Recovery Plan for the Amargosa Vole (Microtus californicus scirpensis)
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Original Approved: September 15, 1997

Original Prepared by: USFWS, Portland OR

RECOVERY PLAN AMENDMENT

We identified best available information needed to amend recovery criteria for the Amargosa vole (*Microtus californicus scirpensis*) since the recovery plan was completed. In this proposed modification, we synthesize the adequacy of the existing recovery criteria, show amended recovery criteria, and describe the rationale supporting the recovery plan modification. The modification is shown as an appendix that supplements the recovery plan, superseding the Historical and Current Threats section in Part I (pp. 9–13) and the Recovery section identified as Part II (pp. 18–30) of the recovery plan.

For
U.S. Fish and Wildlife Service
Region 8
Carlsbad, CA

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Approved: _____
Acting Regional Director, U.S. Fish and Wildlife Service
Pacific Southwest Region

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METHODOLOGY USED TO COMPLETE THE RECOVERY PLAN AMENDMENT

Recovery criteria were updated for this addendum through internal coordination with staff and through external coordination with our partners. Work was done to update criteria for delisting and to provide quantitative criteria. We coordinated with the University of California at Davis (UC Davis), the California Department of Fish and Wildlife (CDFW), the United States Geological Survey (USGS), and the Bureau of Land Management (Bureau) to discuss the subspecies needs and request information regarding recovery goals for the Amargosa vole. We invited external review by the public, partners (State and Federal agencies and species experts), and peer reviewers, prior to preparation of this final amendment (Appendix A). These coordinated efforts helped to develop new quantitative criteria for the recovery plan that will better serve us as we work to recover the Amargosa vole.

ADEQUACY OF RECOVERY CRITERIA

Section 4(f)(1)(B)(ii) of the Endangered Species Act (Act) requires that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list." Legal challenges to recovery plans (see Fund for Animals v. Babbitt, 903 F. Supp. 96 (D.D.C. 1995)) and a Government Accountability Audit (GAO 2006) also have affirmed the need to frame recovery criteria in terms of threats assessed under the five delisting factors.

Recovery Criteria

See recovery objectives in the 1997 recovery plan (Service 1997, pp. 18–19). The recovery criteria below will be added to the plan through an addendum and will supersede the recovery objectives that are present in the current plan.

Synthesis

The Amargosa vole (Microtus californicus scirpensis) is a desert subspecies of the widely distributed California vole (Microtus californicus). The vole historically inhabited a highly localized and isolated wetland of the central Mojave Desert in extreme southeastern Inyo County, California, near the Inyo-San Bernardino County line. The vole's current habitat includes a series of 36 marshes in the Lower Amargosa River Valley. Water flow in the Amargosa River occurs only during and after heavy precipitation, and the river provides little to no water for vole marshes. Water supply to marshes comes largely from a series of fossil-aquifer springs, groundwater seeps, an Artesian well inadvertently created during mineral exploration, overflow from local groundwater wells, and gray water from nearby homes and bath-houses. Relatively few of the marshes depend solely on natural water sources, but rather are highly dependent on human water use. The vole obligately depends upon, and is closely associated with, wetland vegetation dominated by bulrush (*Schoenoplectus americanus*) which provides food and protection from predators and thermal extremes. Figure 1 depicts existing vole habitat near Tecopa and Tecopa Hot Springs, California. The vole was listed as a Federal endangered species with critical habitat on November 15, 1984 (Service 1984). Reasons for listing included loss of historical habitat, re-channelization of water sources needed to perpetuate habitats, and pumping of groundwater.

