New Detections of the Sierra Nevada Red Fox:
2015-2018 Alpine Mesocarnivore Study Progress Report
California Department of Fish and Wildlife
Inland Deserts Region 6
Bishop Field Office

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Sierra Nevada red fox detected by remote camera in Mono Creek, June 2019.

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I. Executive Summary

We present preliminary findings of a study initiated in 2015 by the California Department of Fish and Wildlife's Bishop Field Office (CDFW) to investigate the distribution of alpine mesocarnivores in the Sierra Nevada south of Yosemite National Park (Figure 1). Using noninvasive remote camera and scat surveys during 2015-2018, we detected 12 bird species, 2 ungulate species, 8 rodent species, 2 lagomorph species, and 11 carnivore species, including the Sierra Nevada red fox (SNRF). Notably, we did not detect wolverines.

The SNRF once ranged throughout the alpine and subalpine habitats of the Sierra Nevada and Cascades in California and Oregon. Today, the subspecies likely occupies only portions of its historical range, and is currently state-listed as threatened in California and proposed for federal listing as endangered by the U.S. Fish and Wildlife Service. In 2018, we documented three SNRF individuals in the Mono Creek watershed south of Mammoth Lakes, California. Genetic analysis of scat samples verified that the individuals assign most closely to the historical SNRF population, making these the southernmost confirmed SNRF in nearly 100 years. One of the individuals, a male, was last sampled in September 2017 near Sonora Pass, demonstrating a dispersal of more than 120 km within eight months. The other two individuals, females, had not been detected previously.

Future camera and scat surveys will focus on characterizing the abundance and distribution of SNRF in Mono Creek, while also expanding surveys into unsampled areas of the Sierra Nevada south of Yosemite National Park, including in Sequoia and Kings Canyon National Parks. Efforts are currently underway to prepare a Conservation Strategy for the SNRF; our survey results will help to inform this document's research and management recommendations to conserve the subspecies. In addition, we will continue to investigate the distribution in high-elevation habitats of other mesocarnivore species of interest, including wolverines, coyotes, martens, gray foxes, and kit foxes.


Winter fieldwork conducting alpine mesocarnivore surveys in Mono Creek.

II. Introduction

Background

The Sierra Nevada has undergone major climatic and anthropogenic changes since Europeans settled in the surrounding areas in the mid-1800s. Hunting, trapping, and poisoning of carnivores, livestock grazing, development, land management practices, and climate change are among the factors that have impacted wildlife populations in the region. For much of the Sierra Nevada south of Yosemite National Park, carnivore surveys have not been conducted in decades, and some alpine areas above 2,700 m may never have been surveyed. Consequently, the current range, distribution, and abundance of many carnivore species across the region is unknown. Carnivore surveys can fill these knowledge gaps, aid in the conservation and monitoring of populations over time, and give information about the integrity of the ecosystems that the carnivores inhabit (Thompson 2004, Zielinski et al. 2005, Long et al. 2008).

In 2015, the California Department of Fish and Wildlife's Bishop Field Office (CDFW) began camera and scat surveys to document mesocarnivore occupancy in the Sierra Nevada south of Yosemite National Park. We describe preliminary findings of surveys focusing on upper montane, subalpine, and alpine zones at elevations above 2,700 m between the northern border of Kings Canyon National Park and the southern border of Yosemite National Park (Figure 1). Concurrent surveys in the low-elevation areas of Inyo and Mono counties were documented in Ellsworth et al. (2016, 2017). High-elevation surveys prioritized areas

