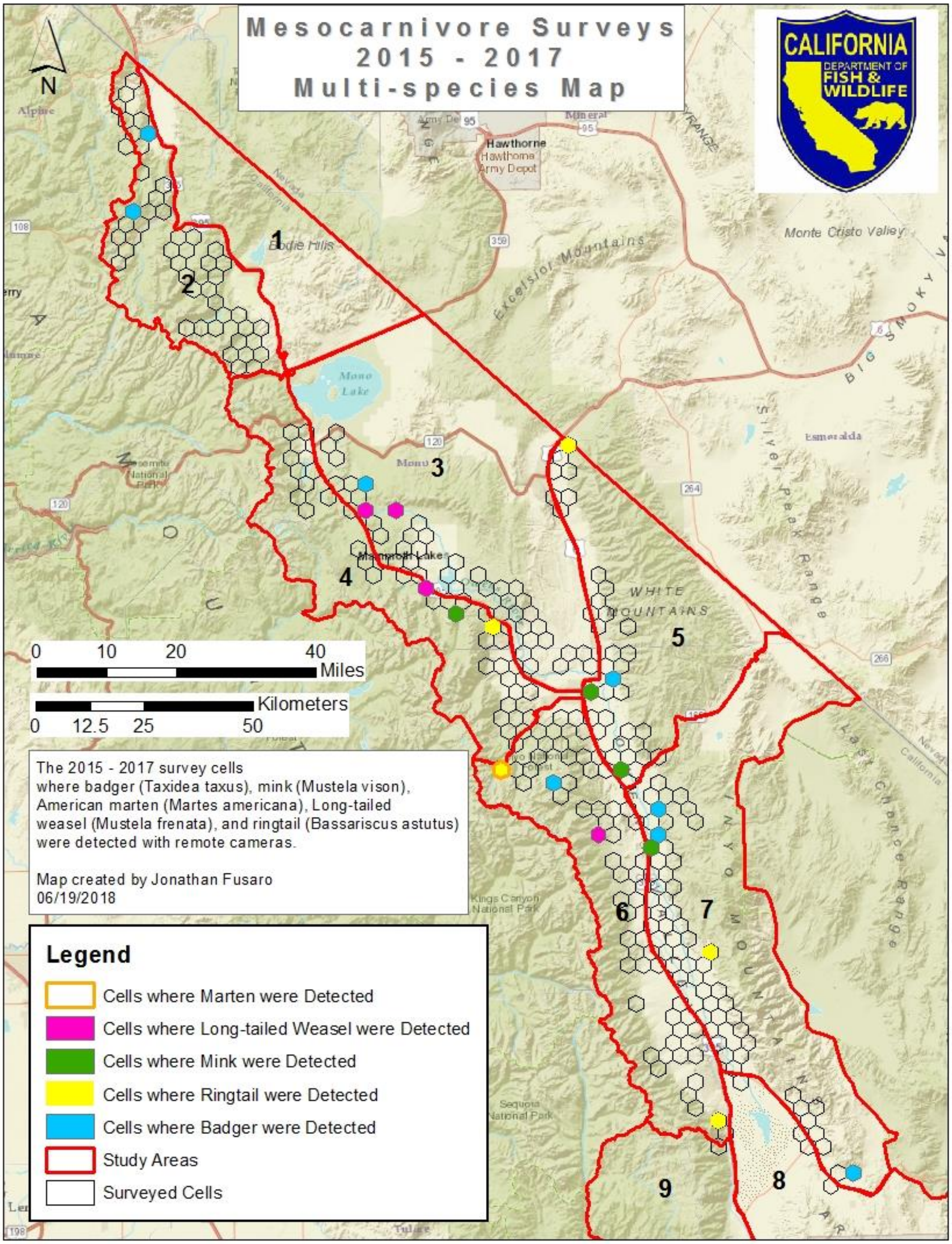
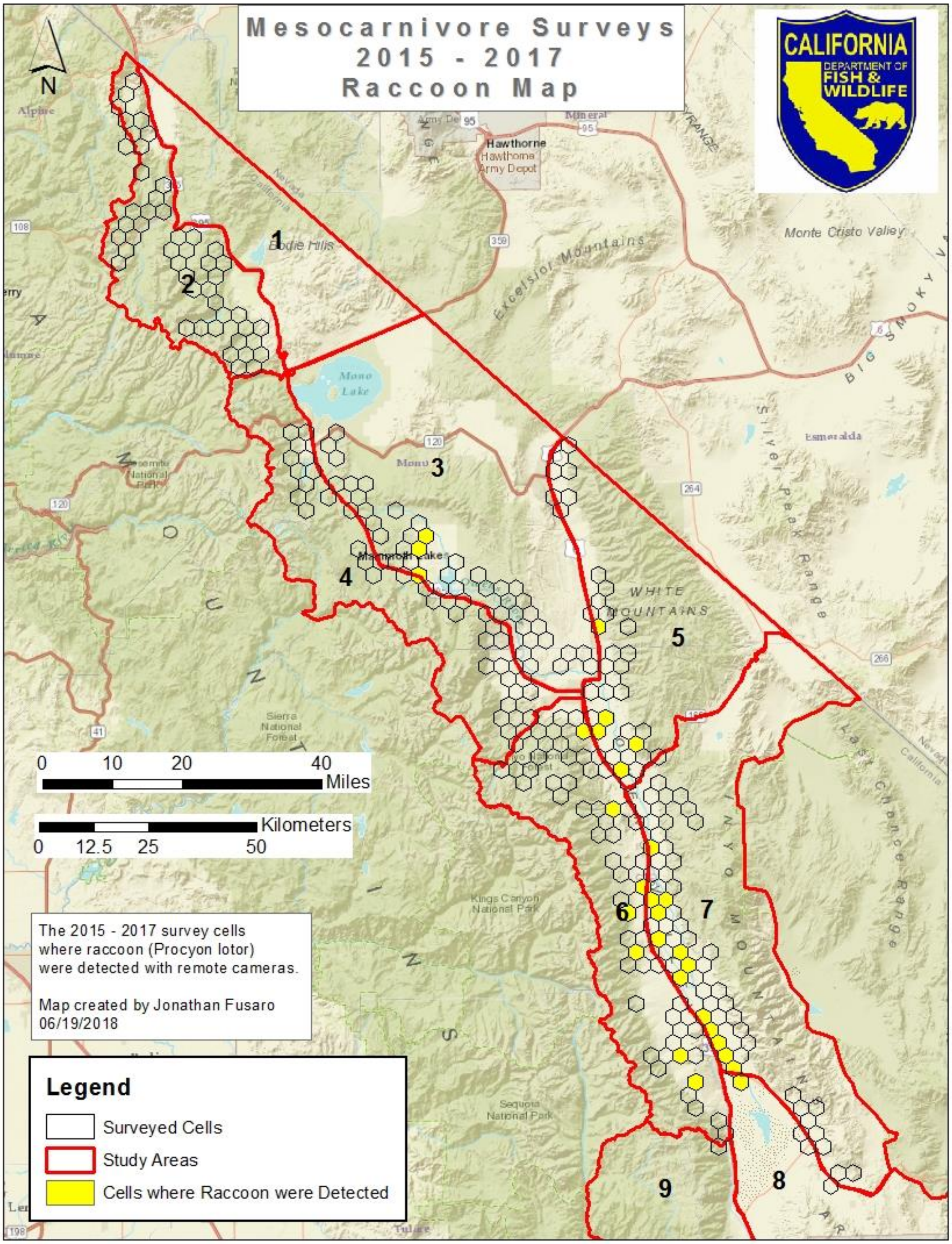
6
7
8
9
Bodie Hills
Mono Lake
Hawthorne
Excelsior Mountains
Monte Cristo Valley
Esmeralda
WHITE MOUNTAINS
INYO MOUNTAINS
Mammoth Lakes
Kings Canyon National Park
0 10 20 40 Miles
0 12.5 25 50 Kilometers
The 2015 - 2017 survey cells
where western spotted skunks (Spilogale gracilis),
stripped skinks (Mephitis mephitis), and skunks
that could not be idenitified to species from the photos
were detected with remote cameras.
Map created by Jonathan Fusaro
06/19/2018
Legend
Cells where Stripped Skunks were Detected
Cells where Spotted Skunks were Detected
Cells where Skunks (Unknown species) were Detected
Study Areas
Surveyed Cells

