

SMALL MAMMAL SURVEYS AT BITTER CREEK NATIONAL WILDLIFE REFUGE



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EXECUTIVE SUMMARY

Surveys were conducted for small mammals at Bitter Creek National Wildlife Refuge (Bitter Creek NWR) in Fall 2012. The objective of this effort was to inventory species occurring on the refuge. Surveys were conducted by live-trapping along 19 transects established in a diversity of plant communities within 3 major habitat types: grasslands, shrublands, and woodlands. In 3,316 trapnights, 202 individual rodents were captured representing 6 species. Heermann's kangaroo rats (*Dipodomys heermanni*) were the most frequently detected species (n = 169) followed by deer mice (*Peromyscus maniculatus*; n = 17), big-eared woodrats (*Neotoma macrotis*; n = 11), California vole (*Microtus californicus*; n = 3), Bryant's woodrats (*Neotoma bryanti*; n = 1), and California pocket mice (*Chaetodipus californicus*; n = 1). The diversity and abundance of rodents increased with the structural diversity of the vegetation. Both the number of species and capture rates for all species combined were highest in woodland habitats (5 species, 9.3 individuals per 100 trapnights), intermediate in shrubland habitats (4 species, 7.8 individuals per 100 trapnights), and lowest in grassland habitats (2 species, 1.1 individuals per 100 trapnights). Two species, Heermann's kangaroo rat and deer mouse, were detected in all habitat types and most plant communities. Three other species were not captured but were verified as present at Bitter Creek NWR based on observations of individuals or diagnostic sign: California ground squirrels (*Otospermophilus beecheyi*), Botta's pocket gopher (*Thomomys bottae*), and Merriam's chipmunk (*Neotamias merriami*). No special status species were detected during the survey. However, the giant kangaroo rat (*Dipodomys ingens*; Federal Endangered, California Endangered), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*; Federal Species of Concern, California Threatened), and the white-eared pocket mouse (*Perognathus alticola inexpectatus*; California Mammal Species of Special Concern) could potentially occur on the refuge in areas not surveyed. Vegetation management, particularly in grasslands, potentially could increase habitat suitability for giant kangaroo rats and San Joaquin antelope squirrels.

INTRODUCTION

Bitter Creek National Wildlife Refuge (NWR) encompasses 14,097 acres (U.S. Fish and Wildlife Service 2012) and is located in the southwestern portion of the San Joaquin Valley, California (Fig. 1). The refuge is part of the Hopper Mountain NWR Complex and is managed by the U.S. Fish and Wildlife Service. Bitter Creek NWR was established in 1985 to provide foraging and roosting habitat for endangered California condors (*Gymnogyps californianus*). In addition to condors, several distinct habitat types are present on the refuge and likely support a diversity of animal and plant species. However, few formal resource inventories have been conducted.



Figure 1. Bitter Creek National Wildlife Refuge, CA.

A comprehensive conservation plan is being prepared for Bitter Creek NWR. Species inventories can help guide the development of conservation strategies on the refuge as well as provide baseline data for evaluating the efficacy of management strategies. No surveys of rodent communities have been conducted at Bitter Creek NWR. The varied habitats present on the refuge may support a diversity of rodent species, potentially including some rare taxa. During Fall 2012, the California State University-Stanislaus, Endangered Species Recovery Program (ESRP) conducted live-trapping surveys in representative habitats on Bitter Creek NWR to determine the presence, relative abundance, and habitat associations of rodent species.

METHODS

SURVEY SITES

Surveys were conducted in a manner that optimized survey effort while also maximizing the diversity of habitats sampled. To optimize effort, surveys were conducted in different regions of Bitter Creek NWR each week. By focusing on a specific region, travel time between traplines was reduced. This minimized the amount of time that animals were in traps after sunrise (a critical factor when temperatures are warm) and also allowed the deployment of more traps than if sites were widely dispersed. Within each region, sites with varied habitat conditions were selected to increase the probability of detecting unique species. Each week, surveys were conducted in one region on 6-8 sites.

LIVE-TRAPPING

The goal of the project was to determine the small mammal species present on Bitter Creek NWR. Thus, sites were subjectively chosen that represented the diversity of habitat conditions found on the refuge. Within each site, traplines were laid out in a linear fashion, but occasionally meandered in order to sample different microhabitats. Most lines consisted of 25 trap stations, but shorter lines were established in locations where topography (e.g., steep terrain) limited line length. Traps were spaced at approximately 15-m intervals. One Sherman aluminum box trap (7.6 cm x 9.5 cm x 30.5 cm; H. B. Sherman Traps Inc., Tallahassee, FL), modified to prevent injury to kangaroo rat (*Dipodomys spp.*) tails, was placed at each trap station. Each trap was provisioned with a handful (ca. 20 ml) of millet seed for bait and an unbleached paper towel or wad of cotton batting for bedding and thermal insulation. Traps were opened and set near dusk and checked beginning prior to sunrise the following morning. All rodents captured were identified to species and marked ventrally with a non-toxic felt-tipped marker to identify recaptured animals. For each animal, we determined sex, estimated age (adult or juvenile based on size and pelage), and measured mass at first capture. Additional morphometric data (e.g. hind-foot length) were collected when such information aided species identifications. All captured animals were released at corresponding capture sites after processing. Traps were operated for 4 consecutive nights on each site.

RESULTS

HABITAT TYPES SURVEYED

Small mammal surveys were conducted at Bitter Creek NWR in 3 broad habitat types: grasslands, shrublands, and woodlands. Within each of these habitat types, traplines were established in several different plant communities (Table 1). A total of 39 traplines were established (see Appendix A for locations and descriptions of individual traplines).

Plant community descriptions were compiled from field observations supplemented with information from the draft conservation plan for the Bitter Creek NWR (U.S. Fish and Wildlife Service 2012). Grassland habitats on the refuge are dominated by a diversity of non-native grasses. Mixed herb/non-native grass sites were dominated by ripgut brome (*Bromus diandrus*) and wild oats (*Avena fatua* and *A. barbata*). During the growing season, common forbs include red-stemmed filaree (*Erodium cicutarium*), lupines

(*Lupinus spp.*), fiddleneck (*Amsinkia tessellata*), California poppy (*Eschscholzia californica*), and California aster (*Lessingia filaginifolia*). Ripgut brome/wild oat sites were heavily dominated by these 2 species with very low cover of any other species. The red brome (*Bromus madritensis*) site was dominated by this non-native species, with low cover of other grasses and forbs. The sandy wash site consisted of a large, wide dry wash with mostly bare ground but some scattered red brome and shrubs.

