California Department of Fish & Wildlife

Inland Deserts Region

Eastern Sierra Nevada Bobcat Study

Annual Report

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February 2016 Eastern Sierra Nevada Bobcat Study Annual Report

Inland Desert Region

This report summarizes work conducted by the eastern Sierra bobcat study crew, during fall 2014 – February 2016. Work on this project was grouped into the following categories:

Summary

The Inland Desert Region Wildlife Program (IDRWP) 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, 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.

A study plan titled "Eastern Sierra Nevada Bobcat Study" initiated a population survey and GPS collar study in the fall of 2014 to learn more about Eastern Sierra bobcat (*Lynx rufus*) densities and population characteristics. This year is the second year of the study which was designed to better monitor and manage low elevation (≤9,000 ft) bobcat populations in Inyo and Mono Counties. The main objective of this study was initially to standardize survey techniques for bobcats that would allow the Department to monitor abundance of bobcats. This study was initiated in response to the proposed statewide ban on bobcat trapping in spring of 2014.

Capture-mark-recapture (CMR) surveys using two techniques, rub stations and remote cameras, were conducted in the fall of 2014 and spring of 2015 to acquire pre-harvest and post-harvest population data. The IDRWP was interested in testing both methods in order to determine if one or both would be necessary to conduct future bobcat CMR surveys in the northern portion of Region 6, Inland Desert Region. CMR survey data produce abundance estimates via statistical models that take into account the frequency of detection of unique individuals during the survey period. Rub stations are used to collect hair samples of bobcats which then provide DNA contained in the tissue (i.e., follicle) of the hair samples in order to identify unique individual animals. Remote Cameras can also be used to identify individual bobcats. This can be done by using photo recognition software combined with visual confirmation looking at spot patterns unique to each animal.

After the fall 2014 and spring 2015 surveys were completed, it was determined that the CMR surveys could be done in conjunction with an occupancy survey in order to detect occupancy of other low elevation mesocarnivores in addition to bobcats. Occupancy survey data produces estimates of the percent of the study area that species of interest occur. In the fall of 2015, a CMR and occupancy survey was conducted that resulted in the detection of multiple carnivore species including bobcats. IDRWP has developed confidence in these survey techniques as a management tool and proposes to continue these occupancy and CMR surveys for low elevation mesocarnivores. They can be used to provide occupancy and abundance estimates which will in turn help manage and conserve these species in the Eastern Sierra.

At this time, the IDRWP recommends using remote cameras (Reconyx PC900 Hyperfire Professional) and occupancy modeling to monitor low elevation mesocarnivores populations in the Eastern Sierra. When dealing with hunted and/or trapped mesocarnivore species, surveys that are designed to obtain abundance estimates such as CMR surveys should be conducted to monitor population size and the effects of harvest if there is evidence to suggest that take may be affecting the population. The CMR results from the surveys for bobcats are pending. However, simulation results reveal detection rates (i.e., capture rates) must be higher than 0.25 to detect more than a major decline in the population size. Occupancy data was collected October to November 2015 for bobcat, coyote (*Canis latrans*), and gray fox (*Urcyon cinereoargenteus*). Based on the highest ranking models, the percent of the fall 2015 study area occupied

by bobcats, gray fox, and coyote was 78%, 50%, and 59%, respectively. Simulation models suggest occupancy surveys should be completed with no fewer than 100 survey stations and three visits. Furthermore, the initial occupancy survey during October and November had a low re-visitation rate which in turn resulted in low detection rates. IDRWP recommends conducting future occupancy surveys between December and January and revisiting surveys stations every 20 days to increase the detection rate. The detection rate achieved for bobcats, as an example, using the current survey design was 0.25. The detection rates must improve in order to have high enough statistical power (>0.80) to detect changes in occupancy of $\geq$40%. With the current sampling design, we can only detect a major crash ($\geq$40%) in a population.

In order to collect regionally specific home range and life history data for Eastern Sierra bobcats, IDRWP fitted 11 bobcats with GPS radio collars (four females and seven males) from January 2015 to January 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 9.3 kg (SD 3.8) and 7.9 kg (SD 4.1), respectively. The GPS collar weight was between 3-5% of each bobcat's weight, as described in the bobcat capture plan. Remote camera photos taken 12 months after the bobcats were fitted with radio collars, revealed body condition of the bobcats remained stable. The ATS (G2110L) iridium system failed and the VHF antenna was damaged on two of the three collars that were out longer than five months. In addition, the Iridium system also failed on two collars deployed for only two months. This has caused significant difficulty in monitoring these animals. We plan to purchase alternative models from other vendors of GPS collars in the future to see if performance and reliability are improved. IDRWP plans to GPS collar an additional 30 bobcats during the 2016/2017 field season.

None of the captured bobcats showed signs of disease, nor were there high parasite loads. Indications of infection or exposure to disease will be further investigated by testing (e.g., blood) biological samples that were collected during captures and by performing gross necropsies on collected carcasses. Body condition was adequate for all captured bobcats except one cat that was thin but not emaciated. Inyo County trappers voluntarily provided 32 bobcat jaws (18 males and 14 females) which were subsequently submitted to the Matson's Laboratory LLC in Missoula, Montana. Age was determined from cementum annuli analyses. The age distribution was bimodal via a high number of young (three year olds) and older aged animals (nine year olds).

A female bobcat (BC001) that was collared in January 2015 had three kittens in Horton Creek in April 2015. There were two known males documented within the vicinity of BC001, one of which was a GPS collared male, BC002. Each kitten was briefly examined, pit tagged, measured and photographed while the female was away. Den site characteristics were also documented. BC001 moved two of the three kittens to a new den site. The abandoned kitten died. The exact reason BC001 abandoned the third kitten is unknown.

Analyses of spatial data are pending. Data analyses will include home range estimates, temporal travel patterns, and intraspecies movement patterns. IDRWP plans 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) and small mammal (i.e., rodents) are the primary prey for bobcats and other mesocarnivores. Survey techniques were tested to better monitor these prey species. Very few lagomorphs were detected using road transects and a combination of road and walking transects. This may be a reflection of the study design or the actual lagomorph population levels being low due to the long standing drought. Field observations and remote camera data suggest there are more lagomorphs on the landscape than surveys were detecting. IDRWP plans to test additional lagomorph survey techniques including pellet counts. Small mammal trapping surveys were successful in determining species occurrence. The surveys in Round Valley detected *Peromyscus boylii* (Brush Mouse) and *Neotoma macrotis* (Big Eared Woodrat), which extended the known northern range of these species. Pending funding and crew availability, small mammal surveys will be continued in order to determine species occurrence and conduct mark-recapture of small mammals to monitor population size of certain species.

I. Bobcat capture-mark-recapture surveys

Camera traps have proven to be the best method so far to survey bobcats in a CMR framework. Final analyses of before-after harvest surveys in study area four and a single season survey of study area six are pending. See Appendix A for maps of survey areas.

Survey methods

IDRWP tested camera traps versus rub stations for surveying bobcats. Testing occurred during the before bobcat harvest survey (mid-October to mid-November 2014) and after bobcat harvest survey (mid-April to mid-May 2015) in Round Valley, approximately 15 miles north of Bishop, CA. After analyzing the results from those surveys, IDRWP concluded that camera trapping is the best method for surveying bobcats based on the pros and cons listed below:

- Rub station
  - Pros – sex and individual identification obtained from DNA and $6 per survey station per survey
  - Cons - ~$60 for analysis of each DNA sample, contract required to do DNA analysis, mixed samples on one survey station from multiple species and/or individual bobcats are useless and camera evidence shows this occurring, making survey devices is labor intensive, slow turnaround of lab results, and DNA degradation (loss of data) is possible
- Camera traps
  - Pros – individual identification, detection of multiple species, and data is available immediately for analyses, survey device is reusable at minimal cost of batteries
  - Cons – poor identification of sex and ~$700 per survey device

Sex ratios are useful for ascertaining the demographic health and cause of population trends. Occupancy surveys with remote cameras will be our primary survey method, which does not allow for accurate identification of sex. In the event that we need to monitor the health or determine the cause of population trends, we will investigate the use of DNA-based survey methods (e.g., rub stations, scat collection) to acquire sex of bobcats. Currently, there are no plans to set up a genetics contract. However, California

Fish and Wildlife is developing plans for an internal population genetics laboratory for wildlife projects. All genetic samples (hair samples) collected to date will be stored in a temperature controlled environment in desiccant. The DNA will be viable for the next two years if future analysis is needed. We will establish a genetics contract in the future if we need to determine sex ratios. In addition, trapping data can be used as an index for changes in sex ratios over time.

Harvest survey

Final analyses are pending for the photo comparison of the Round Valley bobcat population pre and post trapping. Unique individuals must be identified from each photograph. Individuals can be determined from their spot patterns on their ears, hind legs and forelegs. IDRWP will implement methods described in Heilbrun et al. (2003) and Larrucea et al. (2007) to determine unique individuals. This method will require six to eight biologists to independently identify unique individual bobcats from the photographs. All of the biologists will be blind to each other's results. Comparisons will then be made between the observer's results to make a final call on which photographs represent which individuals. We will be storing all the photos in a Microsoft Access database called CPW Photo Warehouse. The database was created by Ivan and Newkirk (2015). This database allows multiple users to manually identify unique individual animals in the photos and assign identification numbers. Discrepancies between users can be summarized and resolved. The database can also be used to create input files that are ready for analyses in statistical programs.

Largescale CMR Surveys

Inyo and Mono Counties have been divided up into eight survey areas (see map in Appendix A) for CMR and occupancy surveys based upon geographical boundaries and access. IDRWP is proposing to survey one to two of these survey areas each year depending upon access, staffing and funding. Area six was surveyed in the fall of 2015. Sixty cells, with each cell representing 10.4 km^2 in area, were randomly chosen to survey in area six for mesocarnivores. This survey methodology is being used throughout the state of California for other mesocarnivore surveys such as the Sierra Nevada red fox and was designed for CMR and occupancy analyses. The CMR analyses for bobcats require determination of individual spot patterns and other body characteristics. The protocol described in the Harvest Survey section will be used to determine unique individuals.