*C. Distribution Maps*




Mesocarnivore Surveys
2015 - 2017
Raccoon Map
CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE
N
Hawthorne
Hawthorne Army Depot
Monte Cristo Valley
Bodie Hills
Excelsior Mountains
Mono Lake
Mammoth Lake
WHITE MOUNTAINS
INYO MOUNTAINS
Silver Peak Range
Last Chance Range
Sierra National Forest
Kings Canyon National Park
Sequoia National Park
1
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6
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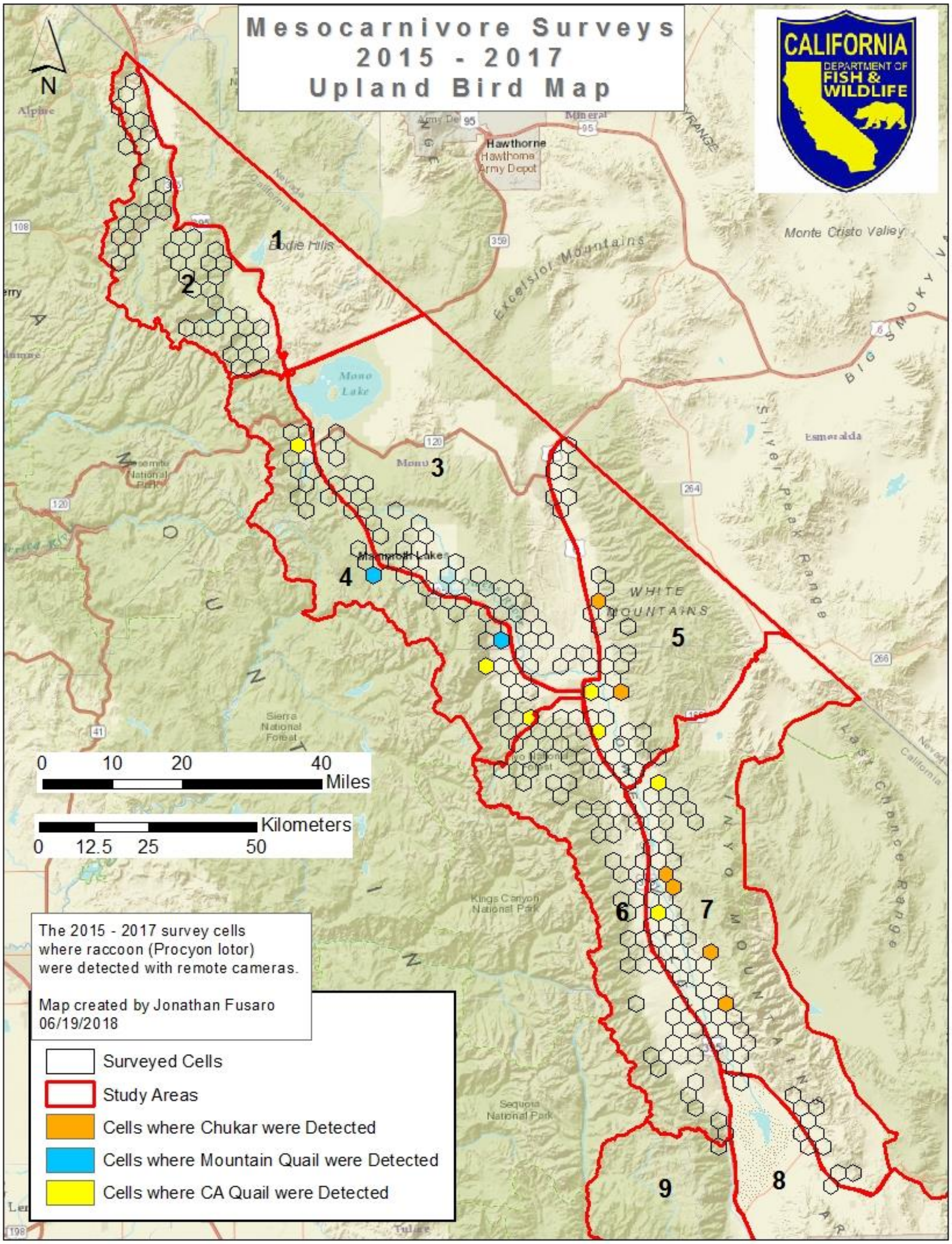
8
9
0 10 20 40 Miles
Kilometers 0 12.5 25 50
The 2015 - 2017 survey cells
where raccoon (Procyon lotor)
were detected with remote cameras.
Map created by Jonathan Fusaro
06/19/2018
Legend
Surveyed Cells
Study Areas
Cells where Raccoon were Detected