Table 1. Habitat types and plant communities surveyed for small mammals at the Bitter Creek NWR, September - November 2012.

Habitat Type	Plant Community	Number of Traplines
<u>Grasslands</u>		
	Mixed herb/non-native grass	9
	Ripgut brome/wild oats	2
	Red brome	1
	Sandy wash	1
<u>Shrublands</u>		
	Goldenbush	5
	Rabbitbrush/seep	1
	Yucca/buckwheat	1
<u>Woodlands</u>		
	Mixed oak/pinyon pine	6
	Tucker oak/juniper	2
	Juniper	5
	Tucker oak	4
	Chokecherry	2

Shrubland habitats were more structurally diverse than grasslands. Shrubland sites usually included moderate to high densities of shrubs and varying densities of herbaceous ground cover. Goldenbush sites were dominated by interior goldenbush (*Ericameria linearifolia*). The rabbitbrush/seep site had a high density of rubber rabbitbrush (*Chrysothamnus nauseosus*) and included a large seep area dominated by rushes (*Juncus spp.*). The yucca/buckwheat site had moderate densities of foothill yucca (*Hesperoyucca [= Yucca] whipplei*) and California buckwheat (*Eriogonum fasciculatum*).

Woodland habitats were structurally variable and diverse. Shrub understories were absent to moderate density. Ground cover generally was absent to sparse under tree canopies and sparse to dense in open areas between trees. Mixed oak/pinyon pine sites included the scrubby Alvord oak (*Quercus x alvordiana*) with some Tucker oak (*Q. john-tuckeri*) and scattered single-leaf pinyon pines (*Pinus monophylla*). Tucker oak and Tucker oak/juniper sites were characterized by scattered scrub oaks with California juniper (*Juniperus californica*) interspersed in the latter community. This species also characterized Juniper sites, while Chokecherry (*Prunus virginiana*) sites were located in a dense thicket of this species in a seep area.

LIVE-TRAPPING

Live-trapping was conducted during 24 September - 9 November 2012. During this period, traps were opened for 22 nights resulting in 3,316 trapnights. Traps were closed a day early during the third and sixth weeks due to heavy precipitation, resulting in just 3 nights of trapping during those weeks. A total of 202 individuals were captured representing 6 species (Table 2): Heermann's kangaroo rat (*Dipodomys heermanni*), deer mouse (*Peromyscus maniculatus*), big-eared woodrat (*Neotoma macrotis*), Bryant's woodrat (*Neotoma bryanti*), California vole (*Microtus californicus*), and California pocket mouse (*Chaetodipus californicus*). The number of species detected increased with the structural diversity of the vegetation. Both the number of species and capture rates for all species combined were highest in woodland habitats and lowest in grassland habitats (Tables 2 and 3). Two species, Heermann's kangaroo rat and deer mouse, were detected in all habitat types and most plant communities.

Three other species were not captured but were verified as present at Bitter Creek NWR based on observations of individuals or diagnostic sign. California ground squirrels (*Otospermophilus beecheyi*) and their burrows were commonly observed on the refuge. Burrows of Botta's pocket gopher (*Thomomys bottae*) also were commonly observed. A chipmunk was observed in a juniper area in the southwestern portion of the refuge on 1 October 2012. This individual was presumed to be a Merriam's chipmunk (*Neotamias merriami*), as that species is listed as present at the refuge (U.S. Fish and Wildlife Service 2012).

Table 2. Small mammals captured at the Bitter Creek NWR by habitat type and plant community, September – November, 2012.

<u>Habitat type</u> Plant community	Trap- lines	Trap- nights	Number of species	Total number of individuals	Species ¹					
					DIHE	CHCA	PEMA	NEMA	NEBR	MICA
<u>Grasslands</u>										
Mixed herb/non-native grasses	9	900	1	3	3					
Ripgut brome/wild oats	2	150	0	0						
Red brome	1	75	1	1	1					
Sandy wash	1	75	2	9	7		2			
Total	13	1200	2	13	11		2			
<u>Shrublands</u>										
Goldenbush	5	375	2	24	21		3			
Rabbitbrush/seep	1	100	4	10	4		4		1	1
Yucca/buckwheat	1	100	1	11	11					
Total	7	575	4	45	36		7		1	1
<u>Woodlands</u>										
Mixed oak/pinyon pine	6	376	3	20	18		1	1		
Tucker oak/juniper	2	200	4	16	12	1	2	1		
Juniper	5	475	3	71	66		2	3		
Tucker oak	4	350	3	33	25		2	6		
Chokecherry	2	140	3	4	1		1			2
Total	19	1541	5	144	122	1	8	11		2

¹ DIHE = Dipodomys heermanni; CHCA = Chaetodipus californicus; PEMA = Peromyscus maniculatus; NEMA = Neotoma macrotis; NEBR = Neotoma bryanti; MICA = Microtus californicus

Table 3. Small mammal capture rates by habitat type at the Bitter Creek NWR, September–November, 2012.

Habitat type	Individuals/100 trapnights						
	All species	DIHE	CHCA	PEMA	NEMA	NEBR	MICA
Grasslands	1.1	0.9		0.2			
Shrublands	7.8	6.2		1.2		0.2	0.2
Woodlands	9.3	7.9	0.1	0.5	0.7		0.1

DISCUSSION

Through live-trapping and opportunistic observations, 9 small mammal species were detected at Bitter Creek NWR during surveys conducted in Fall 2012. Heermann's kangaroo rats were by far the most frequently captured species, comprising about 85% of all individuals captured. These individuals were identified as Heermann's kangaroo rats, although this species can be difficult to distinguish on gross morphological characteristics from the closely related Pacific or agile kangaroo (*D. agilis*). Although the two species potentially can overlap, Pacific kangaroo rats primarily occur on the south side of the Transverse Ranges while Heermann's kangaroo rats occur primarily on the north (Zeiner et al. 1990). This plus the strong resemblance to known Heermann's kangaroo rats captured in the San Joaquin Valley led to the identification of these animals as Heermann's kangaroo rats. Neither species is considered rare, and therefore there would be no regulatory issues regardless of which species is present.