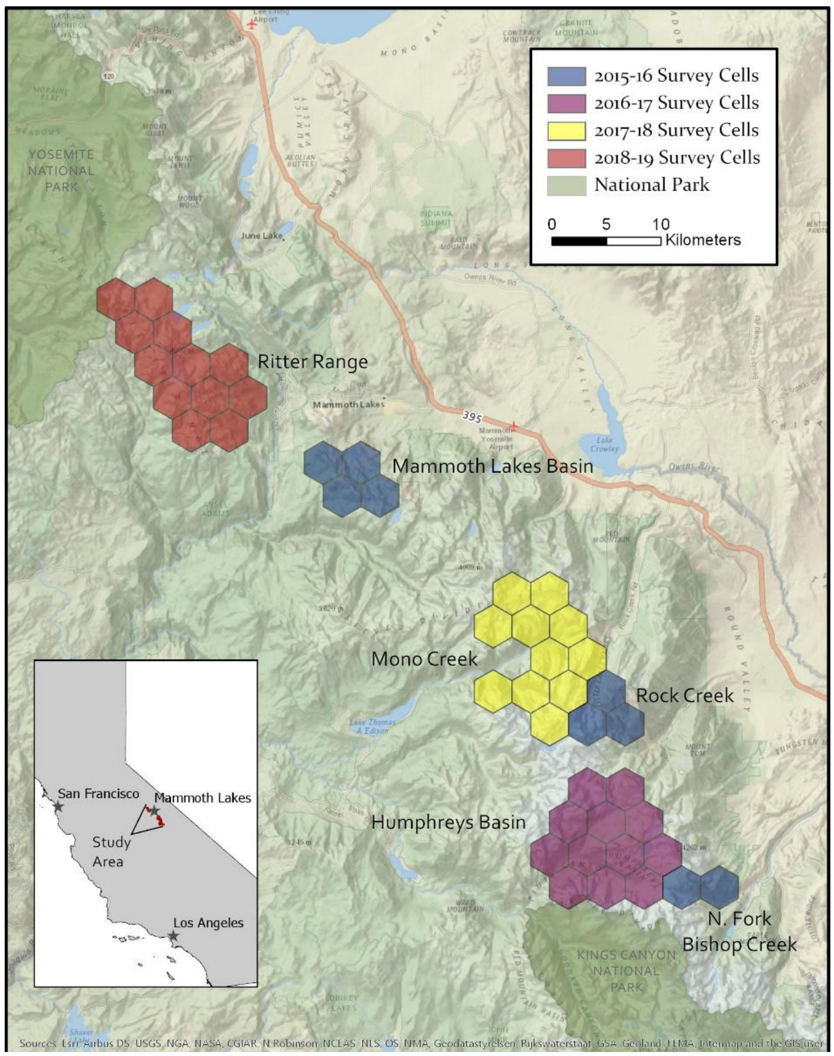

Figure 1. Alpine mesocarnivore survey locations 2015-2019.

that had not undergone recent systematic sampling. Surveys were designed to detect a range of mesocarnivore species, though detections of wolverine and SNRF were of specific interest to CDFW due to the conservation status of these species and the recent lack of definitive evidence of their presence in the central and southern Sierra Nevada.

Wolverine

The North American wolverine (*Gulo gulo luscus*) is a large, solitary mustelid that inhabits remote wilderness areas at very low population densities. Wolverine habitat is characterized by persistent spring snowpacks in subalpine forests and talus fields near treeline. Wolverines are opportunistic feeders but rely mainly on ungulate and rodent prey, or carrion in winter (Copeland and Kucera 1997). Historically, wolverines occurred throughout the high elevations of California's Sierra Nevada, and Schwartz et al. (2007) found that wolverines in the Sierra Nevada were genetically distinct from all other North American wolverines. The wolverine is listed as threatened in California and proposed for federal listing as threatened by the U.S. Fish and Wildlife Service (USFWS 2013). A male wolverine detected near Truckee, approximately 200 linear km north of our study area, in 2008 is the only individual known to exist in California and the first definitive detection of the species in the state since 1922. Based on genetic testing, researchers concluded that this individual dispersed from a population in Idaho (Moriarty et al. 2009). CDFW's alpine mesocarnivore study was motivated in part by the need to evaluate the potential for wolverine occupancy elsewhere in the Sierra Nevada to inform potential reintroduction efforts.

Sierra Nevada Red Fox

The SNRF (*Vulpes vulpes necator*) is a native montane subspecies of red fox (Figure 2). While the red fox is among the world's most widespread carnivores, little is known about the Sierra Nevada subspecies (Perrine et al. 2010). Prior to European settlement, the SNRF was distributed at low densities throughout much of the Sierra Nevada and Cascades in California and Oregon above 2,100 m (Grinnell et al. 1937, Hall 1981, Perrine et al. 2010, Sacks et al. 2010). Declines in harvest and observations led to the subspecies' listing as threatened under the California Endangered Species Act in 1980. The U.S. Fish and Wildlife Service recognized two Distinct Population Segments (DPS) of the SNRF: the Southern Cascades DPS (encompassing the Oregon and Lassen populations) and the Sierra Nevada DPS (a population centered around Sonora Pass in California), and later proposed to list the Sierra Nevada DPS as endangered under the federal Endangered Species Act (USFWS 2015, USFWS 2020).

Efforts are underway to determine the current distribution of SNRF in California and Oregon. SNRF populations are known to exist in the Oregon Cascades from Crater Lake National Park to

Mount Hood, and in the Lassen and Sonora Pass regions of California (Figure 2). Detections in other locations in Oregon and California, including those made during this CDFW study, may represent dispersing individuals or additional geographically distinct populations.