Simulation models were constructed in Program MARK to determine the target levels of capture rate (p) and recapture rates (c) required to obtain the statistical power needed to detect changes in population size (N, Fig. 1). The target statistical power should be $\geq$ 80%. The higher the power, the lower the probability of making a Type II error, or concluding there is no effect when, in fact, there is one. Due to low sample sizes, an alpha level of 0.10 (Mary Conner, Utah State University, personal communication) should be allowed. An alpha level of 0.10 represents a confidence level of 90%. The lower the alpha level, the lower the probability of making a Type I error, or concluding there is an effect when, in fact, there is not one. A Type I error is less concerning because a population will not suffer from a false detection of a decline. It is more critical that declines in the population are not missed (i.e., Type II error).

Simulation models were run by assuming the bobcat population in study area six is either 60 (Fig. 1A) or 35 (Fig. 1B). These population estimates were based on anecdotal evidence from the remote camera photos and spatial data from collared bobcats in study area six. It was predicted the population size in study area six is closer to 60 individuals. The larger the population, the greater the statistical power to detect a lower percent change in the population size with capture rate of 0.25. Increasing recapture rate marginally increases statistical power. However, increasing capture rate to 0.50 and having recapture rate of 0.25 allows the detection of a 10% change in the population size with 0.96 statistical power. A primary objective for future surveys will be to increase the overall capture rate. This may be accomplished by some combination of adding an additional camera per survey cell, shifting surveys from fall to winter when prey availability is lower and mesocarnivores are more attracted to bait, and moving camera stations within cells between survey sessions.

II. Mesocarnivore Occupancy Survey

An occupancy survey was completed in conjunction with the CMR survey in study area six. The occupancy survey had 60 survey sites and six sessions that ran for six weeks, one week per session. Models with six and three sampling sessions were run for bobcat, gray fox, and coyote. Models were run with three sampling sessions because of low detection rates. To run these models, sessions one and two, three and four, and five and six were pooled. The null model and a time varying model were run for each species. Heterogeneity models were not run due to low sample sizes. Model-averaging was used when models were within at least 2 ΔAIC_c units from the top model (Table 1). Detection rates (p) for bobcats were the lowest (Table 2). However, the percent of the study area occupied (psi) by bobcats was higher than gray fox and coyote (Table 2). Detection rates increased over time for gray fox (three sessions) and coyotes (both three and six sessions; Table 1), which results in a bias high detection rate. The reason for this may be that gray fox and coyotes were interested in returning to the lure whereas bobcats we less inclined to revisit lures. The number of detections was too low to derive p for other species (e.g., ringtail, spotted skunk, and mountain lion). The low detection rates are likely a result of the study design being tailored for bobcats. The remote cameras detected a total of fifty two species, a list of which is included in Appendix C.

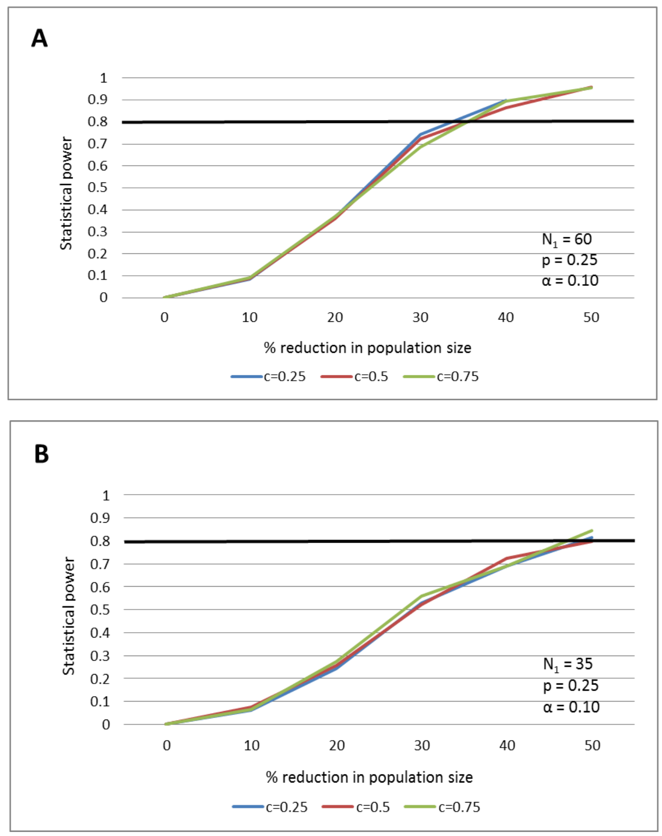


Figure 1. Capture-mark-recapture simulation results. Graph A displays results for an estimated population size of 60 and 35 was used for graph B. Site visits = 6, population size = N_1, capture rate = p, recapture rate = c, significance level = alpha (α) at 90%. Target statistical power is ≥ 80%.

Species	Sessions	Model	AICc	Δ AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
Bobcat	6	{p(.) Psi(.)}	346.7221	0.0000	0.9826	1.0000	2.0000	50.1951
		{p(t) Psi(.)}	354.7843	8.0622	0.0175	0.0178	7.0000	46.3141
	3	{p(.) Psi(.)}	229.4880	0.0000	0.6373	1.0000	2.0000	7.5634
		{p(t) Psi(.)}	230.6149	1.1269	0.3628	0.5692	4.0000	4.1735
Gray Fox	6	{p(.) Psi(.)}	327.5035	0.0000	0.9042	1.0000	2.0000	57.0937
		{p(t) Psi(.)}	331.9921	4.4886	0.0958	0.1060	7.0000	49.6390
	3	{p(t) Psi(.)}	189.2417	0.0000	0.6101	1.0000	4.0000	17.5469
		{p(.) Psi(.)}	190.1374	0.8957	0.3899	0.6390	2.0000	22.9593
Coyote	6	{p(t) Psi(.)}	293.2446	0.0000	0.7971	1.0000	7.0000	22.4339
		{p(.) Psi(.)}	295.9819	2.7361	0.2029	0.2546	2.0000	37.1134
	3	{p(t) Psi(.)}	195.8687	0.0000	0.7928	1.0000	4.0000	0.9207
		{p(.) Psi(.)}	198.5519	2.6832	0.2073	0.2614	2.0000	8.1206

Table 1. Occupancy models run for mesocarnivores. Data obtained during fall 2015 survey in study area six. Sessions refers to the number of visits (i.e., resamples). p is the detection rate and psi is the occupancy level. Dot models (.) are null models and time varying models are represented by (t).

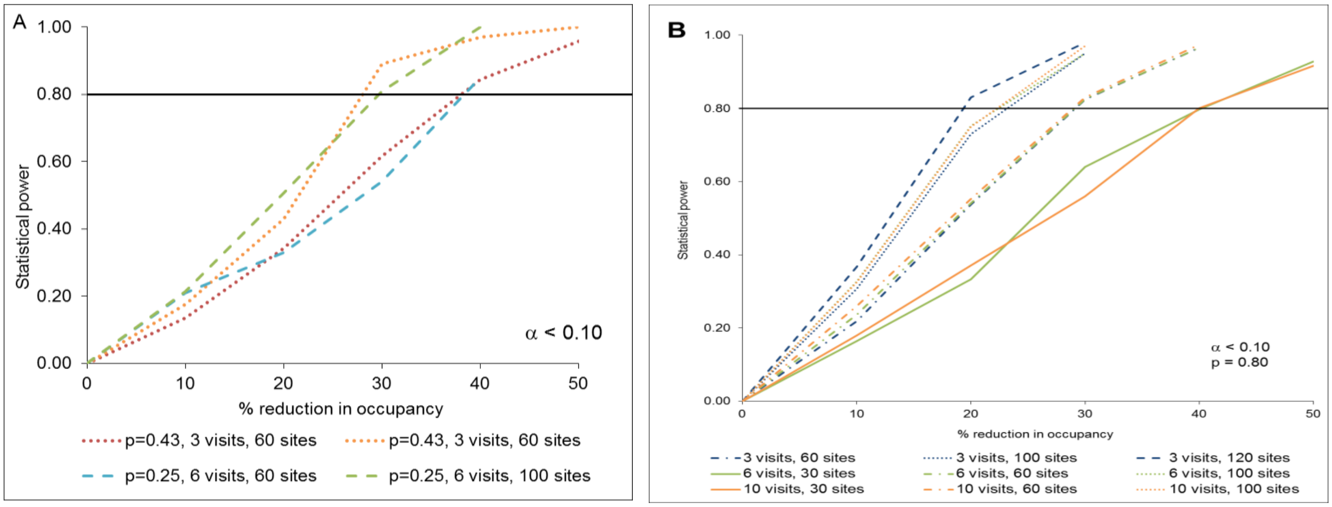
Species	Sessions	Detection Rate (p)	SE of p	95% confidence interval of p		Occupancy (psi)	SE of psi	95% confidence interval of psi	
				Lower	Upper			Lower	Upper
Bobcat	6	0.25	0.04	0.19	0.33	0.75	0.09	0.54	0.88
	3	0.45	0.07	0.31	0.61	0.78	0.10	0.54	0.91
Gray Fox	6	0.51	0.04	0.43	0.59	0.49	0.07	0.37	0.62
	3	0.60	0.11	0.38	0.78	0.50	0.07	0.37	0.62
		0.72	0.08	0.55	0.85				
		0.76	0.09	0.55	0.89				
Coyote	6	0.15	0.08	0.05	0.38	0.56	0.08	0.40	0.71
		0.20	0.07	0.09	0.38				
		0.25	0.07	0.13	0.41				
		0.27	0.07	0.15	0.43				
		0.34	0.09	0.19	0.53				
		0.45	0.13	0.23	0.69				
	3	0.31	0.10	0.16	0.52	0.59	0.09	0.40	0.75
		0.40	0.09	0.24	0.58				
		0.56	0.13	0.32	0.78				

Table 2. Occupancy model results for the fall 2015 survey in study area six. 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.

Simulations were completed based on the pilot data we received from the bobcat occupancy survey (Fig. 2). Based on these simulations, currently, there is only the ability to detect a major crash in bobcat populations using this study design (Fig. 2 A and B).

Co-occurrence analyses will be conducted to investigate interspecies relationships. Relationships between prey and mesocarnivore presence can also be tested because the remote cameras captured images of prey as well. Occupancy levels and detection rates may vary by survey area for all species. Occupancy simulations will need to be completed routinely after data is acquired from each survey area.

Figure 2. Simulation results for determining the statistical power to detect reductions in occupancy levels. Graph "A" depicts data from the 2015 bobcat occupancy survey. Graph "B" represent the target level of detection (p = 0.80) in order to monitor lower changes in occupancy.