Heermann's kangaroo rats were captured in all habitat types and all of the plant communities sampled except for areas with dense ripgut brome and wild oats. This species tends to be ubiquitous in central California and are habitat generalists compared to other kangaroo rat species (Zeiner et al. 1990). Although kangaroo rats are generally adapted to arid habitats with relatively sparse ground cover, Heermann's kangaroo rats have sufficient ecological plasticity that they also are able to use some shrublands and woodlands as long as the ground cover is not too dense. Deer mice also were captured in all habitat types and many plant communities, although at much lower frequencies than Heermann's kangaroo rats. Deer mice also are ubiquitous and are habitat generalists that are able to use a wide diversity of plant communities (Zeiner et al. 1990).

Woodrats from the *Neotoma fuscipes* complex (Matocq 2002) were captured in all woodlands with oaks or junipers. Although capture rates were not high, this species is common and wide-spread in these plant communities, based on the abundance of woodrat nests observed during the survey. The correct taxonomic classification of these animals is uncertain. Matocq (2002) found sufficient variation in the *N. fuscipes* complex to propose that animals in certain portions of the *N. fuscipes* range warranted recognition as a separate species, namely *N. macrotis*. The 2 species are distinguished based on cranial, glans penes, and genetic characteristics. Data on these characteristics were not collected from captured animals. Furthermore, Bitter Creek NWR appears to be located in the vicinity of a contact zone between these 2 species (Matocq 2002) increasing the difficulty of a positive species identification. Despite the taxonomic uncertainty, neither species is

considered rare, and therefore there would be no regulatory issues regardless of which species is present.

A Bryant's woodrat also was captured. This species is a form of desert woodrat (*N. lepida* complex; Patton et al. 2008) and commonly occurs throughout the region in areas with yucca plants. The individual was captured at the base of a southwest facing hillside on which yucca were abundant. California voles were detected at 2 locations. This species generally occurs on more mesic sites (Zeiner et al. 1990), and indeed, seeps with more mesic vegetation were present on both sites where voles were detected. One California pocket mouse also was captured. This species and the Bryant's woodrat apparently had not been reported previously from Bitter Creek NWR (U.S. Fish and Wildlife Service 2012).

Small mammal abundance (based on captures of individuals) and diversity (based on the number of species captured) appeared to be related to the structural complexity of vegetation. Accordingly, abundance and diversity were highest in woodlands and lowest in grasslands. In plant communities with higher structural complexity, more niches may be available which may accommodate more species. Grasslands had the lowest structural complexity, and therefore may have fewer niches available for exploitation by different species. Furthermore, grasslands in this region have been significantly altered due to invasion by non-native grasses such as wild oats, ripgut brome, red brome, soft chess (*Bromus hordeaceus*), and cheat grass (*Bromus tectorum*). Indeed, these areas likely were historically dominated by annual and perennial forbs prior to invasion by non-native grasses (Hamilton 1997, Minnich 2008, Holstein 2011). Small mammal abundance and community composition in these areas prior to invasion by non-native grasses is unknown. The low abundance and diversity of rodents in grasslands on Bitter Creek NWR is consistent with results from small mammal surveys conducted in similar habitats on the nearby Wind Wolves Preserve (Cypher et al. 2011) and Tejon Ranch (Cypher et al. 2010). Conversely, abundance and diversity both were higher in shrub habitats and highest in woodland habitats. Rodent abundance and diversity also were higher in areas with shrubs compared to areas without shrubs in the nearby Lokern Natural Area (Nelson et al. 2007).

We attempted to survey in areas that differed in topographic or vegetation attributes in an effort to detect any species that might have been restricted to specific microhabitats. However, additional species may be present that were not detected during this survey. Species that were detected, as well as species that potentially may occur on the refuge, are listed in Appendix C. A species was listed as potentially occurring if its known range included the refuge and if appropriate habitat is present on the refuge, based on habitat descriptions in the California Wildlife Habitat Relationships System (Zeiner et al. 1990). In addition to the 9 species detected, 10 other species were identified as potentially occurring on the refuge.

No special status species were detected during the survey. Habitat potentially is present for 3 special status species, including the giant kangaroo rat (*Dipodomys ingens*; Federal Endangered, California Endangered), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*; Federal Species of Concern, California Threatened), and the white-eared pocket mouse (*Perognathus alticola inexpectatus*; California Mammal Species of Special Concern). Giant kangaroo rats occur in arid scrub habitat with sparse ground cover in gentle to moderate terrain (Williams and Kilburn 1991). Giant kangaroo rats are known to occur approximately 3 km north of the refuge (K. Sharum, Bureau of Land

Management, personal communication; B. Stafford, California Department of Fish and Game, personal communication). San Joaquin antelope squirrels are found in similar habitat conditions (Best et al. 1990) and are known to occur 1.5-2 km north of Bitter Creek NWR (K. Sharum, Bureau of Land Management, personal communication; B. Stafford, California Department of Fish and Game, personal communication). Indeed, in November 2012, 2 individuals were observed along Soda Lake Road just 1.5-2.0 km north of the refuge boundary (Cypher, personal observation). Both giant kangaroo rats and San Joaquin antelope squirrels could potentially be present in areas along the northern boundary of the refuge. Habitat conditions may be particularly suitable along the Bitter Creek drainage in the northeastern portion of the refuge. However, no surveys were conducted in this area due to difficult access. White-eared pocket mice occur in arid shrub-steppe type habitats, and also are occasionally found in arid grasslands and even yellow pine (*Pinus ponderosa*) forests (Best 1994). The nearest occurrences for this species are approximately 15 km southeast near Mt. Pinos. Arid shrublands on the refuge, particularly those with California buckwheat and scattered junipers, are potential habitat for this species.