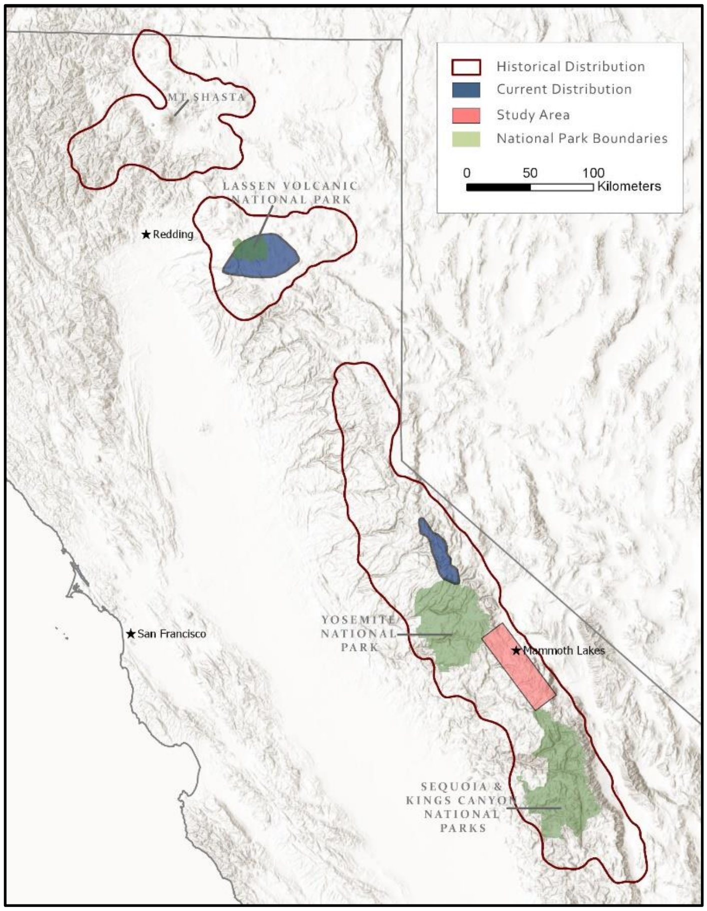

Figure 2. Estimated historical distribution of the SNRF adapted from Grinnell et al. 1937, vs. known contemporary distribution prior to this study.

Grinnell et al. (1937) attributed the paucity of SNRF detections to the animal's elusive behavior and low population density, even in areas of apparently high habitat suitability. The SNRF has eluded detection in multi-species surveys at Lassen Volcanic National Park, where the small canid is known to exist (Perrine 2005, Zielinski et al. 2005). Further research is needed to optimize methods for monitoring this threatened subspecies, as well as to understand its ecology and distribution.

Objectives

Our objectives during 2015-2018 were to detect SNRF or wolverines if they were present in high-elevation areas of the Sierra Nevada between Yosemite and Kings Canyon National Parks, to characterize the distribution of mesocarnivore species using these areas, and to determine the most effective sampling protocol for detecting SNRF and other mesocarnivores at high elevations. Results will support planning for conservation management actions which may include federal listing or reintroductions. Data will also inform planned future analysis of mesocarnivore occupancy within the study area.

III. Methods

Study Area

We sampled areas above 2,700 m between the northern boundary of Kings Canyon National Park and the southern boundary of Yosemite National Park (Figure 1). Habitat types represented in our study included pinyon forest, montane forest, subalpine forest, and alpine.

During 2015-2018, we conducted camera surveys in the following areas: Mammoth Lakes Basin, Rock Creek, North Fork of Bishop Creek, Humphreys Basin, and Mono Creek (Figure 1). We placed passive monitoring cameras near a campground in Rock Creek and in the North Fork of Lubken Creek in 2016, on Shepherds Pass and Bishop Pass in 2017, and in Twenty Lakes Basin and Mono Creek in 2018 (Figure 7). Also in 2018, we placed hair snares at the Mono Pass and Trail Lake Pass camera stations, and conducted scat surveys in the vicinity of Pioneer Basin, Hopkins Creek, Trail Lake, and Mono Pass in the Mono Creek study area.

Systematic Camera Surveys

We used noninvasive camera trapping methods to survey for alpine mesocarnivore species with a particular focus on detecting SNRF and wolverines. These methods were adapted from the CDFW camera survey protocol used successfully to detect SNRF in the Sonora Pass area (Stermer et al. 2015). The sampling frame was a grid composed of 10.4 km² hexagonal cells placed in a layer across the Sierra Nevada. Detections of SNRF in other regions tend to be at elevations above 2,500 m, at or near treeline in subalpine and upper montane zones. Based on these criteria, as well as the SNRF habitat suitability model developed by Cleve et al. (2011), we delineated a focal alpine watershed for each survey season. We then selected 20-30 camera sites within that area. Camera site selection was based primarily on terrain (prioritizing likely corridors for animal movements such as narrow passes and wind-scoured ridges), exposure to prevailing winds (to reduce the probability of cameras being buried by snow) and accessibility by field staff. In order to meet the assumptions of an occupancy analysis similar to Zielinski and Kucera (1995), we placed two camera sites a minimum of 1.6 km apart within a grid cell, with at least 1.6 km between camera placements in adjacent grid cells.

We deployed Reconyx motion detection cameras (Reconyx, Holmen, Wisconsin, USA) with commercial scent lure (Gusto, Minnesota Trapline Products, Pennock, Minnesota, USA) placed 5 m away from the camera trap to attract carnivores. We placed cameras on large boulders or trees and oriented the camera lenses to within 30 degrees of north (Figure 3). We programmed camera triggers at the highest sensitivity setting and set cameras to take 10 photos per trigger. Stations were active for a minimum of 120 days, with a target revisit rate of every 20 days if travel conditions were safe. During revisits, we added fresh lure, collected and replaced the camera's memory cards, and adjusted the cameras as needed.

Figure 3. A camera deployed on Hopkins Pass during the 2017-18 survey season.