III. Bobcat Radio Collaring

Summary

Trapping with the intent to radio collar bobcats commenced in early January 2015 and ceased in late January 2016. These efforts were split up into two main time periods in attempts to a.) not overlap the occupancy survey period, and b.) not interfere with reproductive events such as rearing kittens. Furthermore, a short trapping period in July was initiated in attempts to re-collar BC001 (Female) and BC002 (Male) because their collars had stopped transmitting GPS locations. GPS collars were programmed to take seven locations per night and one location per day. All collars were programmed to drop off after being on the animal for one year. To date, the drop-off mechanisms have been working properly. The two collars that were programmed to drop off this past winter dropped off on schedule.

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 traplines, the average number of trap nights to catch a bobcat was 103.27. Figure 3 displays the results of total number of trap nights for each bobcat collared. The number of trap nights per individual trapline was 57.81 (Fig 4).

Bobcats were trapped using cage traps with a single dropdown style door. Trap doors were modified by reducing the gaps in the bars to <1 inch to prevent bobcats from breaking their teeth. All traps were checked twice a day. Non-target species were released immediately. The majority of bobcats were captured using waterfowl carcasses as bait (provided by local hunters) and a combination of bobcat urine and scent lure. Trapping seemed to be most successful later in the year when prey numbers were lowest, and the weather was cold and/or a storm was approaching. Trapping success also significantly improved when experienced trappers, Vicki and Jeff Davis, ran a trapline. They successfully caught bobcats by making mock packrat nests in the traps and using ground squirrels and rabbits as bait.

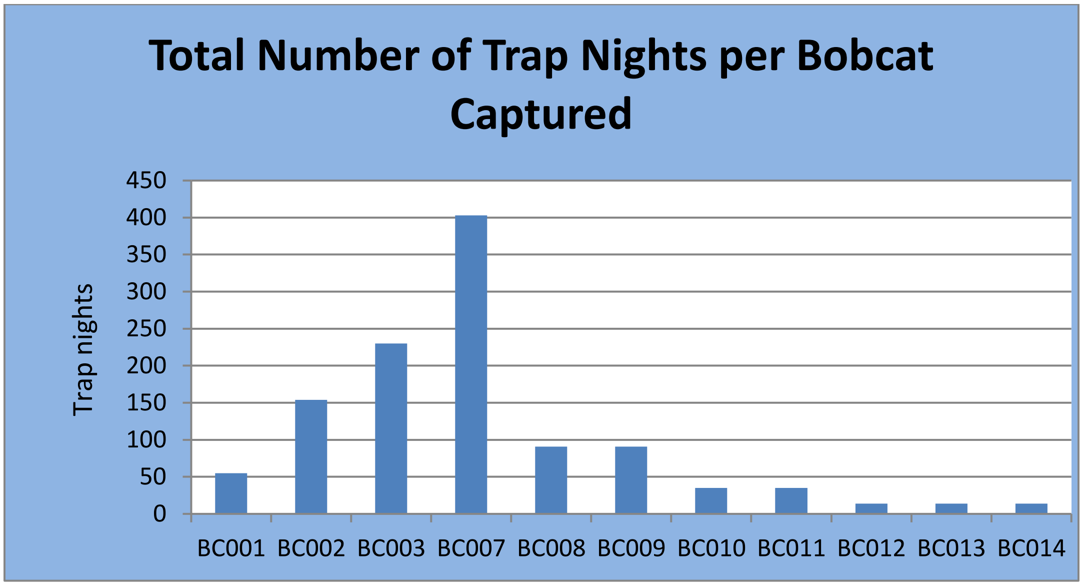


Figure 3. Total number of trap nights to collar each bobcat. Collaring efforts occurred from January 2015 to January 2016.

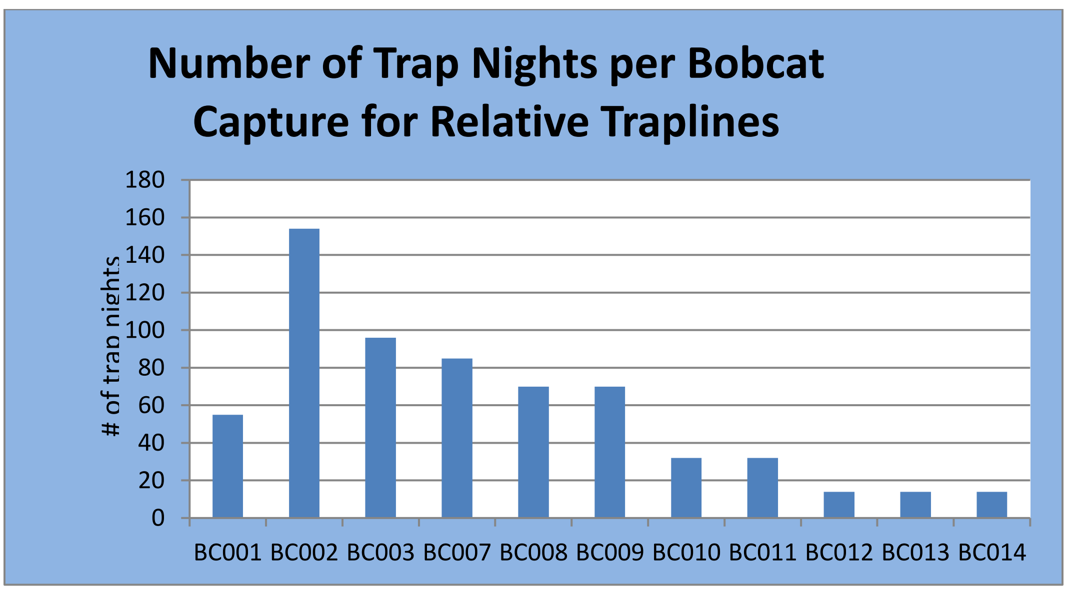


Figure 4. The number of trap nights per trap line per individual bobcat captured.

An attempt was made to pre-bait deactivated traps with consumable bait and lure in an attempt to habituate bobcats to traps and positively reinforce trap entry. However, this proved to be ineffective and is not recommended. Several individuals entered the traps without doors and then never returned and/or reentered traps once the doors were replaced and the traps were activated. Hypothetically, curiosity is an important behavioral factor to consider when trapping bobcats. Bobcats respond to new traps and stimuli within their home range and then may quickly lose interest. Upon deactivation of the traps in all areas, multiple un-collared bobcats were detected visiting the traps using the trail cameras. Trapping efforts were suspended on Jan 22nd 2016 after all radio collars were deployed. Up to 30 new radio collars will be deployed in the 2016/2017 field season with the goal of maintaining 30 radio collared bobcats for statistical analysis purposes.

IV. Animal Health and Morphology

Age Structure and Sex Ratios

Age structure of harvested bobcats was determined using 32 jaw samples from bobcats harvested during the 2014/2015 season. Canines were extracted and sent to Matson's Laboratory where individuals were aged using cementum annuli analysis. Ages ranged from zero, born that year, to 10 years old and the population had a bimodal distribution (Fig.7) peaking at three and nine years old. This distribution differs from other harvested bobcat populations which peak with juveniles and number of individuals per age class tends to decrease with age, as shown in both Wyoming and Oklahoma populations (Crowe 1975 and Rolley 1985). Our age structure is potentially biased towards adult cats, since some trappers release kittens; however, more jaw samples are necessary to more accurately determine age structure.

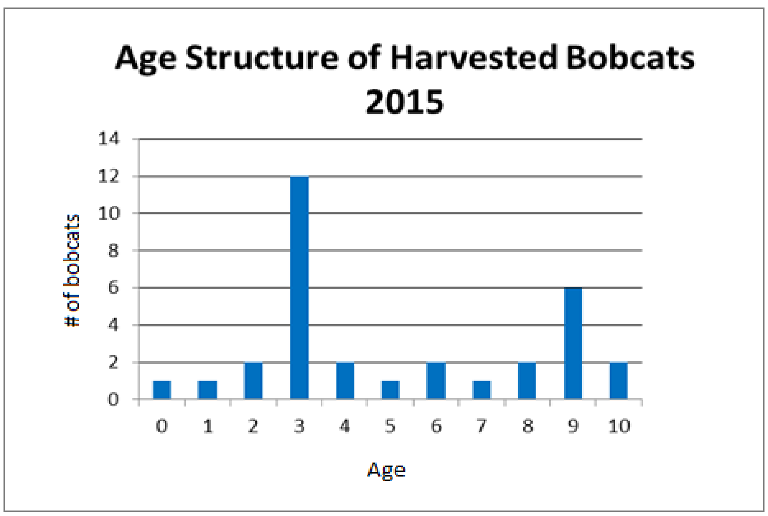


Figure 7. Age structure of harvested bobcats from 2014/2015 trapping season.

Using the same 32 harvested bobcats, we calculated a male to female sex ratio of 9:7 (Fig. 8). Based on other harvested populations we expected a 1:1 ratio (Johnson et al. 1981). However, our data is potentially biased against females, due to trapper's preference for males, especially large males which tend to be older (Table 6). This difference is also likely due to our small sample size and more samples would likely see the shift the sex ratio closer to 1:1. All trappers are required to report the sex of the bobcats that they harvest. We plan to acquire the archived Inyo County trapping data from the CDFW License and Revenue Branch and analyze sex ratios further.

We further analyzed the harvested population based on number of males and females in each age class (Fig. 9). It appears that females may follow the age structure found in other studies. However, males do not follow that trend. More samples are needed to determine if this is an accurate reflection of the population. However, bobcat trapping is now prohibited statewide (Fish and Game Code §478). These data will no longer be available from trapped animals. Future data for this section will be obtained from collared bobcats and opportunistically collected specimens (i.e., road kill).

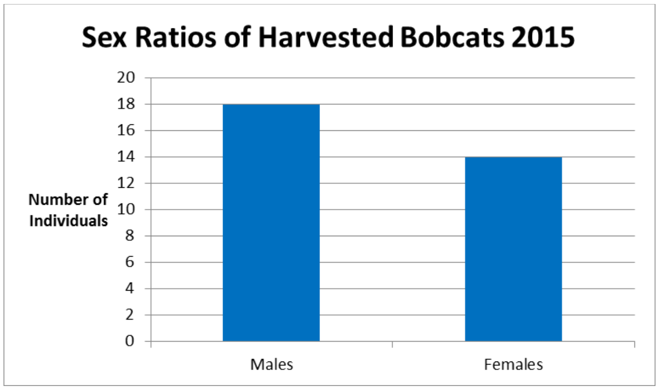


Fig 8. Sex ratios of harvested bobcats from the 2014/2015 trapping season.