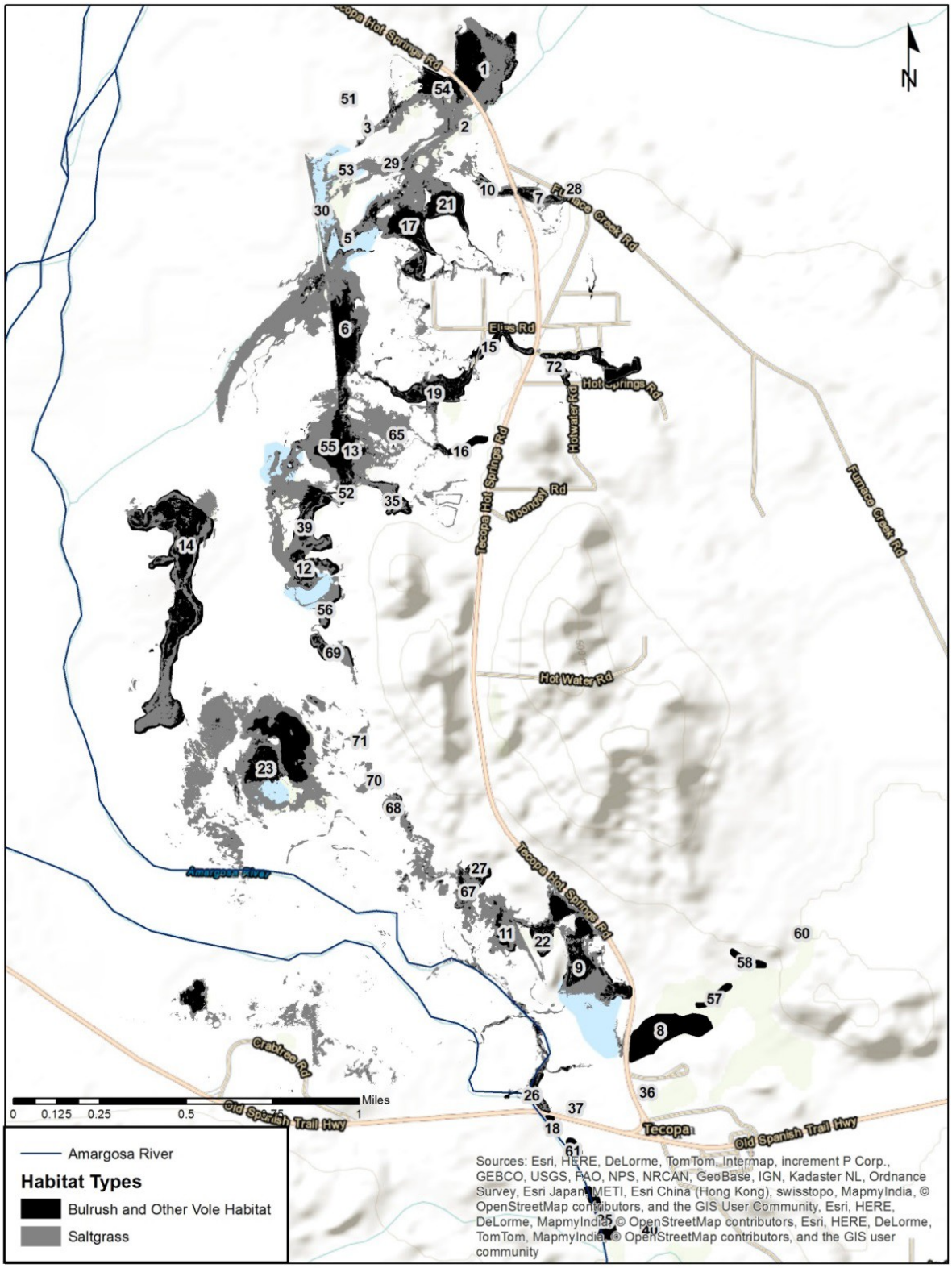

Figure 1: Map of locations of bulrush marsh vegetation and desert saltgrass (*Disticlis spicate*) near Tecopa and Tecopa Hot Springs, California

Due to a paucity of existing information on the species' biology and management needs, the recovery plan for the Amargosa vole included no subspecies-specific recovery criteria (Service 1997). The plan did make the following general recommendations: 1) implement short-term actions critical for the near-term survival of the Amargosa vole; 2) conduct population surveys and assessment; 3) conduct habitat surveys and assessment; 4) conduct genetic analysis; 5) enhance vole populations and habitat; 6) monitor habitat trends; and 7) establish a public outreach program (Service 1997). A 5-year Review for the vole was completed in 2009 and recommended no change in status because of ongoing threats (Service 2009).