Passive Monitoring Cameras

In addition to systematic surveys, we occasionally deployed passive monitoring cameras in response to reports of rare carnivore sightings. We also deployed passive cameras on Bishop Pass and Shepherds Pass in 2017 to monitor carcass piles where dozens of migrating mule deer died after falling on steep ice. In 2018, we maintained passive camera stations in cells where SNRF detections occurred in the Mono Creek study area to monitor continued SNRF occupancy. We followed a similar protocol to deploy passive monitoring versus systematic survey cameras, but passive camera detections were not included in results from systematic surveys, and passive cameras were typically revisited and rebaited less frequently than cameras deployed as part of a survey.

Photo Identification

We classified photos by species and number of individuals. All detections of a single individual of a species within a 30-minute time window were considered a single detection record. We did not attempt to identify mice or chipmunks to species, though several species are present in our study area. When photos clearly contained an animal but we were unable to identify the species, we classified these as "unknown." Animal detections of unknown species constitute a very small proportion of our results, and we do not report them here. We also do not report photos of humans or domestic dogs, photos triggered by wind, or photos with no apparent trigger.

Hair Snares

After confirming SNRF detections in the Mono Creek study area, we deployed two hair snares in June 2018 near Mono Pass and Trail Lake Pass. Each snare consisted of five bore brushes arranged linearly along a piece of tag board affixed to a boulder with paracord (e.g., Figura and Knox 2008). We positioned a bait sock above each snare and aimed a camera at the snare to corroborate the species identity of any samples obtained.

Scat Surveys

We conducted scat surveys in cells where SNRF were detected on camera. During scat surveys, field staff scoured terrain features where scat was most detectable, such as trails and high, barren ridges or passes. We collected all apparent carnivore scats following a noninvasive DNA sampling protocol developed by the Mammalian Ecology and Conservation Unit at the University of California, Davis (2014). We also collected scat opportunistically during camera set-up and revisit trips. After returning from the field, we placed each scat in a sample tube with ethanol, labeled the tubes, and mailed them to the Mammalian Ecology and Conservation Unit for DNA analysis.

SNRF scat collected in Mono Creek in summer 2018.

IV. Results

The following tables summarize camera detections of mammals in each survey season. In 2015-16, we conducted surveys in three noncontiguous drainages, so we summarize camera detections for each drainage. 2016-17 and 2017-18 surveys took place in a single drainage or several contiguous drainages.

We report the total number of mammal detections per study area, the number of detections per species, the number of remote cameras deployed, and the number of nights during which remote cameras were operational (excluding nights when cameras were buried by snow or otherwise non-operational). We also report the number of camera sites per study area located on alpine passes, where the probability of detecting mesocarnivores may be higher, as discussed in Section V.

In addition to mammals, we detected 12 bird species: American kestrel, American pipit, American robin, Clark's nutcracker, common raven, dark-eyed junco, gray-crowned rosy finch, rock wren, sooty grouse, white-crowned sparrow, white-tailed ptarmigan, and a flycatcher species, as well as two birds we were unable to identify.

Inferences about abundance and occupancy and between-survey comparisons require further analyses, as detailed in Section V.

Porcupine detected in the Mammoth Lakes Basin study area.

2015-16 Mammoth Lakes Basin Study Area Survey

We deployed eight remote cameras in the Mammoth Lakes Basin study area for a total of 1,299 trapping nights with 344 mammal detections (Table 1). The mammal species most frequently detected by remote cameras were Douglas squirrels and coyotes. A porcupine was detected in a heavily forested area at Emerald Lake.

Table 1. Mammal detections during 2015-16 in the Mammoth Lakes Basin study area.

Carnivores		**Rodents**	
American black bear	3	Belding's ground squirrel	5
American marten	25	Chipmunk *sp.*	16
Bobcat	1	Douglas squirrel	154
Coyote	105	Golden-mantled ground squirrel	1
Ungulates		Porcupine	1
Mule deer	11	Lagomorphs	
		White-tailed jackrabbit	22

2015-16 Rock Creek Study Area Survey

We deployed six remote cameras in the Rock Creek study area. These cameras were active for 825 trapping nights and produced 508 mammal detections (Table 2). The mammal species detected most frequently were Douglas squirrels, coyotes, golden-mantled ground squirrels, and American martens.

A coyote rolls in scented lure at a camera station in the North Fork Bishop Creek study area.

Table 2. Mammal detections during 2015-16 in the Rock Creek study area.

Carnivores		**Rodents**	
American marten	18	Chipmunk *sp.*	9
Bobcat	2	Douglas squirrel	402
Coyote	29	Golden-mantled ground squirrel	21
Long-tailed weasel	1	Yellow-bellied marmot	5
Western spotted skunk	1	**Lagomorphs**	
Ungulates		American pika	10
Mule deer	9	White-tailed jackrabbit	1

2015-16 North Fork Bishop Creek Study Area Survey

We deployed five remote cameras for 690 trapping nights in the North Fork Bishop Creek study area. These cameras yielded 451 mammal detections; the species most frequently detected were golden-mantled ground squirrels, Douglas squirrels, and coyotes (Table 3). This study area produced the fewest American marten detections (n = 3) and the most mule deer detections (n = 18) during the 2015-16 survey season.