Sex	Number of Individuals	Average Age
Male	18	5.41
Female	14	4.78

Table 6. The number of male and female bobcats from the 32 samples and the average age based on sex.

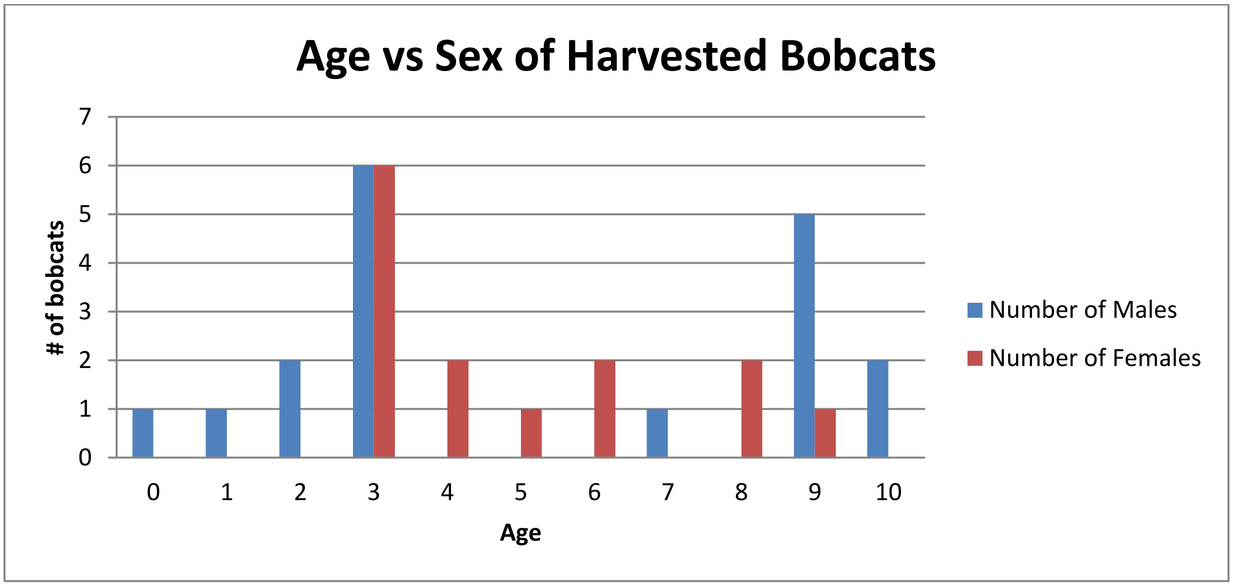


Figure 9. Number of harvested bobcats in each age class (years) based on sex.

Capture Data

Of the 14 captured bobcats, there were six females and eight males (Table 7). The average weight for all bobcats was 8.78 kg (excluding kittens). Adult males had a higher average than females (Table 7, Fig. 10). During each capture, we measured neck circumference and found males averaged 20.91cm and females averaged 18.83 cm. This is consistent with other bobcat populations (Lembeck 1978). Both weight and neck circumferences are important, not only for size distribution, but also GPS radio collaring. 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. One bobcat was fitted with a radio collar that was approximately five percent of the bobcat's body weight but the other bobcats averaged between three and four percent of the individuals total body weight (Table 8). In the future, it is recommended that bobcats only be radio collared if the weight of the collar is between >4% of the animal's weight. Otherwise it should receive a pit tag and be re-captured at a future date.

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. Ten bobcats were classified as being in adequate body condition, while one, BC010, was categorized as thin (Table 7). All three kittens were also of adequate body condition. Four cats had fleas (Table 7) but 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. One bobcat had broken a canine on the trap doors prior to our modifications. No bobcats broke their canines after we modified the trap doors to have <1 spacing between the bars.

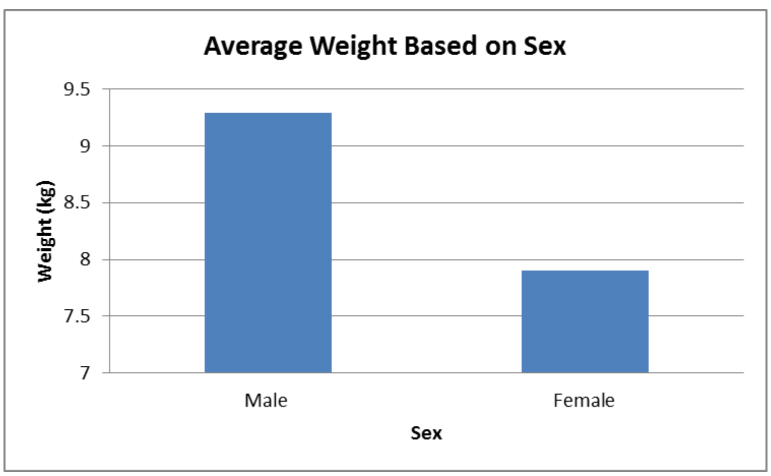


Figure 10. Average weight (kg) of the 14 captured bobcats, excluding kittens, based on sex.

Bobcat	Sex	Age Class	Capture Date	Weight (kg)	Neck Circum (cm)	Body Condition	Parasites
BC001	Female	Adult 2	1/17/2015	9	21	Adequate	Yes
BC002	Male	Adult 1	2/23/2015	8.3	24	Adequate	Yes
BC003	Male	Adult 2	3/17/2015	8.5	21	Adequate	No
BC004	Male	Juvenile (Kitten)	4/24/2015	0.15	NA	NA	No
BC005	Female	Juvenile (Kitten)	4/24/2015	0.15	NA	NA	No
BC006	Female	Juvenile (Kitten)	4/24/2015	0.15	NA	NA	No
BC007	Male	Juvenile (Yearling)	11/20/2015	5.4	6.2	Adequate	No
BC008	Male	Adult 2	1/18/2016	11.2	26.5	Adequate	No
BC009	Female	Adult 2	1/18/2016	7.8	18.5	Adequate	Yes
BC010	Female	Adult 2	1/20/2016	7	17	Thin	No
BC011	Male	Adult 2	1/20/2016	11.2	25.5	Adequate	Yes
BC012	Female	Adult 2	1/21/2016	7.8	NA	Adequate	No
BC013	Male	Adult 2	1/21/2016	9.4	20.2	Adequate	No
BC014	Male	Adult 2	1/22/2016	11	23	Adequate	No
Average				8.78	20.29		

Table 7. Health and morphometric data for captured bobcats, including: sex, age class (Juvenile 0-12 months, Adult 1 12-24 months, and Adult 2 >24 months), capture date, weight (average excluding kittens), neck circumference (average excluding kittens), body condition, and parasites

Bobcat	Total Body Weight	Percent Weight
BC001	9.00	3.67
BC002	8.30	3.98
BC003	8.50	3.88
BC007	5.40	6.11
BC008	11.20	2.95
BC009	7.80	4.23
BC010	7.00	4.71
BC011	11.20	2.95
BC012	7.80	4.23
BC013	9.40	3.51
BC014	11.00	3.00

Table 8. Individual bobcat's total body weight and the percent body weight of the GPS collar (330 grams)

Mortality

Mortality data was collected for both collared and un-collared bobcats when possible. From 2014 to 2016, we collected data from four bobcat mortalities, three collared bobcats and one unknown bobcat (Table 9). 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 has been seen on cameras as recent as February 2016. None of her kittens have shown up in the photos. It appears BC001 is pregnant again based on photos taken from a remote camera in April 2016. The photos also confirmed that her GPS collar dropped off as it was programmed to do. However, this was one of the GPS collars that the Iridium system and VHF failed. We were unable to retrieve the collar because the collar malfunctioned.

The other three bobcat mortalities appeared to be caused by vehicle collisions and occurred on or close to highway 395 (Fig. 11, Table 9), two within a few hundred meters of each other. Vehicle related trauma was visible on each cat; however, the carcasses have been sent to the California Department of Fish and Wildlife Wildlife Investigations Lab for necropsy. Any additional findings will be detailed in future reports. All three cats were male (two adults and one yearling). Two were collared, BC003 and BC007, and one was un-collared. GPS points are available for BC003 and BC007.

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

Table 9. 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 (depredations, road kill, public safety, or other) and general location

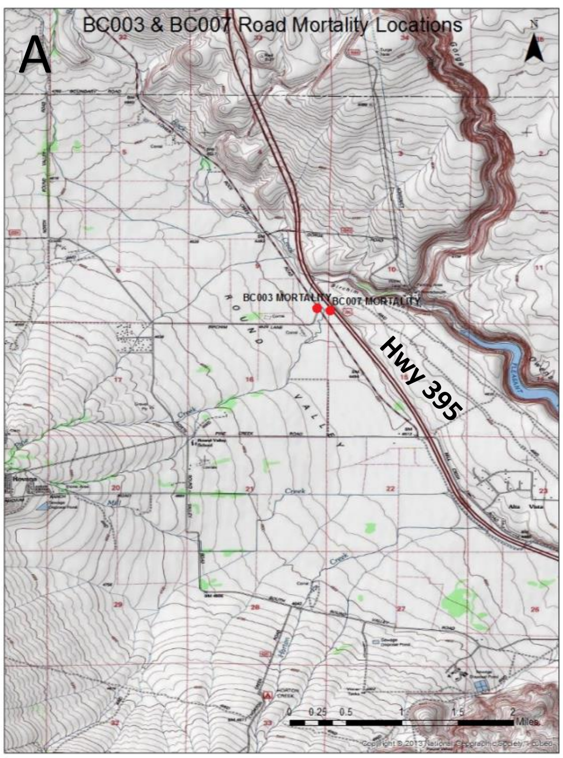
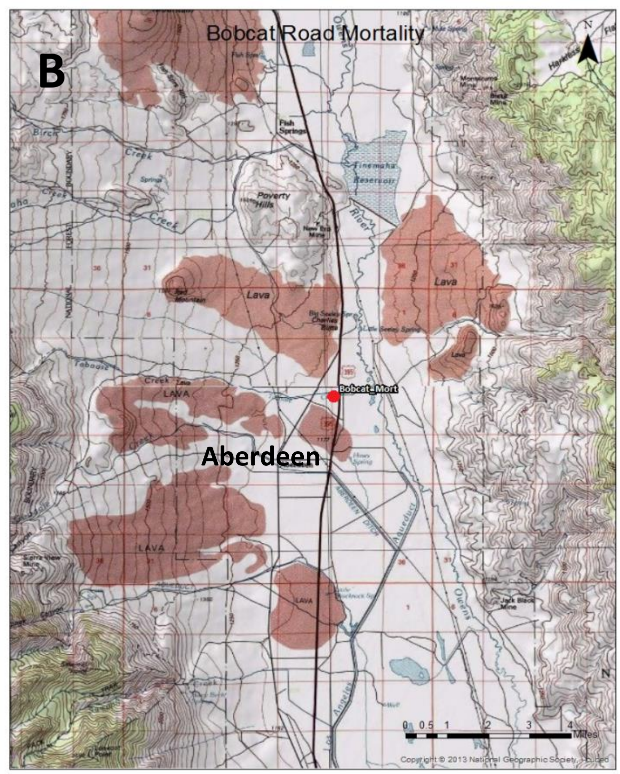