Habitat suitability for both giant kangaroo rats and San Joaquin antelope squirrels potentially could be increased through vegetation modification. In particular, management strategies that reduce the height and density of vegetation in the non-native grasslands might benefit these species. Potential strategies include grazing, burning, and mowing. Of these, grazing is likely the most feasible. Burning and mowing are difficult to conduct on a landscape scale, can be expensive, and may involve other significant challenges (e.g., air pollution control permits for burning). Bitter Creek NWR already has significant infrastructure (e.g., fencing, water storage and distribution capacity), and grazing could actually generate income for the refuge. Standards and goals presented in a proposed grazing plan for Bitter Creek NWR (U.S. Fish and Wildlife Service 2012) would constitute appropriate strategies for potentially improving suitability for giant kangaroo rats and San Joaquin antelope squirrels. Even if habitat modification did not result in colonization by special status species, it might increase rodent populations in grasslands, which could benefit other species such as raptors and endangered San Joaquin kit foxes (*Vulpes macrotis mutica*).

CONCLUSIONS AND RECOMMENDATIONS

This initial survey of small mammals at the Bitter Creek NWR detected 9 species: 6 through live-trapping and 3 through observations of individuals or diagnostic sign. No special-status species were detected during the survey. There is some chance that certain special-status species could occur in portions of the refuge where surveys were not conducted, particularly in the northeastern portion in the Bitter Creek canyon. It also is possible that additional species might colonize the refuge or, if already present, increase to a more easily detected level if habitat conditions change on the refuge, such as through habitat manipulations (e.g., grazing) or climate change. Based on survey results, the following suggestions and recommendations are provided.

1. CONDUCT ADDITIONAL SURVEYS

Consider additional small mammal surveys, particularly in areas with habitat conditions different from those sampled in the 2012 survey. Conducting such surveys may be challenging, particularly in areas such as the Bitter Creek canyon. Thus, the value and necessity of additional surveys will have to be balanced against the considerable effort it might require to conduct them. In Appendix C, a list is provided of species known to occur or that potentially occur on the refuge. In Appendix D, a key is provided to assist in identifying these species.

2. MONITOR RESPONSE TO HABITAT MANAGEMENT

Consider monitoring responses by small mammal populations to habitat management programs. In particular, grazing is being considered at Bitter Creek NWR as a tool to manipulate habitat conditions, primarily by reducing the cover of non-native grasses. If grazing or other habitat management strategies are implemented, it may be desirable to assess the response by small mammal communities (e.g., changes in community composition, changes in the relative abundance of species). Preferably, monitoring could be implemented prior to the initiation of the management in order to better assess responses.

3. INTRODUCE SPECIAL-STATUS SPECIES

Consider potentially introducing and establishing populations of special-status species. Such species may be most effectively conserved on lands that are permanently protected. Thus, if habitat conditions are determined to be appropriate to support certain special-status species, then introductions could be conducted. Particular candidates might include giant kangaroo rats and San Joaquin antelope squirrels.

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APPENDIX A: SURVEY TRAPLINES

For the 2012 small mammal survey at Bitter Creek NWR, live-trapping was conducted on 39 trap lines over 6 weeks. Each week, 6-8 lines were established. Table A.1 provides details on habitat attributes, trapping effort, and captures for each trapline. Figure A.1 shows the locations of weekly trapping efforts while Figures A.2-A.7 provide a more detailed view of trapline locations on the refuge.

Table A.1 Habitat attributes, trapping effort, and captures for small mammal traplines at Bitter Creek NWR during 24 September – 8 November, 2012.

Week/dates	Line	Habitat type	Plant community	No. traps	No. trap-nights	Individuals captured ¹					
						DIHE	CHCA	PEMA	NEMA	NEBR	MICA
1 9/24-9/28	1A	Woodland	Mixed oak/pinyon pine	12	48	1					
	1B	Woodland	Mixed oak/pinyon pine	12	48	1					
	1C	Woodland	Mixed oak/pinyon pine	20	80	4					
	1D	Woodland	Mixed oak/pinyon pine	20	80	5					
	1E	Woodland	Mixed oak/pinyon pine	15	60	2					
	1F	Woodland	Mixed oak/pinyon pine	15	60	5		1	1		
	1G	Woodland	Chokecherry	15	60			1			1
	1H	Woodland	Chokecherry	20	80	1					1
2 10/1-10/5	2A	Woodland	Juniper	25	100	14		2			
	2B	Woodland	Juniper	25	100	6			1		
	2C	Shrubland	Rabbitbrush/seep	25	100	4		4		1	1
	2D	Shrubland	Yucca/buckwheat	25	100	11					
	2E	Woodland	Juniper	25	100	17					
	2F	Woodland	Juniper	25	100	24			1		
3 10/8-10/11	3A	Grassland	Ripgut brome/wild oats	25	75						
	3B	Grassland	Ripgut brome/wild oats	25	75						
	3C	Woodland	Juniper	25	75	5			1		
	3D	Shrubland	Goldenbush	25	75	2					
	3E	Woodland	Tucker oak	25	75	8		1			
	3F	Woodland	Tucker oak	25	75	2				4	

Week/dates	Line	Habitat type	Plant community	No. traps	No. trap-nights	Individuals captured ¹					
						DIHE	CHCA	PEMA	NEMA	NEBR	MICA
4 10/22-10/26	4A	Grassland	Mixed herb/non-native grasses	25	100						
	4B	Grassland	Mixed herb/non-native grasses	25	100						
	4C	Grassland	Mixed herb/non-native grasses	25	100						
	4D	Woodland	Tucker oak/juniper	25	100	7	1	2	1		
	4E	Woodland	Tucker oak/juniper	25	100	5					
	4F	Woodland	Tucker oak	25	100	8		1	2		
	4G	Woodland	Tucker oak	25	100	7					
5 10/29-11/2	5A	Grassland	Mixed herb/non-native grasses	25	100						
	5B	Grassland	Mixed herb/non-native grasses	25	100						
	5C	Grassland	Mixed herb/non-native grasses	25	100	3					
	5D	Grassland	Mixed herb/non-native grasses	25	100						
	5E	Grassland	Mixed herb/non-native grasses	25	100						
	5F	Grassland	Mixed herb/non-native grasses	25	100						
6 11/5-11/8	6A	Shrubland	Goldenbush	25	75	4					
	6B	Shrubland	Goldenbush	25	75	5		3			
	6C	Shrubland	Goldenbush	25	75	6					
	6D	Shrubland	Goldenbush	25	75	4					
	6E	Grassland	Red brome	25	75	1					
	6F	Grassland	Sandy wash	25	75	7			2		