Table 3. Mammal detections during 2015-16 in the North Fork Bishop Creek study area.

Carnivores		Rodents	
American black bear	1	Belding's ground squirrel	65
American marten	3	Chipmunk *sp.*	4
Bobcat	3	Douglas squirrel	94
Coyote	84	Golden-mantled ground squirrel	149
Mountain lion	1	Yellow-bellied marmot	20
Ungulates		Lagomorphs	
Mule deer	18	White-tailed jackrabbit	8

2015-16 Survey Summary

A total of 19 remote cameras were deployed in the three study areas of the 2015-16 survey. These cameras were operational for 2,814 nights and obtained 1,303 mammal detections. No cameras were buried during the survey season. Only one camera was positioned on an alpine pass during this survey season; that camera was active for 162 trapping nights.

2016-17 Humphreys Basin Study Area Survey

The 2016-17 Humphreys Basin study area produced the most detections of any survey during the three seasons of this study. Many of these detections were rodents, and coyotes were the most commonly detected carnivore. Eleven badger detections occurred in alpine terrain. An animal tentatively identified as a kit fox was detected in April near Lobe Lake above Piute Canyon at 3,200 m.

Badger detected above 3,500 m in the Humphreys Basin study area.

We deployed 24 remote cameras in the study area, including five cameras placed on alpine passes. In 4,444 total trapping nights, we obtained 2,200 mammal detections (Table 4). Thirteen remote cameras were buried under snow for much of the 2016-17 survey season, reducing total trapping nights for all cameras to 62% of total nights deployed (4,444 nights operational out of 7,164 nights deployed). When possible, a second camera was deployed near the buried camera in March or April in order to continue gathering data for that site.

Table 4. Mammal detections during 2016-17 in the Humphreys Basin study area.

Carnivores		Rodents	
American badger	11	Belding's ground squirrel	361
American black bear	5	Chipmunk *sp.*	72
American marten	42	Douglas squirrel	597
Bobcat	10	Golden-mantled ground squirrel	371
Coyote	189	Mouse *sp*.	9
Kit fox	1	Woodrat	4
Long-tailed weasel	7	Lagomorphs	
Mountain lion	1	American pika	26
Short-tailed weasel	2	White-tailed jackrabbit	47
Ungulates			
Mule deer	125		

2017-18 Mono Creek Study Area Survey

The 2017-18 survey in Mono Creek produced a total of 449 mammal detections on 19 cameras (Table 5). Cameras were operational for 4,546 trapping nights out of 4,907 nights deployed. Cameras detected fewer coyotes and more black bears than in other study areas. A Sierra Nevada bighorn sheep was captured on camera near Italy Lake, west of Bear Creek Spire, and a porcupine was detected in May in Mills Creek at 2,800 m. Thirteen SNRF detections occurred at camera stations located at Crocker Col, Steelhead Pass, Golden Creek, and Mono Pass. An additional SNRF detection occurred at a passive monitoring camera deployed in the Mono Creek study area in June 2018, after the systematic survey concluded. Six remote cameras in five survey cells were placed on alpine passes; 11 of the 13 SNRF detections occurred on passes.

Table 5. Mammal detections during 2017-18 in the Mono Creek study area.

Carnivores		Rodents	
American badger	3	Belding's ground squirrel	4
American black bear	20	Chipmunk *sp.*	15
American marten	34	Douglas squirrel	157
Bobcat	3	Golden-mantled ground squirrel	21
Coyote	50	Porcupine	1
Long-tailed weasel	5	Woodrat	2
Mountain lion	6	Yellow-bellied marmot	36
Sierra Nevada red fox	13	Lagomorphs	
Ungulates		White-tailed jackrabbit	66
Mule deer	12		
Sierra Nevada bighorn sheep	1		

2018 Mono Creek Study Area Scat Surveys

Following the camera detections of SNRF in Mono Creek, we conducted scat surveys to obtain samples for genetic analysis. We collected 27 scat samples from the Mono Creek study area in 2018. Over half of these samples were American marten; five were determined to be SNRF (Table 6). All of the SNRF samples were found between Crocker Col and Mono Pass above 3,800 m; most were found near high passes. Of the SNRF scats, four contained haploytype C and one contained haploytype A. Haplotype C is found only in SNRF, while haplotype A is more widespread, found in all North American montane red foxes (Quinn et al. 2019). Sequencing of nuclear DNA revealed that the scats were deposited by three individual SNRF: two females and one male. The male was last detected by scat in 2017 at Sonora Pass, more than 120 linear kilometers to the north of Mono Creek (C. Quinn, UC Davis, personal communication).

Table 6. Scat samples collected during 2018 in the Mono Creek study area.

Species	Number of Detections
American marten	15
Coyote	4
Sierra Nevada red fox	5
Unable to determine	3
Total Samples	27

The two hair snares in the Mono Creek study area were removed after one month. The hair samples collected were presumed to be marten, as the associated cameras showed that only martens had visited the bait.