Figure 11. Maps of road mortalities. **A:** mortality locations for BC003 (collected 10/12/2015) and BC007 (collected 02/18/2016) **B:** Mortality location of unknown bobcat collected 05/11/2015



V. Reproductive Biology

Bobcats are primarily solitary predators with a polygamous mating system. Social interactions are suggested to be predominantly influenced by reproduction and survival (Ferguson et al., 2009; Neilsen and Woolf, 2001). It is suggested that females are more influenced by prey abundance and resource accessibility whereas males are influenced primarily by access to females (Donovan et al. 2011; Ferguson et al. 2009; Lynch et al. 2008). From observations of the collar data obtained from nine bobcats (four females & five males) overlapping males and females are potentially breeding. While data from the past six months is yet to be obtained, BC001's (female) location data has a home range almost completely overlapped by BC002 (male; Appendix B). An un-collared bobcat was detected on a camera within the home range of BC001. If this bobcat is another male, it is possible that that male may have also bred with BC001.

On April 24th 2015, a den with three bobcat kittens was discovered through observations of clustering of GPS radio collar data points obtained from the collar on BC001. Three kittens were briefly examined, pit tagged for future identification and morphometric data was collected while collar data indicated the female was away from the den (Table 4 & Table 5). Den site characteristics were also recorded. These kittens were identified as BC004, BC005, and BC006. Upon re-visitation to the den site the following day it was found that two of the kittens were moved and one had been abandoned. Methods for den visitation are continuously being evaluated to minimize capture-induced abandonment. Photos of BC001 on camera traps have not depicted her with any kittens or other individuals. It is unknown if any of the remaining two kittens survived to present. Of the four females captured from 1/17/2015 to 1/21/2016, two showed evidence of prior reproduction based on teat condition while none were currently lactating (Table 5). A second cat was visible in the photos taken of BC012. The second individual was smaller and may have been her kitten (yearling).

Bobcat	Weight (kg)	Body Length (cm)
BC004	0.15	17
BC005	0.15	16
BC006	0.15	18.5

Table 4. Body length and weight of three bobcat kittens from female BC001 litter

Bobcat	Lactation Evidence	Lactating
BC001	Y	N
BC009	N	N
BC010	N	N
BC012	Y	N

Table 5. Reproductive status of female bobcats captured as determined by teat condition.

VI. Spatial Use

Analyses of spatial data are pending. Data analyses will include home range estimates, temporal travel patterns, and intraspecies movement patterns. The maps in appendix B depict all of the collar data we have to date.

VII. Resource Use

A Habitat Suitability Index shall be produced using the radio collar data as well as Resource Selection Functions for bobcats relative to season, home range, and den sites.

VIII. Prey Base

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

Small Mammal Trapping

One hundred Sherman traps were set out on the Departments Pine Creek unit of the Round Valley Wildlife Area immediately east of the community of Pine Creek Village. Trapping occurred over four nights from 10/19/2015 through 10/23/2015. Traps were set approximately 25 m apart along four transects consisting of 25 traps each. Traps were checked each morning and the species, age class, sex, reproductive status was recorded for each animal caught. Individuals were marked with black permanent marker on the back to determine if an animal was a recapture. Six species were recorded (Fig. 5)

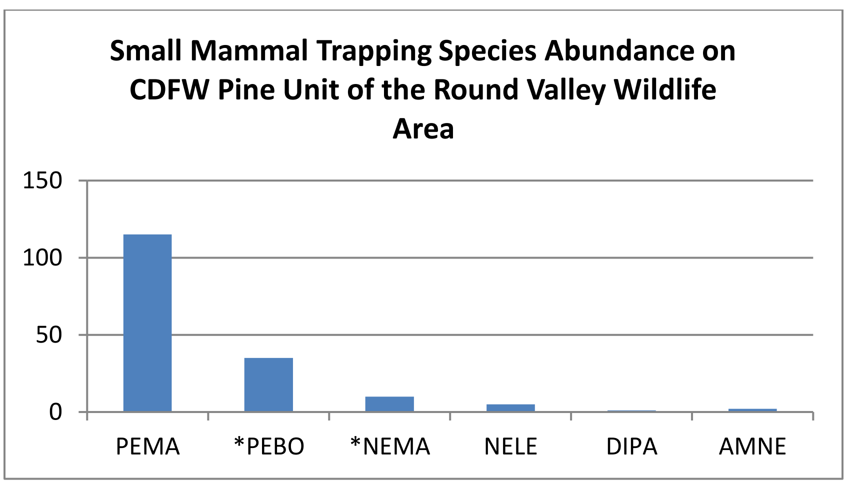


Figure 5. Results from the small mammal survey at the Pine Creek Unit of the Round Valley Wildlife Area in Bishop, CA. Species identified were *Peromyscus maniculatus* - deer mouse (PEMA), *Peromyscus boylii* - brush mouse (PEBO), *Neotoma macrotis* - big eared woodrat (NEMA), *Neotoma lepida* - desert woodrat (NELE), *Dipodomys panamintinus* - panamint kangaroo rat (DIPA), *Ammospermophilus nelson* - Nelson's antelope ground squirrel (AMNE)

*brush mouse and big eared woodrat are evidence of northern range extension

The most abundant species captured was the deer mouse (*Peromyscus maniculatus*; Fig. 5). According to the California Natural Diversity Database (CNDDB), staff documented a northern range expansion of two species; *Peromyscus boylii* (brush mouse) and *Neotoma macrotis* (big eared woodrat). The range expansion was recorded in the CNDD database.

A CMR survey of the small mammals was attempted; however, only two recaptures were recorded. This could either indicate a large population, the permanent marker wearing off so recapture wasn't detected, high mortality due to trap-related injury, trap aversion or the result of the study design. It is likely that the permanent marker wore off of the fur as this was observed twice where it looked like the animal had been marked but there was only a small amount left. Hair clippings should be used instead of permanent marker in future surveys.

Survey designs should be adjusted to increase the recapture rate. The traplines were widely spaced (Fig. 6), which may have resulted in one to two traps per individual home range. Traditional CMR surveys of small mammals place traps in a radial pattern and attempt to have three to four traps per individual home range (Seber 1982, White et al. 1982, and Huggins 1989).

Methods for obtaining an estimation of prey density and abundance are continuously being explored for this study. Research has shown that perhaps analysis of owl pellets and scat reveal a higher representation of species richness than live trapping alone (Torre et al. 2004). Approximately 30 bobcat scat samples have been collected throughout the study area. Scat samples are continuously being collected throughout the year. Once we have collected approximately 100 samples, these samples will be analyzed to determine bobcat diet from remains in the samples.

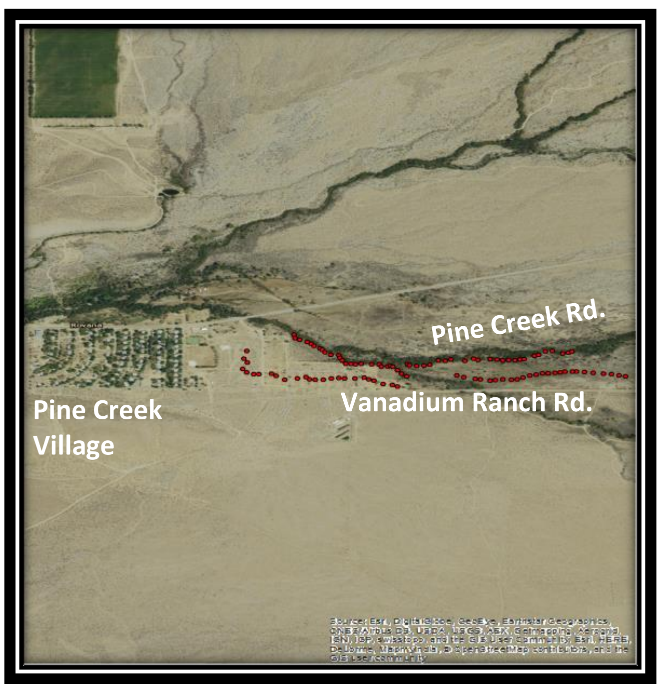


Figure 6. Trapline for the small mammal survey, October 2015 in the CDFW Pine Creek Wildlife Area. Red dots represent trap locations.

Lagomorph surveys

Summary

Lagomorph surveys were successfully conducted twice in the fall of 2014 during the CMR survey in study area four and three times during the course of the survey in study area six in fall 2015 (on one occasion, spotlights malfunctioned and the survey had to be ceased prematurely). These surveys consisted of driving unpaved road transects one hour after sunset at ~16 km/h. Lagomorphs were detected and identified using spotlights. During the 2015 surveys, the methods were adapted to include walking 100 m perpendicular transects every two miles to flush lagomorphs from the brush. All lagomorph sightings were tallied and the number of each species was recorded. Table three displays the results of the 2014 and 2015 lagomorph surveys.

Study Area 4 Route		**Study Area 6 Route**	
Survey Number	*Total Lagomorphs*	*Survey Number*	*Total Lagomorphs*
Survey 1	11	Survey 1	1
Survey 2	8	Survey 2*	0
		Survey 3	1

Table 3. Results for the 2015 lagomorph surveys in study areas four and six.
* spot lights failed

The low detection rate of lagomorphs throughout the study area could be a result of various factors:

- Time of year - Possibly conducting surveys at different periods of the reproductive cycle would yield different results.
- Road characteristics - The road transects are not disturbing the lagomorphs in the area effectively and they are not being detected.
- Behavioral characteristics – Lagomorphs are hiding as opposed to flushing and are thus not being detected.
- Ineffective methods of detection- Perhaps additional methods such as pellet counts, burrow density evaluations and habitat modelling could be used in addition to the current methods to obtain better population estimates and trend monitoring.