Population Surveys - 2012

Various survey efforts have occurred for the Amargosa vole since its discovery in 1891 (Bleich 1979a, 1979b; Rado and Rowland 1984; McClenaghan and Montgomery 1998), but all surveys prior to 2012 focused on determining the subspecies' distributional limits and collected little information on abundance. Since this time, UC Davis, USGS, the Service, the Bureau, and other partners have supported a long-term population monitoring program. In 2012, the USGS surveyed six trapping grids to estimate population size and determine habitat selection criteria (Klinger *et al.* 2014, 2015). The results showed a pooled, range-wide density ranging 2.5 to 7.5 individuals per hectare within the trapping grids, with approximately 85 to 90 percent of the population occurring in the 2-hectare Marsh 1 (Table 1). Even though habitat quality was determined to be in a declining state, density at Marsh 1 ranged from 11.4 to 41.3 individuals per hectare between January and May 2012, while density in the other grids ranged from 0.8 to 3.4 individuals per hectare. Consideration of range-wide density information in combination with the amount of suitable habitat (estimated as 30 hectares) provided an extrapolated population estimate that ranged between 75 and 225 individuals during the 5-month study in 2012 (Klinger *et al*. 2014, Klinger 2014).

The sex ratio during the 2012 surveys was approximately 1 to 1 (85 males and 81 females), and the proportion of subadults and juveniles in the population was low with adults comprising 71 to 93 percent of the population across all months. Rates of survival were constant across the 5 months in 2012 but were considered low. Additionally, the body mass of individual voles was lower when densities were low, and the proportion of adults that were reproductively active decreased when density in the marsh exceeded 30 individuals per ha. Klinger *et al.* (2014) suggests that density-dependent factors may be influential in changes observed in the Amargosa vole population.

In contrast to survival, recruitment rates of the Amargosa vole appeared to vary among months and to have a strong relationship with rates of population change. While there was a general increase in the population between January and the end of May in 2012, the change was characterized by punctuated periods of increases and decreases, not a gradual change. There were rapid increases in January and February and again in April and May. The interplay between recruitment and survival suggests that rate of change in the population may be driven by these two factors and is primarily responsible for abundance (Klinger *et al.* 2014).

Table 1: Density and population size estimates for the range-wide population and the Marsh 1 subpopulation of the Amargosa vole (Klinger *et al*. 2014; Klinger 2016a, pers. comm.; Foley 2014, pers. comm.).

Year	Month	Density Marsh 1 (per hectare)	Range-wide Density (per hectare)	Marsh 1 Population Size (2-hectare habitat estimate)	Range-wide Population Size (30-hectare habitat estimate)	Range-wide Population Size (80.7-hectare habitat estimate)**
2012	January	11.4	2.5	23	75	
	February	29.6	6	59	180	
	March	34.3	6.5	69	195	
	April	18.1	3.4	36	102	
	May	41.3	7.5	83	225	
2013	March	2.3	ND*	5	ND	ND
	November	3	ND	6	ND	ND
2014	January	17.8	ND	36	ND	ND
	March	10.5	ND	21	ND	ND
	May	14.2	ND	28	ND	ND
	June	37.5	ND	75	ND	ND
	July	58.2	ND	116	ND	ND
	Aug./Sept.	46.5	ND	93	ND	ND
	November	18.2	ND	36	ND	ND
	December	14.6	17.5	29	1225	605
2015	February	5.9	13.2	12	196	258
	March	5.9	17.3	12	1219	589
	May	7.7	15.9	15	1177	476
	June	16.7	19.1	33	1273	734
	August	17.2	19.1	34	1273	734
	September	17.9	114.1	36	1423	1138
	November	14.8	7.1	30	213	573

* ND indicates range-wide density estimates and total population size estimates could not be made between June 2012 and November 2014.