2018-19 Ritter Range Study Area Survey

The 2018-19 Ritter Range survey is not yet complete as of the writing of this report, but our preliminary results include one notable detection: a fisher on Beck Lakes Pass, at 3,291 m in barren alpine terrain (Figure 4). The nearest fisher detection documented by USFS surveys between 2011 and 2018 was about 25 km away to the southwest (J. Tucker, USFS, personal communication). Fishers have been detected as high as 3,134 m elsewhere in the Sierra, but most previous detections in this region are concentrated in montane forests below 2,140 m (Spencer et al. 2015).

Figure 4. Fisher detected near Beck Lakes Pass in December 2018.

Passive Monitoring Camera Results

A passive monitoring camera in the Mono Creek study area obtained a SNRF detection on Mount Starr Ridge in December 2018. Non-SNRF detections at passive monitoring cameras have not yet been tabulated.

V. Discussion

Survey Methods and Camera Placement

In the vast, heterogeneous landscape of the Sierra Nevada, species that exist at low population densities can be very difficult to detect, particularly if their habitat use is not well understood. Over the course of three survey seasons, we gained insight into best practices for remote camera placement. During the 2015-16 survey season, we placed cameras preferentially in forested environments (18 out of 22 camera stations) at lower elevations (2,300 m to 3,500 m) to reflect what we understood as the typical habitat association for SNRF in winter (Perrine 2005). The 2016-17 and 2017-18 surveys took place at higher elevations (2,800 m to 3,700 m) and in more alpine habitat types (a majority in barren areas above treeline, with some cameras in subalpine or montane forests) than the 2015-16 survey.

During these latter survey seasons, we used topography rather than habitat type to guide camera placement (Figure 5). We reasoned that narrow passes bounded by impassable terrain on either side offered the highest probability of detection since mesocarnivores would be constrained to use these passes in order to travel between areas within their home ranges. Furthermore, depending on the orientation to prevailing winds, snow accumulation can be limited on high passes and cameras there are less likely to be buried by snow. The placement of more cameras in forested habitat in 2015-16 may have biased results in favor of more forest-adapted mesocarnivores like American martens (Golding et al. 2017), and reduced the probability of detection for SNRF if they were present in the 2015-16 study area. Cameras on high-elevation passes above treeline were more successful at detecting SNRF than cameras in other locations within the Mono Creek study area: 12 of 14 SNRF detections were captured by remote cameras located on passes, while lower elevation cameras in close proximity often did not detect SNRF. These results suggest that SNRF may be more detectable on high-elevation snow-free passes, but should not be interpreted as indicating that SNRF are more common or abundant in these areas.

Figure 5. Approaching a barren high-elevation pass in the Mono Creek study area.

Variability in Survey Areas and Seasons

Environmental conditions varied between the three survey seasons, potentially affecting results. The second survey season took place during 2016-17, the second-wettest winter on record in California (California Department of Water Resources 2017). Snow buried 30% of cameras in the survey area and reduced trapping nights to 4,444 out of 7,164 camera nights deployed.

The heavy winter also affected wildlife populations in the Sierra Nevada, causing considerable documented mortality in Sierra Nevada bighorn sheep (Greene et al. 2019) and mule deer (CDFW personal communication). It is unclear whether other wildlife species experienced similar effects. If so, it is possible that the reduction in camera detections during the 2018 survey resulted from lower abundances of certain species.

SNRF detected on a high-elevation pass in Mono Creek during the winter of 2017-18.

Level of human recreation varied between our survey areas, but the extent of this variation is difficult to quantify. Anecdotally, human presence was rare in winter in the 2016-17 and 2017-18 survey areas and more common in the 2015-16 survey areas. In summer, the 2017-18 survey area likely experienced less human visitation than the 2016-17 and 2015-16 survey areas. Individual SNRF vary in their response to human presence: Grinnell et al. (1937) considered SNRF averse to humans, but SNRF in the Sonora Pass, Lassen, and Oregon populations have been known to beg, scavenge garbage, and demonstrate other signs of habituation to humans (Perrine 2005, J. Bowles, Oregon Department of Fish and Wildlife, personal communication, USFS personal communication). It is unclear how human recreation might affect SNRF habitat use in our study areas, if at all.

Camera Detections

Douglas squirrels were the most frequently detected mammal across all survey areas, and coyotes were the most frequently detected carnivore, followed by American martens. The 2018 survey produced the fewest total mammal detections but the most SNRF detections, suggesting that SNRF are relatively detectable in the Mono Creek survey area, particularly on high-elevation passes.

Further analysis is needed before the camera detections tabulated in Section IV can be used to make inferences about occupancy or abundance. The naive detection results should not be interpreted as estimates of abundance because they do not differentiate between individuals (i.e. 30 coyote detections could be 30 different coyotes, or one coyote that visited the camera 30 times). Also, some species may be more detectable because they use space differently (for example, if a camera is located within the small home range of a rodent, the camera may detect that rodent every day, while a more wide-ranging animal like a mountain lion may intersect much more rarely with any cameras in its home range). Certain species or individuals may perceive and avoid camera stations, further complicating interpretation of results (Sequin et al. 2003, Meek et al. 2016). Environmental variation between study areas, camera locations, and seasons may also affect detectability, as discussed above.