¹ DIHE = *Dipodomys heermanni*; CHCA = *Chaetodipus californicus*; PEMA = *Peromyscus maniculatus*; NEMA = *Neotoma macrotis*; NEBR = *Neotoma bryanti*; MICA = *Microtus californicus*

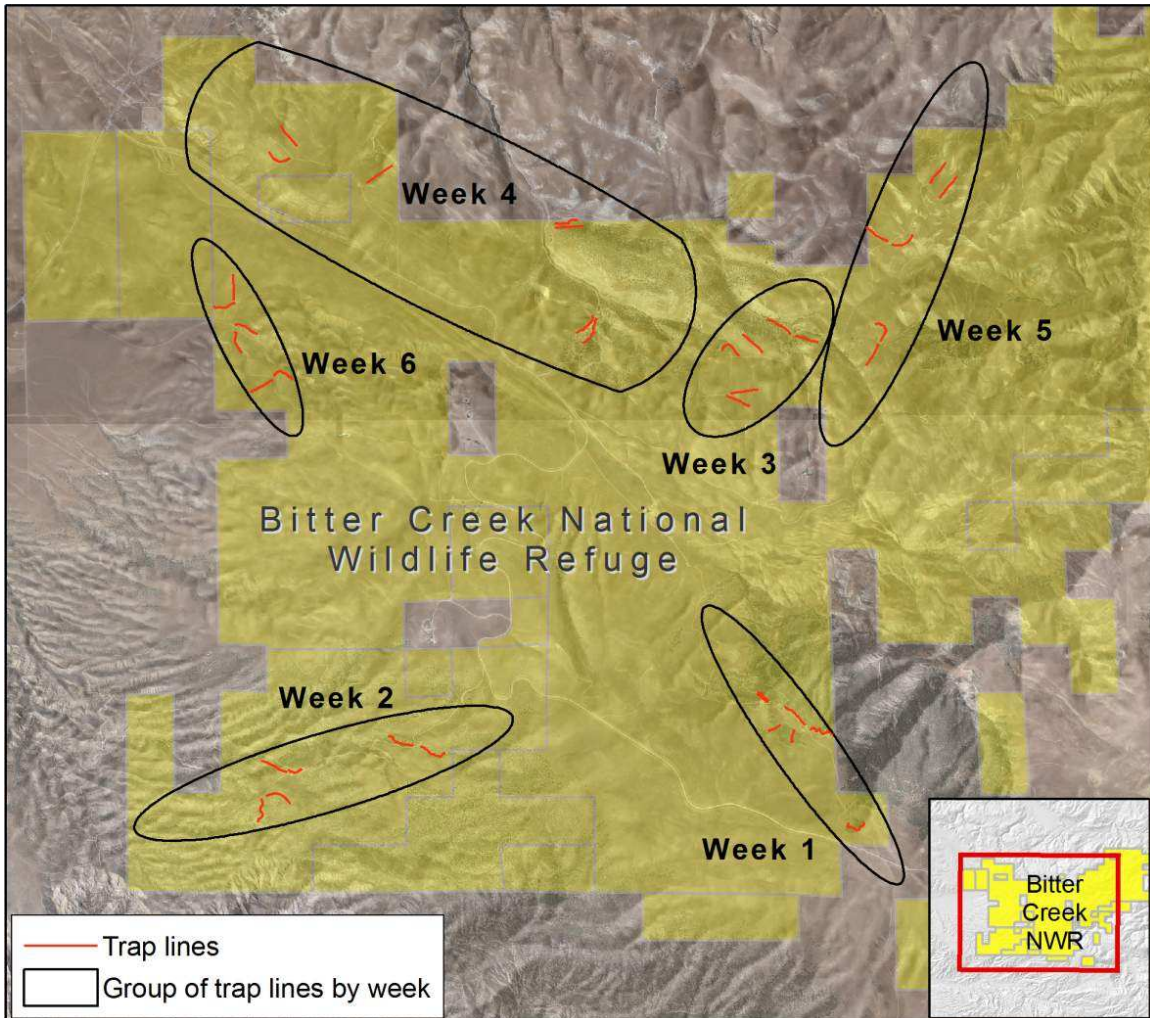


Figure A.1 Locations of groups of small mammal traplines at Bitter Creek NWR.

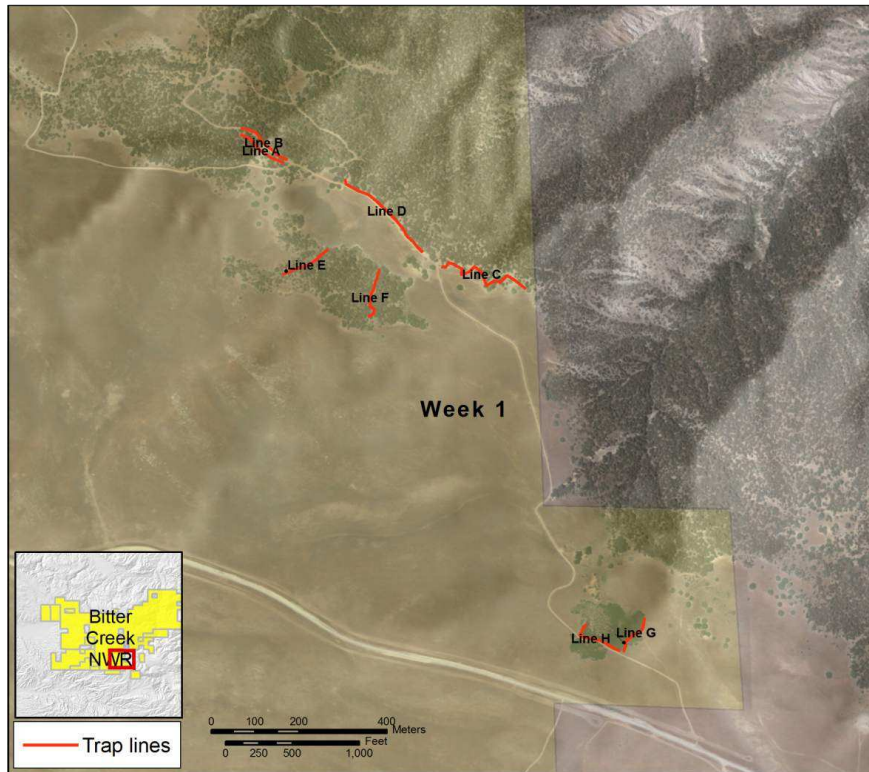


Figure A.2 Locations of small mammal traplines surveyed during Week 1 at Bitter Creek NWR.