Detailed Results and Discussion

All lagomorph surveys were conducted during approximately the same time of year (November-December). Conducting surveys during the spring birth pulse could yield different results. Conducting surveys throughout different times of year and reproductive cycle could demonstrate a significant trend. The methods of these surveys are continuously being researched and modified to increase detection probability of lagomorphs and to obtain a better representation of the lagomorph population. It is apparent that lagomorphs are being undetected in the landscape from observations during field work. It is possible that behavioral characteristics of the individuals themselves are affecting the detection rate. Lagomorphs are hunted during the survey period. Hunting may have an effect on our surveys because lagomorphs near roads and less elusive individuals may be harvested by hunters. Furthermore, characteristics of the road transects themselves could be influencing detection rate. More lagomorphs were detected while driving narrow road transects where the vehicle contacted the brush. Survey results from survey routes where the roads are wider may be biased low because the vehicle did not make contact with the brush and flush lagomorphs.

Research on various methods of determining population estimates of lagomorphs suggests that active burrow density can serve as an effective method of monitoring lagomorph populations and changes in abundance (Price & Rachlow, 2010). Furthermore, pellet density counts could be an effective and efficient method for estimating lagomorph densities (Schmidt et al. 2011). Habitat characteristics could also potentially be used to estimate occupancy probability of lagomorphs within the study area (Scharine et al. 2011). Efficiency and effectiveness of these methods and/or combinations of methods will be evaluated and implemented to gain a good prey index of bobcats in the eastern Sierra Nevada.

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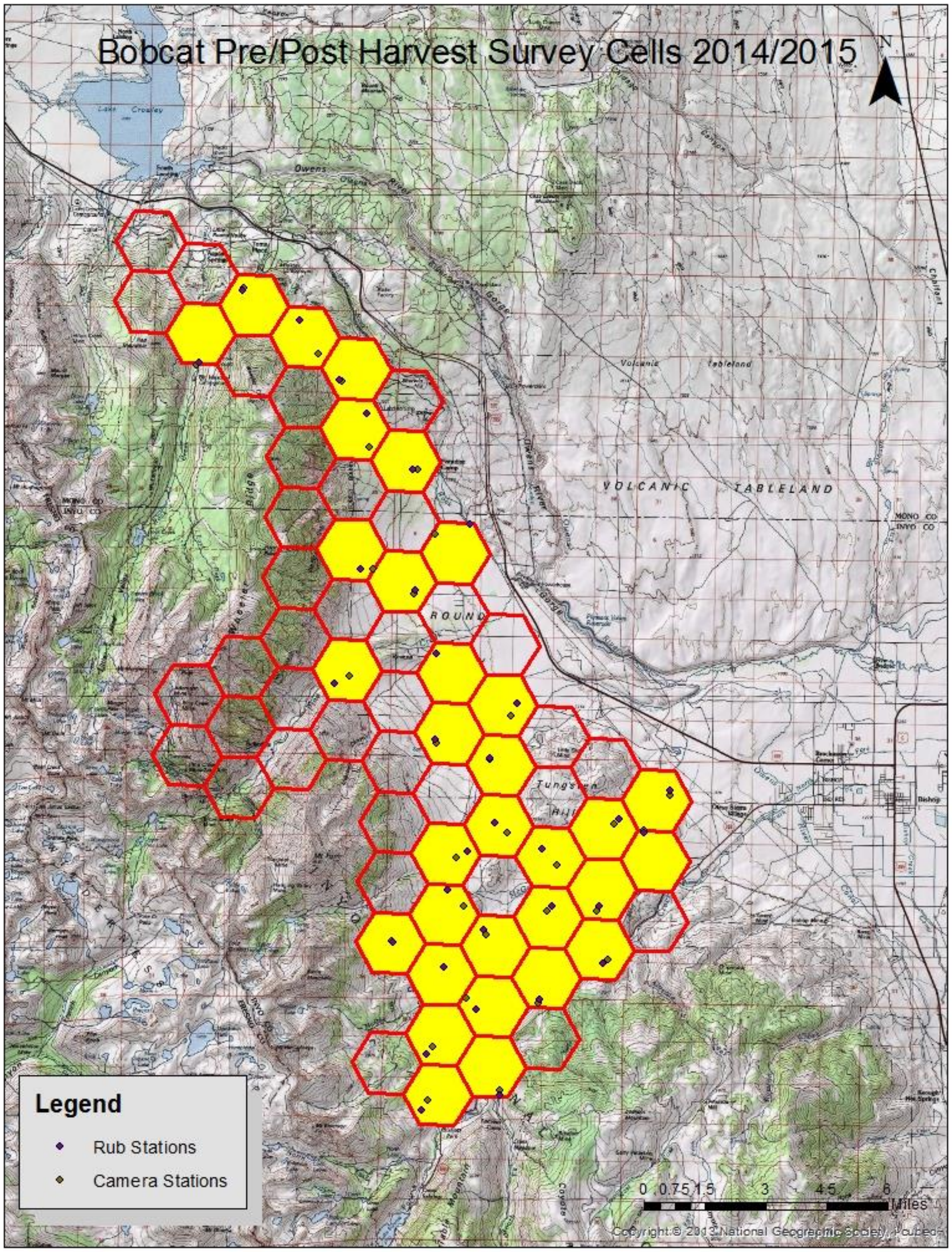
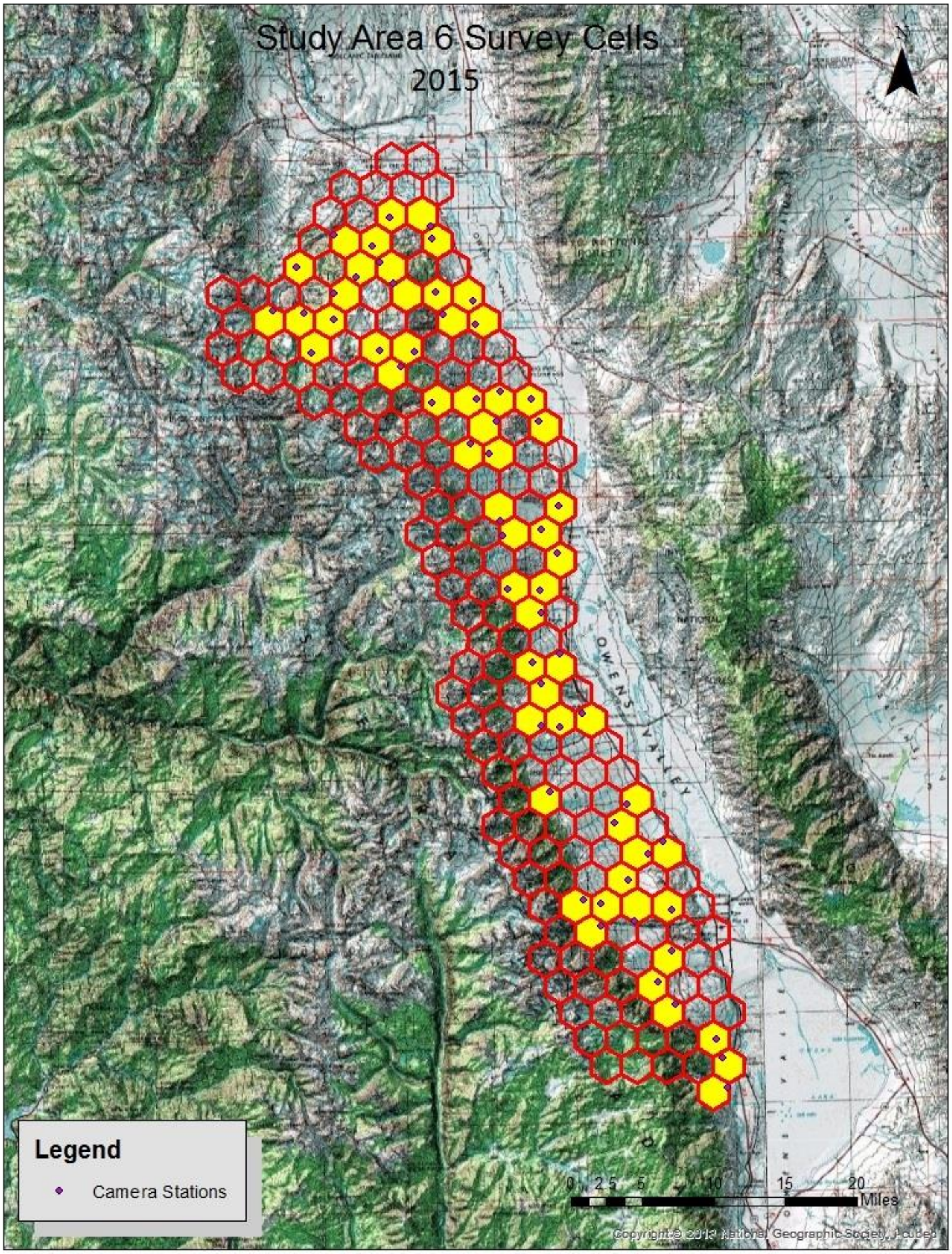
Appendix