Occupancy

Remote camera survey results can be misleading because failure to detect a species on camera does not necessarily indicate that the species is absent from a survey cell—only that it did not trigger the camera. Occupancy models, which account for this fact, provide a non-invasive and cost-effective way to elucidate the geographic distribution of wildlife populations by incorporating estimates of detectability at survey sites to determine the probability that the species of interest occupies a site (Bailey and Adams 2005). We are currently working to generate occupancy estimates for the alpine mesocarnivore species detected in this study.

Lack of Wolverine Detections

Wolverine home ranges are much larger than the home ranges of other carnivores of similar size, typically encompassing hundreds of square kilometers (Hornocker and Hash 1981, Copeland 1996, Inman et al. 2012). The large size of wolverine home ranges likely reflects the low productivity within their alpine habitat (Inman et al. 2012). In addition to traveling throughout large home ranges, wolverines are capable of long-distance exploratory movements (Magoun 1985, Gardner et al. 1986, Copeland 1996, Inman et al. 2012). Remote camera surveys for wolverines are thought to be more effective in winter, when food resources are scarce and evidence suggests they are more attracted by bait (Hornocker and Hash 1981, Zielinski and Kucera 1995, Hudgens and Garcelon 2007).

During 2015-2018, our winter surveys did not detect wolverines in the Sierra Nevada between Yosemite and Kings Canyon National Parks. Passive monitoring cameras also did not produce any wolverine detections, though some were set in response to reported wolverine sightings or the presence of large amounts of deer carrion that would be expected to attract resident carnivores. Concurrent winter remote camera surveys in Yosemite National Park also did not detect wolverines (S. Stock, Yosemite National Park, unpublished data), nor did CDFW's fall and winter low-elevation mesocarnivore surveys (Ellsworth et al. 2016, 2017, unpublished data). While conducted using slightly different protocols, these additional camera surveys add considerably to the total area surveyed by remote camera stations during this period (Figure 7). Typical wolverine surveys deploy only one camera per 225 km^2 grid cell (Welander 2017, Multi-state Wolverine Working Group 2015). CDFW and NPS mesocarnivore surveys, by contrast, deployed one or more cameras per 10.4 km^2 grid cell, totaling a minimum of 473 cameras across the 66 wolverine grid cells sampled. Our surveys would therefore be expected to have a higher-than-standard probability of detection within the majority of the wolverine grid cells sampled.

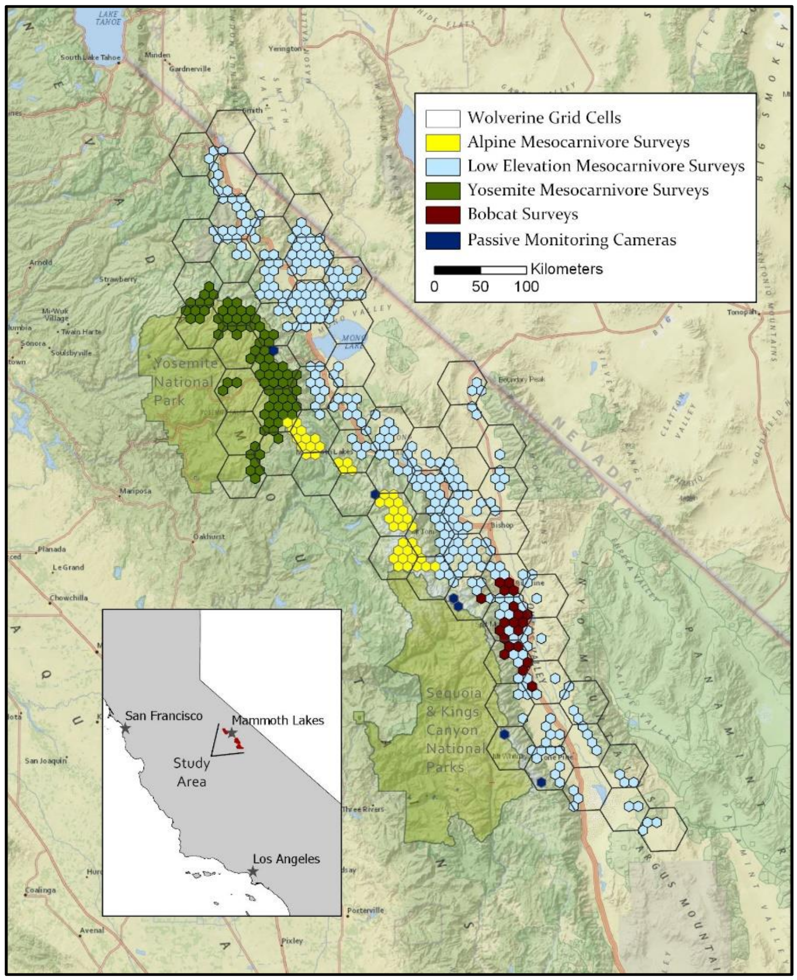

Figure 7. Cells surveyed by remote camera during 2014-2019. Different colors denote different survey methods, however all surveys were conducted following protocols that would be expected to have a high probability of detection for wolverines if they were present.