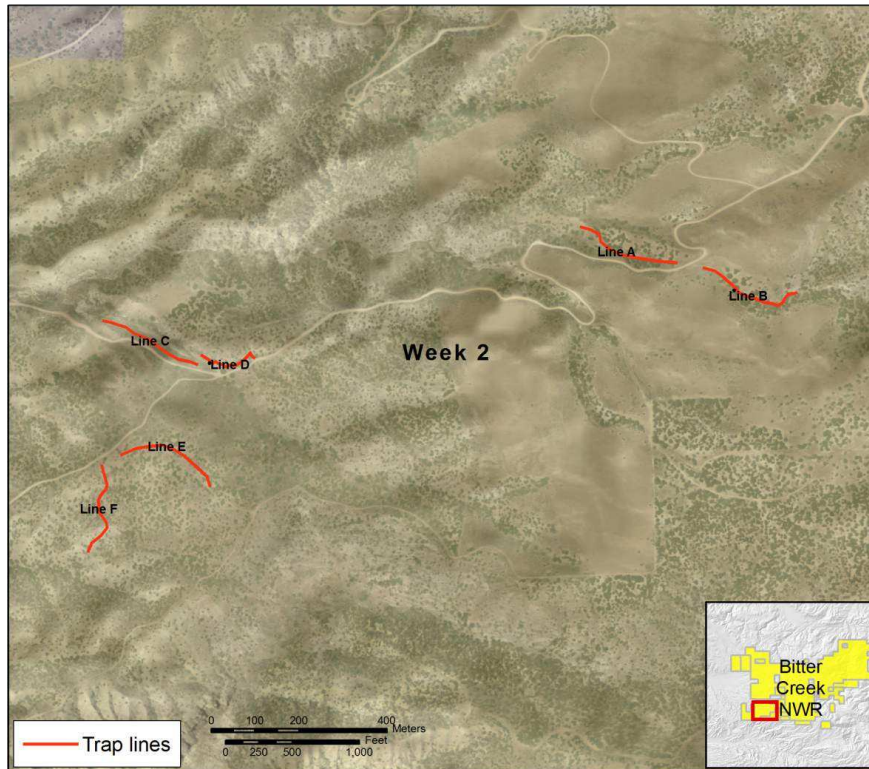


Figure A.3 Locations of small mammal traplines surveyed during Week 2 at Bitter Creek NWR.

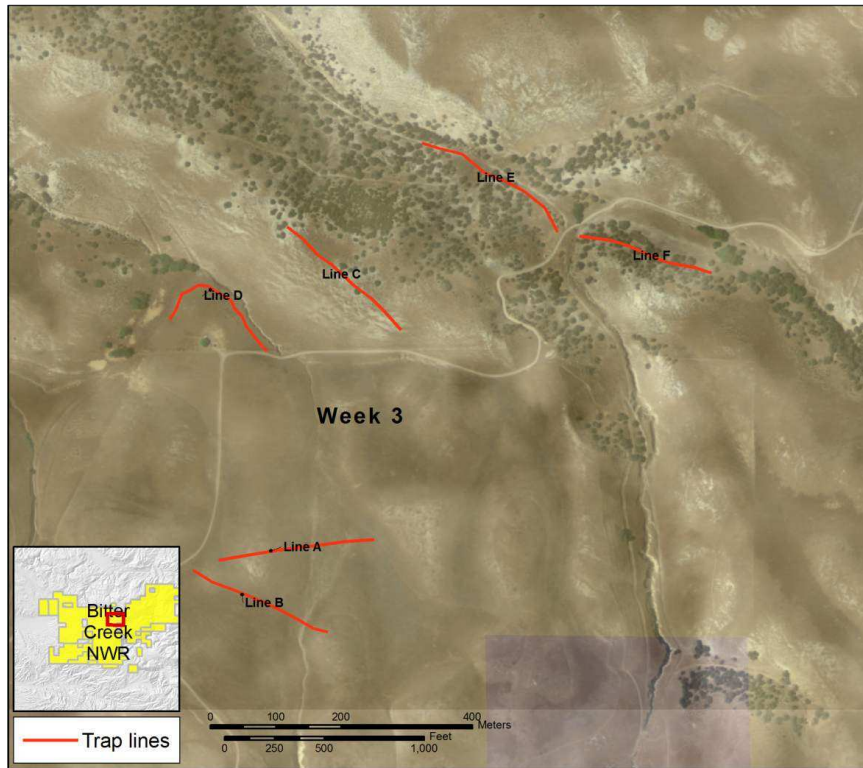


Figure A.4 Locations of small mammal traplines surveyed during Week 3 at Bitter Creek NWR.