A. *Survey areas*

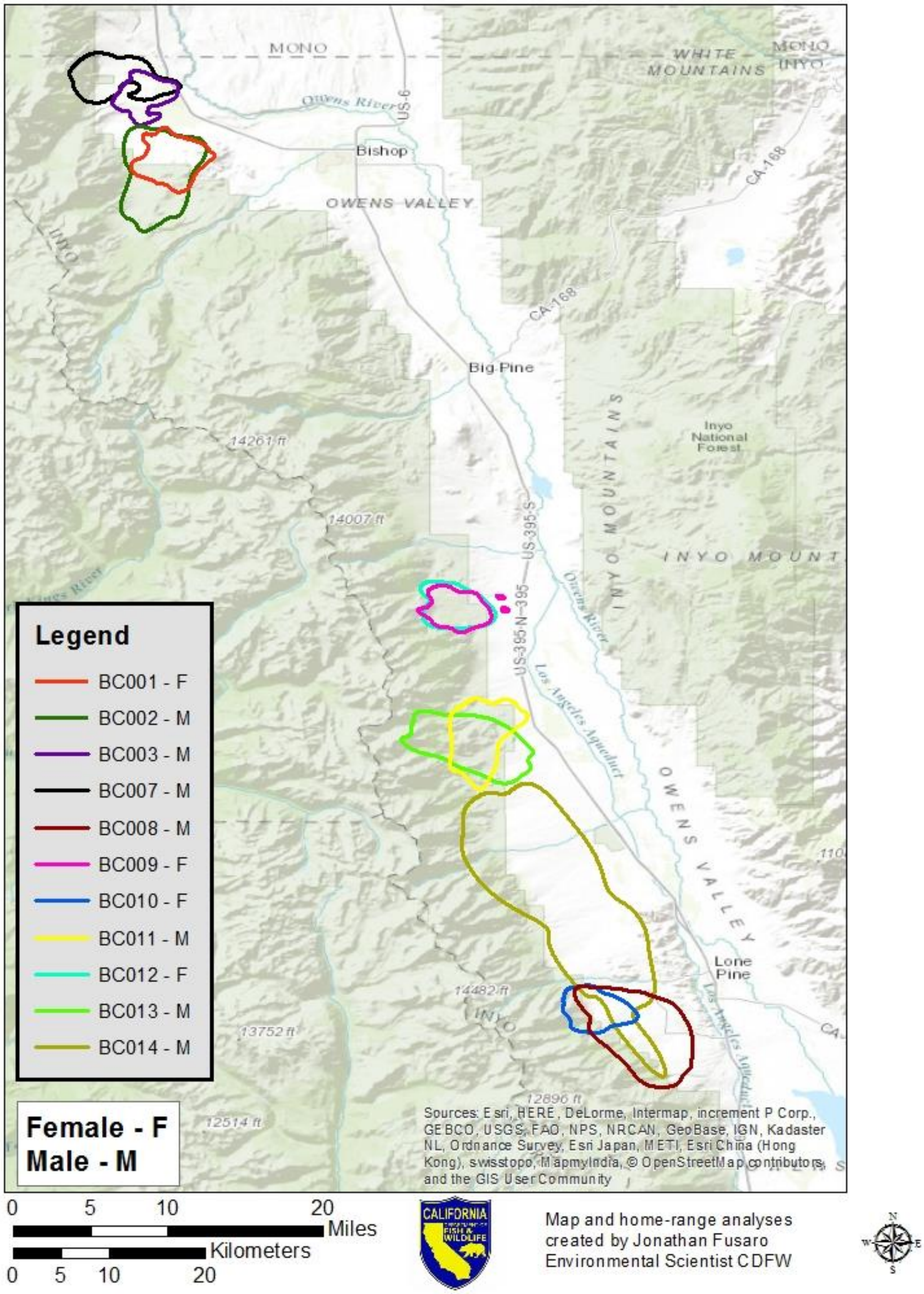




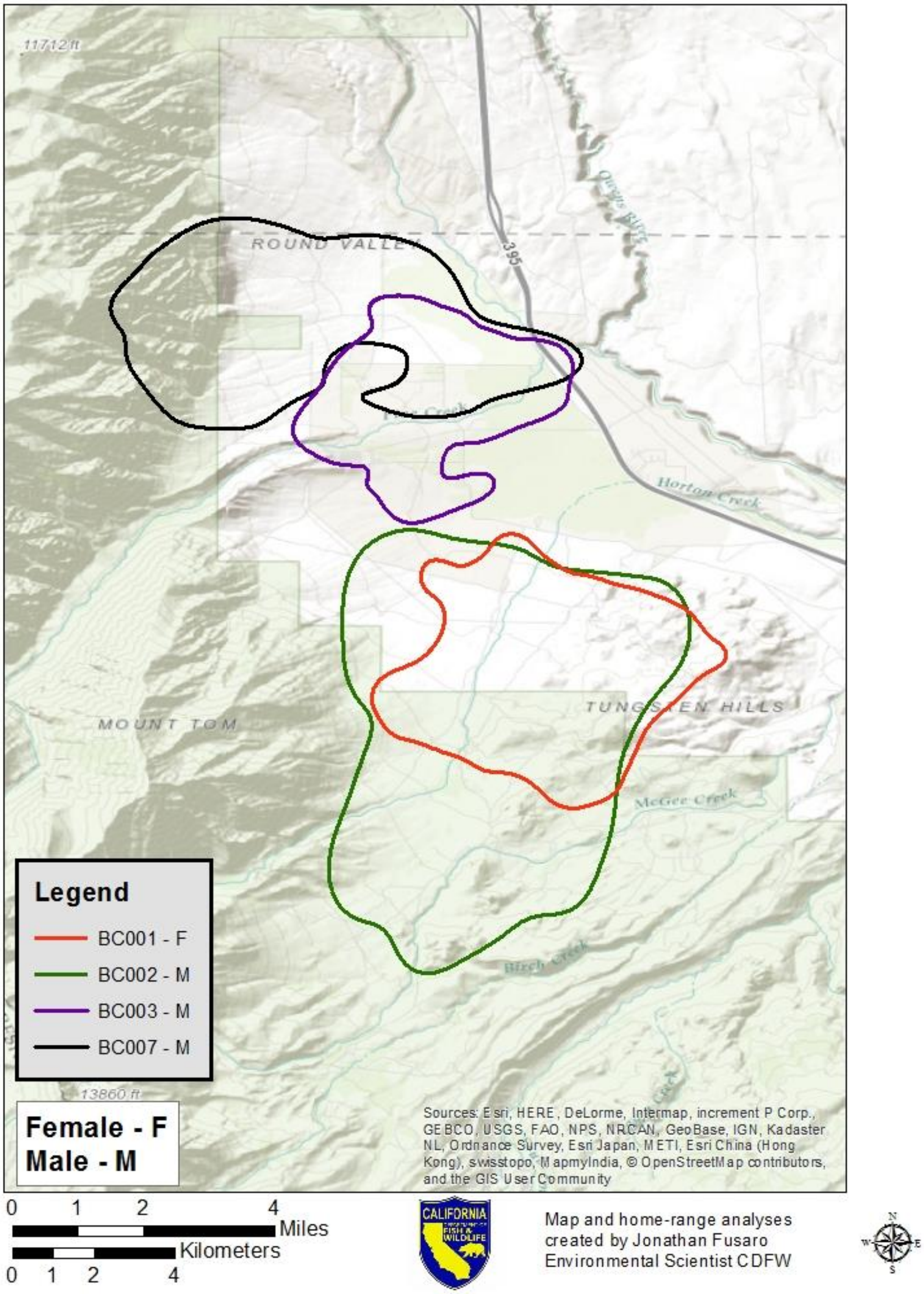
Study Area 6 Survey Cells
2015
Legend
Camera Stations
0 2.5 5 10 15 20
Miles
OWENS VALLEY
Copyright © 2013 National Geographic Society, i-cubed

B.   Collar Data

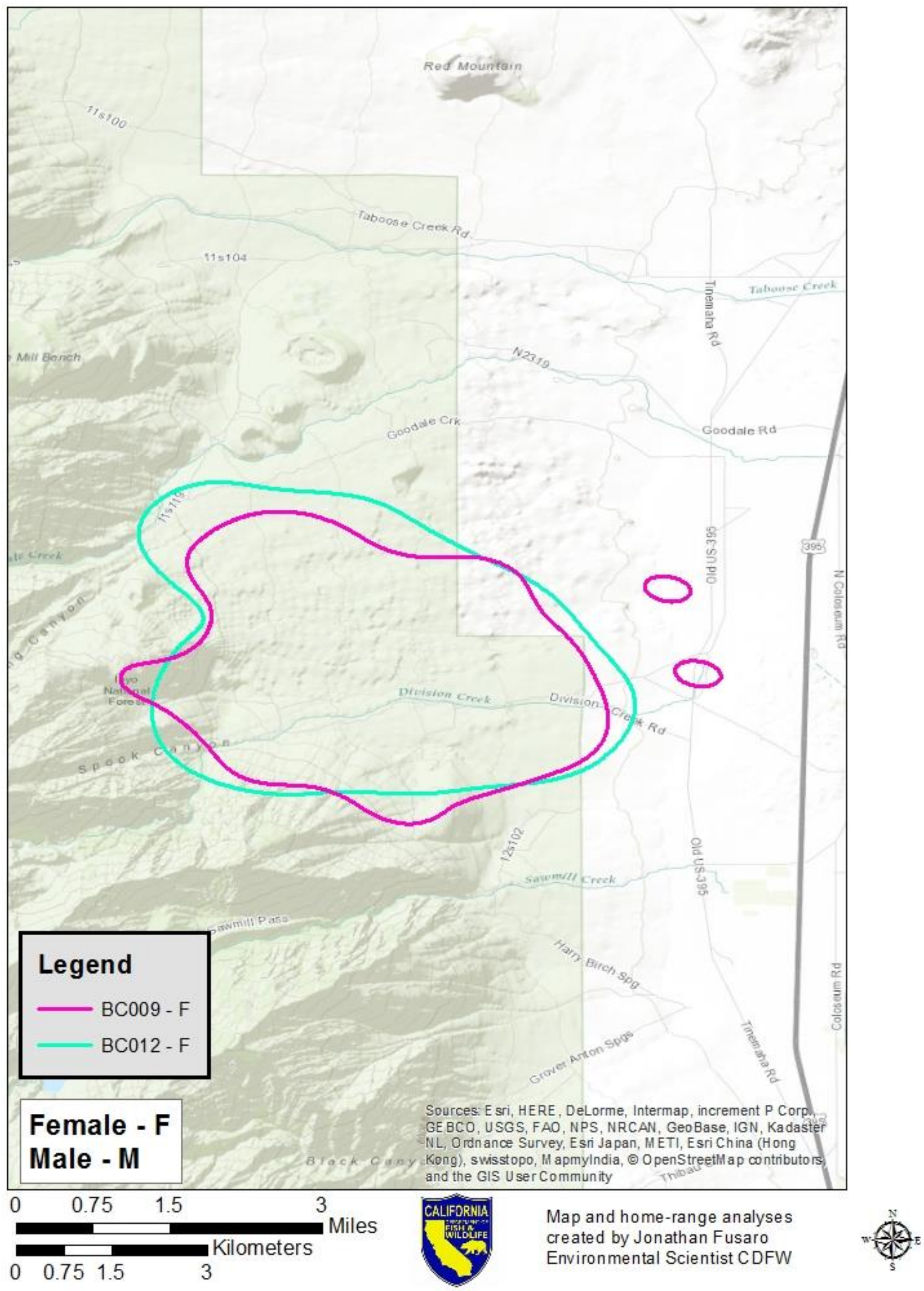
Home-Range Polygons for the 11 Bobcats Captured in 2015/2016