Species that occur at low densities are challenging to detect by remote camera, and lack of detection is not necessarily equivalent to absence. However, given the success of our methods in detecting other rare carnivores, and the wolverine's apparent high mobility and attraction to bait and lure, our results suggest that the central and southern Sierra Nevada may no longer host a resident wolverine population.

SNRF Detections

CDFW's 2018 detections confirm the presence of at least three SNRF individuals in the Mono Creek watershed. While this result does not enable inferences about population status, it certainly prompts further study.

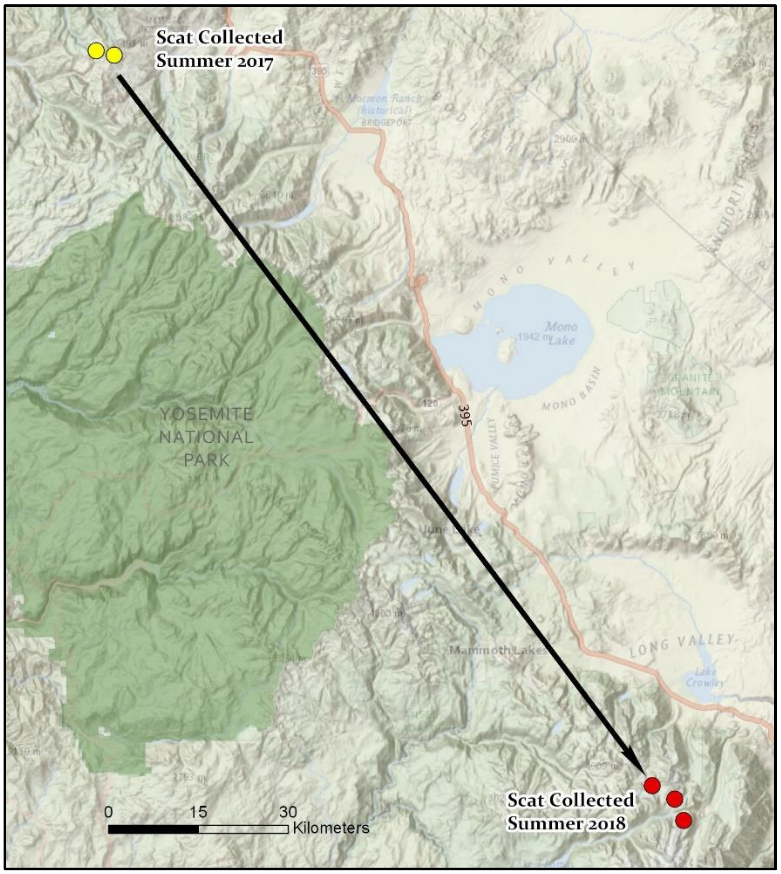

Figure 8. Dispersal movement of male SNRF from Sonora Pass in summer 2017 to Mono Creek in summer 2018.

One of the SNRF individuals detected at Mono Creek was a male previously sampled by scat near Sonora Peak in August and September 2017 (C. Quinn, UC Davis, personal communication). The linear distance from Sonora Peak to Steelhead Pass in Mono Creek is more than 120 km (Figure 8). Because the terrain between Sonora Pass and Mono Creek is extremely mountainous, the actual distance traveled by this SNRF male was likely much farther than the linear distance. Typical dispersal distances for SNRF are not known, but eight studies summarized by Trewhella et al. (1988) found mean dispersals for juvenile males of 2.8-43.5 km. Studies in the midwestern United States have documented male red fox dispersals as far as 346 km (Storm et al. 1976) and 395 km (Ables 1965). Dispersal distances have not been well studied in other montane red fox populations, though large movements have been reported: Cross (2015) documented a female Rocky Mountain red fox with a home range of 90 km^2, and Akins (2017) found closely related Cascade red foxes more than 90 km apart.

The other two SNRF individuals detected at Mono Creek were females of unknown origin. Dispersal distances are typically shorter for female than male red foxes (Trewhella et al. 1988, Cross 2015). These females may also have dispersed from Sonora Pass, may be descendants of previous dispersers, or may represent a distinct local population that was previously undetected.

Future Efforts

During the winter and spring of 2019, CDFW continued its alpine mesocarnivore surveys up to the southern border of Yosemite National Park. Survey sites were between 2,800 m and 3,700 m in elevation and were predominantly located in alpine habitat (19 out of 24 camera stations). Results from the 2018-2019 survey are not yet tabulated.

The detection of SNRF in a region where the subspecies was previously thought to be extirpated has generated momentum for a focused planning effort to work toward conservation of the subspecies. A team of agency representatives and researchers has convened to develop a Conservation Strategy for the SNRF. This document will detail research needs and management priorities, and will guide SNRF conservation throughout its range. A draft Conservation Strategy is slated for completion in 2020.

SNRF detected on a high-elevation pass in Mono Creek during the winter of 2017-18.

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