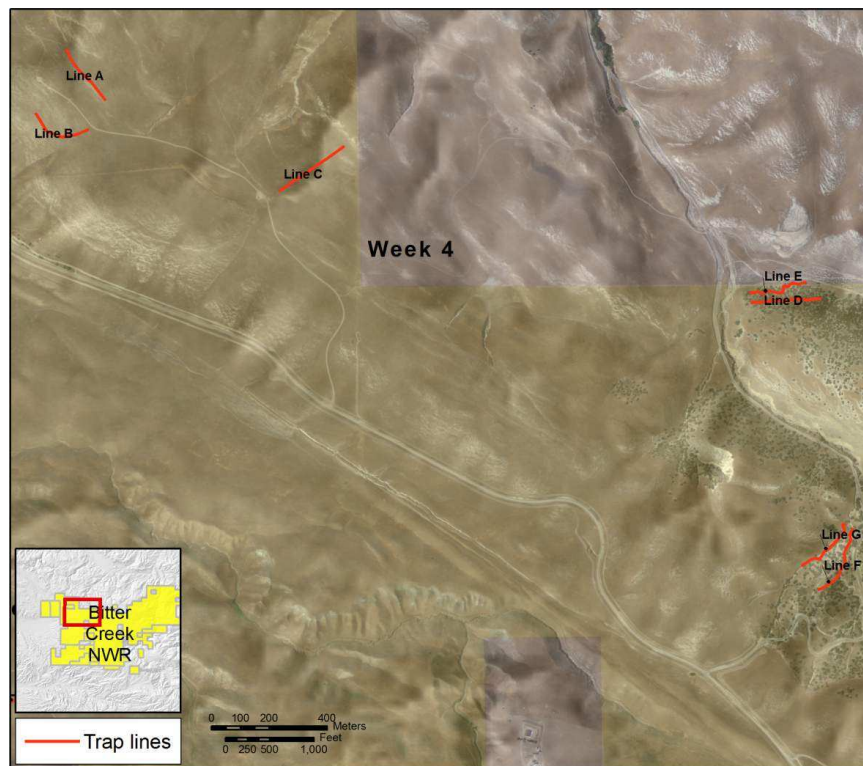


Figure A.5 Locations of small mammal traplines surveyed during Week 4 at Bitter Creek NWR.

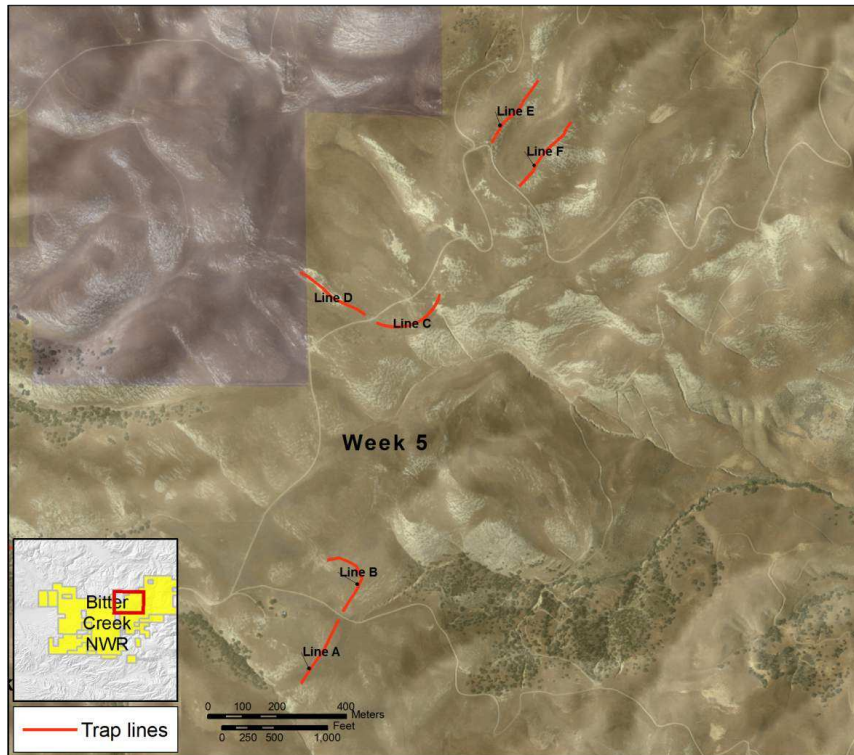


Figure A.6 Locations of small mammal traplines surveyed during Week 5 at Bitter Creek NWR.

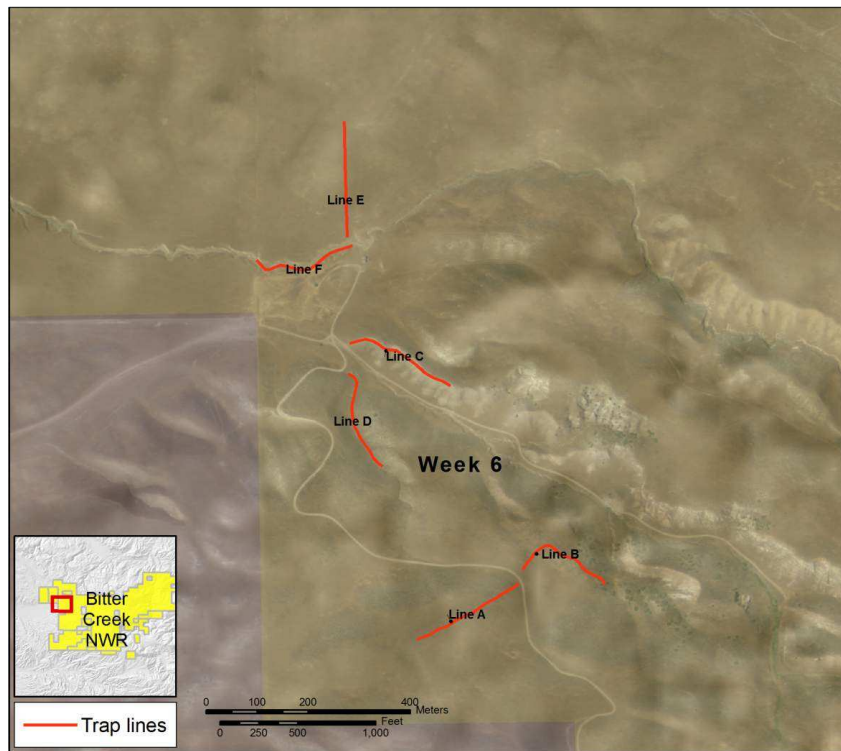


Figure A.7 Locations of small mammal traplines surveyed during Week 6 at Bitter Creek NWR.

APPENDIX B: IMAGES OF SPECIES AND HABITATS

Heermann's kangaroo rat
(*Dipodomys heermanni*)



California pocket mouse
(*Chaetodipus californicus*)



Deer mouse
(*Peromyscus maniculatus*)



Big-eared woodrat
(*Neotoma macrotus*)



Bryant's woodrat
(*Neotoma bryanti*)



California vole
(*Microtus californicus*)



APPENDIX C: LIST OF SPECIES KNOWN OR POTENTIALLY OCCURRING AT BITTER CREEK NWR

Small mammal species that are known to occur (based on this survey) or that could potentially occur (based on the presence of appropriate habitat and proximity to known occurrences) on Bitter Creek National Wildlife refuge and their current status; California Species of Special Concern (SSC), California Threatened (CT), California Endangered (SE), and Federally Endangered (FE). Habitat descriptions are from Zeiner et al. (1990).