Mesocarnivore Surveys
2015 - 2017
Upland Bird Map
CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE
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8
9
Bodie Hills
Mono Lake
Hawthorne
Hawthorne Army Depot
Excelsior Mountains
Monte Cristo Valley
Esmeralda
Mammoth Lakes
WHITE MOUNTAINS
INYO MOUNTAINS
Sierra National Forest
Kings Canyon National Park
Sequoia National Park
0 10 20 40 Miles
Kilometers 0 12.5 25 50
The 2015 - 2017 survey cells where raccoon (Procyon lotor) were detected with remote cameras.
Map created by Jonathan Fusaro 06/19/2018
Surveyed Cells
Study Areas
Cells where Chukar were Detected
Cells where Mountain Quail were Detected
Cells where CA Quail were Detected

*D. Occupancy Models*

**A**

**Study Areas 3 and 4**

| Species | Sessions | Detection Rate (p) | SE of p | 95% confidence interval of p Lower | Upper | Occupancy (psi) | SE of psi | 95% confidence interval of psi Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|
| **Bobcat** | 1 | 0.3757 | 0.0811 | 0.2146 | 0.5699 | 0.3729 | 0.0741 | 0.2421 | 0.5254 |
| | 2 | 0.4345 | 0.0871 | 0.2588 | 0.6282 | | | | |
| | 3 | 0.4149 | 0.0854 | 0.2590 | 0.5898 | | | | |
| **Coyote** | 1 | 0.4079 | 0.0622 | 0.2778 | 0.5523 | 0.8051 | 0.0573 | 0.6686 | 0.8942 |
| | 2 | 0.6391 | 0.0649 | 0.4969 | 0.7604 | | | | |
| | 3 | 0.6246 | 0.0650 | 0.4856 | 0.7457 | | | | |
| **Gray Fox** | 1 | 0.3412 | 0.0878 | 0.1940 | 0.5270 | 0.3980 | 0.0630 | 0.2831 | 0.5254 |
| | 2 | 0.4032 | 0.0922 | 0.2417 | 0.5888 | | | | |
| | 3 | 0.7444 | 0.0972 | 0.5169 | 0.8880 | | | | |

**B**

**Study Areas 5 and 7**

| Species | Sessions | Model | AICc | Δ AICc | AICc Weight | Model Likelihood | No. Par. | Deviance |
|---|---|---|---|---|---|---|---|---|
| Bobcat | 3 | {p(.) Psi(.)} | 253.6458 | 0.0000 | 0.6817 | 1.0000 | 2.0000 | 2.4656 |
| | | {p(t) Psi(.)} | 255.1690 | 1.5232 | 0.3183 | 0.4669 | 4.0000 | -0.3287 |
| Coyote | 3 | {p(t) Psi(.)} | 322.8999 | 0.0000 | 0.8173 | 1.0000 | 4.0000 | 1.4806 |
| | | {p(.) Psi(.)} | 335.8965 | 2.9966 | 0.1827 | 0.2235 | 2.0000 | 8.7947 |
| Kit Fox | 3 | {p(.) Psi(.)} | 171.4271 | 0.0000 | 0.8271 | 1.0000 | 2.0000 | -5.5169 |
| | | {p(t) Psi(.)} | 174.5572 | 3.3101 | 0.1729 | 0.2091 | 4.0000 | -6.7044 |
| Raccoon | 3 | {p(.) Psi(.)} | 168.4400 | 0.0000 | 0.8738 | 1.0000 | 2.0000 | -5.8699 |
| | | {p(t) Psi(.)} | 172.3090 | 3.8690 | 0.1263 | 0.1445 | 4.0000 | -6.3185 |
| Skunk spp. | 3 | {p(t) Psi(.)} | 147.8024 | 0.0000 | 0.9999 | 1.0000 | 4.0000 | -6.1642 |
| | | {p(.) Psi(.)} | 170.2014 | 22.3990 | 0.0001 | 0.0000 | 2.0000 | 20.5524 |

Occupancy models run for mesocarnivores. Data was obtained during remote camera surveys conducted in the winter and fall of 2017. Sessions refers to the number of visits (i.e., resamples). Detection rate is p and psi is the occupancy level. Dot models (.) are null models and time varying models are represented by (t).