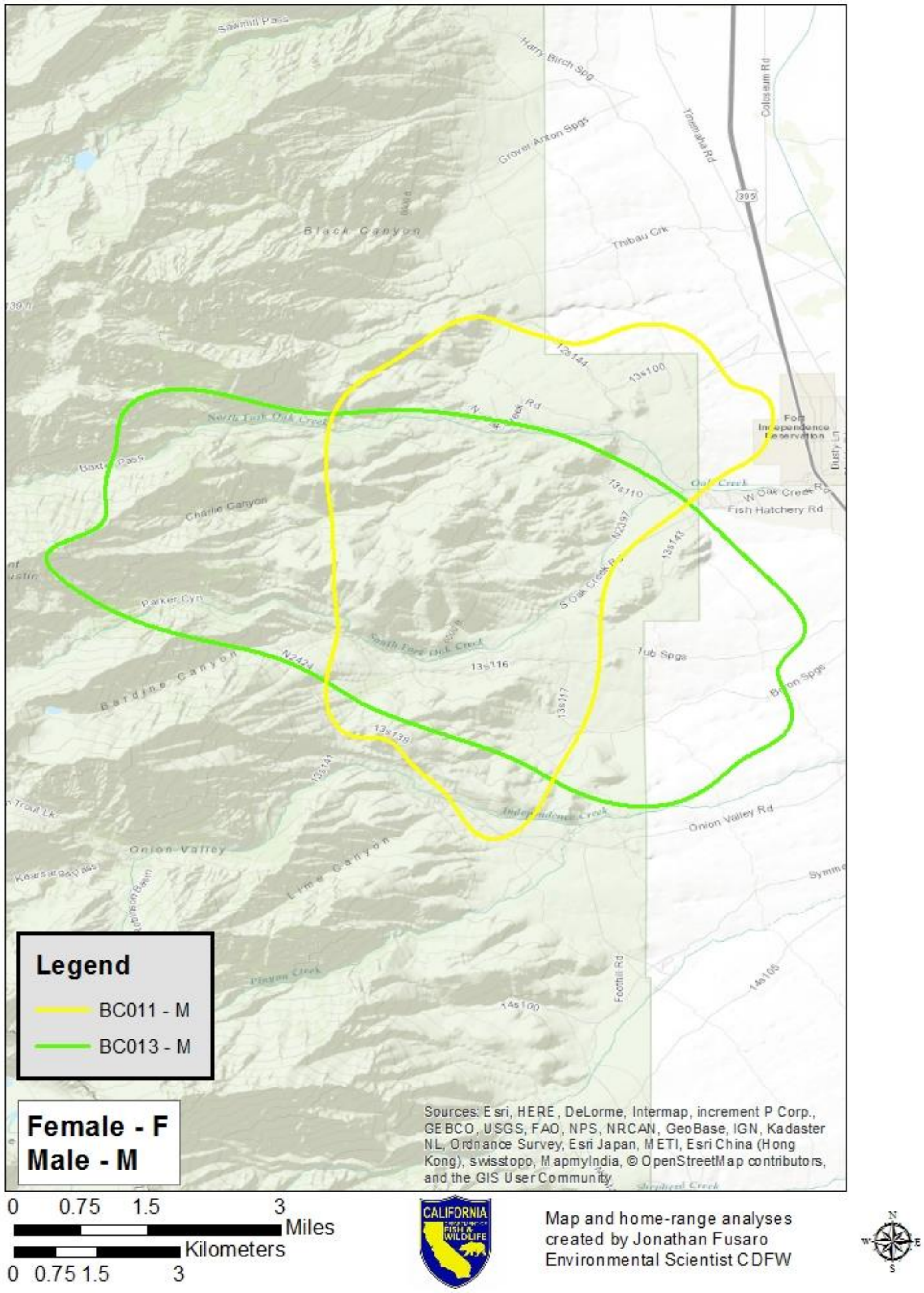
Home-Range Polygons for the 4 Bobcats Captured in Round Valley 2015/2016



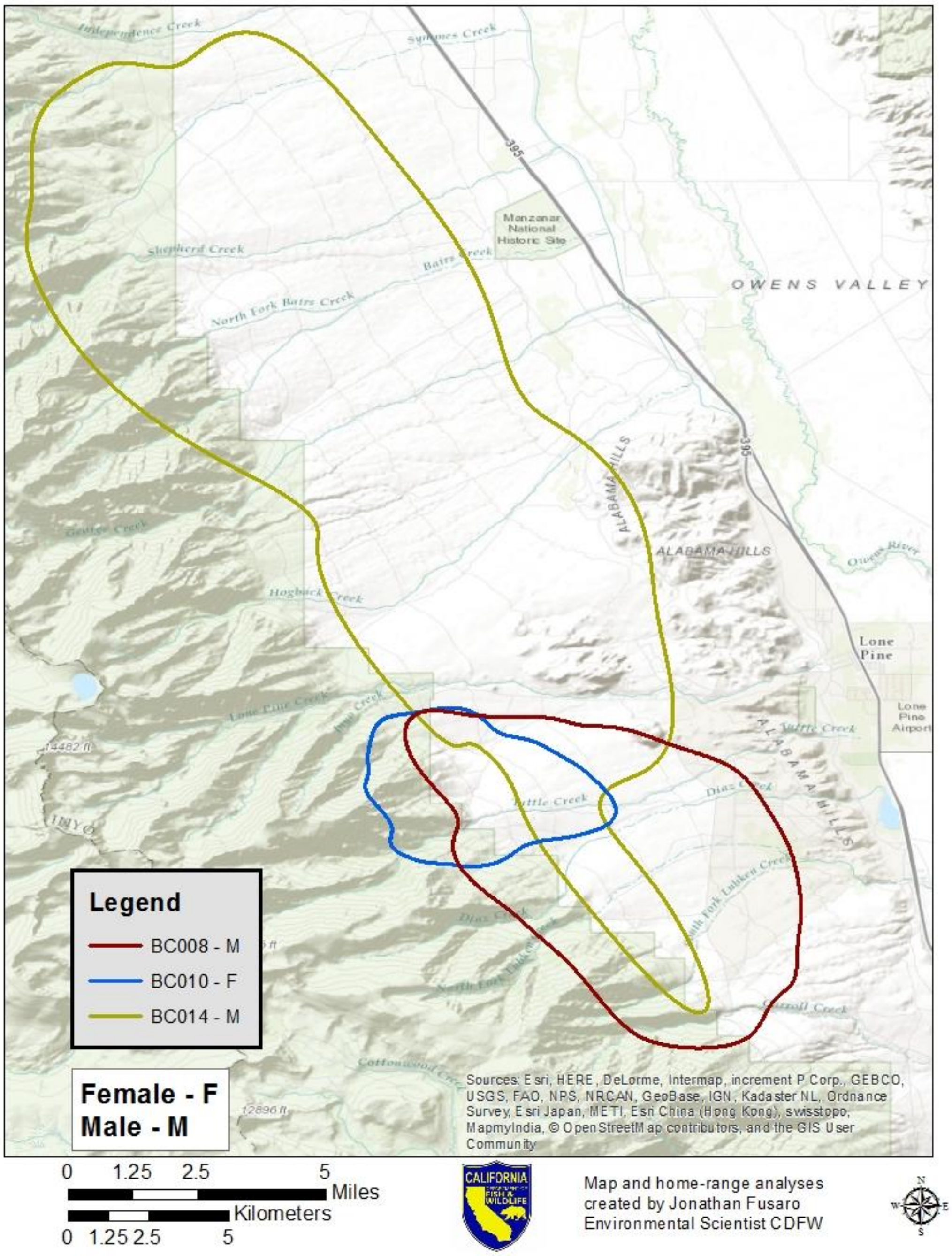
Home-Range Polygons for the 2 Bobcats Captured Near Division Creek 2015/2016



Home-Range Polygons for the 2 Bobcats Captured Near Oak Creek 2015/2016



Home-Range Polygons for the 3 Bobcats Captured Near Lone Pine 2015/2016



C. Species – remote camera surveys

American Badger	Taxidea taxus
American crow	Corvus brachyrhynchos
big eared woodrat	Neotoma spp.
black bear	Ursus americanus
black-billed magpie	Pica hudsonia
blacktailed jackrabbit	Lepus californicus
bobcat	Lynx rufus
brewer's blackbird	Euphagus cyanocephalus
brush mouse	Peromyscus boylii
burro	Equus africanus asunus
California ground squirrel	Spermophilus beecheyi
California kangaroo rat	Dipodomys californicus
California quail	Callipepla californica
chipmunk	Tamias spp.
Chukar	Alectoris chukar
clark's nutcracker	Nucifraga columbiana
Common Nighthawk	Chordeiles minor
Common Raven	Corvus corax
cottontail rabbit	Sylvilagus spp.
coyote	Canis latrans
dark-eyed junco	Junco hyemalis
deer mouse	Peromyscus maniculatus
desert woodrat	Neotoma lepida
domestic dog	Canis spp.
domestic horse	Equus caballus
Douglas squirrel / chickaree	Tamiasciurus douglasii
Eurasian Collared-Dove	Streptopelia decaocto
Great Blue Heron	Ardea herodias
greater roadrunner	Geococcyx californicus
grey fox	Urocyon cinereoargenteus
Hairy woodpecker	Picoides villosus
Hermit Thrush	Catharus guttatus
human	Homo sapiens
Lark Sparrow	Chondestes Grammacus
Mountain Chickadee	Poecile gambeli
mountain lion	Felis concolor
mountain quail	Oreotyx pictus
mule deer	Odocoileus hemionus
northern flicker	Colaptes auratus
raccoon	Procyon lotor
Red-Breasted sapsucker	Sphyrapicus ruber
ringtail	Bassariscus astutus
Spotted Towhee	Pipilo maculatus
Stellar's Jay	Cyanocitta stelleri
striped skunk	Mephitis mephitis
Thrush	Catharus spp.
western grey squirrel	Sciurus griseus
western scrub-jay	Aphelocoma californica
western spotted skunk	Spilogate gracilis
white tailed antelope squirrel	Ammospermophilus leucurus