Common Name	Scientific Name	Habitat	Status	Occurrence
<u>Insectivora</u>				
Ornate Shrew	<i>Sorex ornatus</i>	Streamsides with dense vegetation, upland woodlands, and forests	SSC	Potential
Broad-footed mole	<i>Scapanus latimanus</i>	Moist soils from sea level up to 3000m		Potential
<u>Rodentia</u>				
Botta's pocket gopher	<i>Thomomys monticola</i>	Ranges from desert to coniferous forest, mainly open areas with deep soil		Known
White-eared pocket mouse	<i>Perognathus alticola inexpectatus</i>	Open grassland and upland arid shrub communities between 1000 and 2000m	SSC	Potential
San Joaquin pocket mouse	<i>Perognathus inornatus</i>	Arid annual grassland, savanna, and desert scrub, with sandy washes, fine soils and scattered vegetation		Potential
California pocket mouse	<i>Chaetodipus californicus</i>	Arid grassland, desert coastal scrub, and montane chaparral		Known
Heermann's kangaroo rat	<i>Dipodomys heermanni</i>	Dry grassy plains and partly open gravelly ground on slopes with sparse chaparral		Known
Giant kangaroo rat	<i>Dipodomys ingens</i>	Sandy loamy soil on level and gently sloping ground vegetated with annual grasses and forbs and widely scattered shrubs	CE, FE	Potential
Western harvest mouse	<i>Reithrodontomys mega lotus</i>	Grassland, open desert, and weed patches; dense vegetation near water		Potential
Parasitic mouse	<i>Peromyscus californicus</i>	Chaparral and oak woodland, redwood forests, and coastal sage scrub		Potential

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Common Name	Scientific Name	Habitat	Status	Occurrence
Deer mouse	<i>Peromyscus maniculatus</i>	Almost all habitats within its range		Known
Canyon mouse	<i>Peromyscus crinitus</i>	Grasslands and shrublands, and slickrock deserts		Potential
Brush mouse	<i>Peromyscus boylii</i>	Rock outcroppings and brushy or forested areas above 2000m		Potential
Pinyon mouse	<i>Peromyscus truei</i>	Rocky slopes with pinyon pine and juniper		Potential
Bryant's woodrat	<i>Neotoma bryanti</i>	Desert scrub and coastal sage scrub habitats		Known
Big-eared woodrat	<i>Neotoma macrotus</i>	Scrub and woodland communities		Known
California vole	<i>Microtus californicus</i>	Low-elevation grasslands, wet meadows, coastal wetlands, and open oak savannas		Known
House mouse (introduced)	<i>Mus musculus</i>	Common around human habitations, old fields, and disturbed habitat		Potential
Merriam's chipmunk	<i>Tamias merriami</i>	Chaparral slopes, mixed oak and digger pine forests, streamside thickets, rock outcroppings, and foothills		Known
San Joaquin antelope squirrel	<i>Ammospermophilus nelsoni</i>	Dry sparsely vegetated areas	CT	Potential
California ground squirrel	<i>Otospermophilus beecheyi</i>	Pastures, grainfields, slopes with scattered trees, and rocky ridges		Known

APPENDIX D: IDENTIFICATION KEY TO SPECIES KNOWN OR POTENTIALLY OCCURRING AT BITTER CREEK NWR

Key to assist in the identification of small mammal species known to occur or that potentially occur on Bitter Creek NWR.

Mice and Other Small Rodents

Small Ears

Tail shorter than body

Unicolor tail with little hair
80-250g

THMO Botta's pocket gopher
(*Thomomys monticola*)

Strongly bicolored tail
30-81g

MICA California vole
(*Microtus californicus*)

Tail as long or longer than body

Stiff white hairs on rump
18-29g

CHCA California pocket mouse
(*Chaetodipus californicus*)

Lobed antitragus (in ear)
Dark crest on tail
16-24g

PEAL White-eared pocket mouse
(*Perognathus alticola*)

No guard hairs, smooth fur
No lobed antitragus
7-12g

PEIN San Joaquin pocket mouse
(*Perognathus inornatus*)

Large Ears

Scaly unicolor tail and mostly unicolor body
11-25g

MUMU House mouse
(*Mus musculus*)

Distinctly bicolored tail

Orange lateral line from cheek to rump
End of tail tufted
Tail is longer than head plus body
23-36g

PEBO Brush mouse
(*Peromyscus boylii*)

Distinctly bicolored body
Tail length equals head plus body
11-25g

PEMA Deer mouse
(*Peromyscus maniculatus*)

Indistinctly bicolored tail

Ears longer than hind foot
Tail hairy with dark dorsal stripe
15-50g

PETR Pinyon mouse
(*Peromyscus truei*)

Distinct hairs off the tip of the tail White feet Tail length equals head plus body 13-23g	PECR	Canyon mouse (<i>Peromyscus crinitus</i>)
Tail is longer than head plus body Largest mouse 33-55g	PECA	Parsitic mouse (<i>Peromyscus californicus</i>)
Tail length equal to head plus body No distinct hairs off the tip of the tail Ears shorter than hind foot 7-11g	REME	Western harvest mouse (<i>Reithrodontomys megalotus</i>)

Kangaroo Rats

Hind foot <44mm Adult 55-95g, Juv. 30-60g	DIHE	Heermann's kangaroo rat (<i>Dipodomys nitratooides nitratooides</i>)
Hind food >44mm Adult 100-140g, Juv. 60-100g	DIIN	Giant kangaroo rat (<i>Dipodomys ingens</i>)

Woodrats

Sooty colored hairs on tops of the hind feet Faintly bicolored tail 205-360g	NEMA	Big-eared woodrat (<i>Neotoma macrotus</i>)
White feet Dark throat hairs Distinctly bicolored tail 130-160g	NEBR	Bryant's woodrat (<i>Neotoma bryanti</i>)

Squirrels and Chipmunks

Light gray and brown dorsal stripes 70-80g	TAME	Merriam's chipmunk (<i>Tamias merriami</i>)
Single white stripe from shoulder to rump 142-179g	AMNE	San Joaquin antelope squirrel (<i>Ammospermophilus nelsoni</i>)
Gray mantle from from ears to back of shoulders Spotted 350-885g	OTBE	California ground squirrel (<i>Otospermophilus beecheyi</i>)