** Values in 80.7-hectare are extrapolated from Marsh 1 and range-wide densities for 2013-2015. Range-wide density estimates and total population size were derived from only three grids between December 2014 and September 2015 and are likely to be biased high so should be interpreted cautiously.

Population Surveys – 2013-2016

Altered hydrologic conditions resulted in a collapse in live bulrush cover in Marsh 1 between June 2012 and November 2013. Therefore, in 2013 and 2014, USGS, CDFW and UC Davis continued trapping efforts to further monitor population size and trend in Marsh 1. Due to resource limitations, density data collected during this time by CDFW and UC Davis were restricted to the single survey grid at Marsh 1 (Table 1). Foley (2014, pers. comm.) estimated that the population size of Marsh 1 ranged between 12 and 303 individuals in 2013 and 2014, depending on the season. As discussed above, Klinger *et al*. (2014) estimated the extent of habitat at Marsh 1 and range-wide to be 2 hectares and 30 hectares, respectively. This was based on data indicating that voles are restricted almost entirely to live in aboveground bulrush vegetation, presumably because of predation pressure (Klinger *et al*. 2015; Foley *et al*. 2017). In calculating population size, Foley (2014, pers. comm.) incorporated other habitat types into their estimate of habitat extent at Marsh 1 and range-wide. Consequently, the population estimates derived by multiplying the Marsh 1 density by the extent of habitat differ from what would be calculated using only the extent of live aboveground bulrush marshes. For comparison, Table 1 provides estimates for 2012-2015 using the habitat extent from Klinger *et al.* (2014; Klinger 2016b, pers. comm.) and estimates for 2013- 2015 using the habitat extent from Foley (2014, pers. comm.).

Klinger *et al*. (2014) indicated that the population size of Marsh 1 ranged seasonally between 5 and 116 individuals in 2013 and 2014, (Table 1). In general, since 2012, the population trend for the vole at Marsh 1 has declined overall. The density of Marsh 1 decreased by 80 percent (February) and 81 percent (May) from 2012 to 2015, respectively (Table 1). The estimate for overall population size in all marshes ranging from a low of 69 individuals in March 2013 to a high of 426 individuals in March 2014. Finally, Foley *et al*. (2017) calculated 2016 range-wide density estimates for marshes using an overall marsh area of 30 hectares. In total, estimated vole occupancy in the marshes ranged from 100 to 500, with numbers lowest in January and highest at the end of the summer. Vole densities across marshes ranged from approximately 2 to 10 voles per hectare. Overall male to female sex ration for these surveys was lowest in November (0.8 to 1.0) and highest in August and September (1.2 to 1.0). The number of juvenile voles was highest in May (n=20) and lowest in November (n=1). Most voles were in the adult age class, with approximately 20 percent of these being subadults. These surveys also detected some level of occupancy at most of the marshes in the Tecopa area.

The greatest population sizes from 2013 through 2016 tended to be in June- September and the lowest in February-May. These data indicate that the population is characterized by very strong seasonal variability, with much greater numbers in the summer than winter. Critically, it appears that numbers during the winter months may often be as low as a few dozen individuals.

Marsh 1 Conditions

Marsh 1 has been considered to be the highest quality habitat and has historically been where the majority of voles have been observed. However, in 2009 deteriorating conditions and a dramatic decline in vole density were reported there. These impacts were as the result of a water culvert that was installed deeper than permitted under Tecopa Hot Springs Road, which delineates the southern boundary of Marsh 1. This caused a considerable increase in outflow, eventually

degrading conditions to the extent that Marsh 1 was no longer able to support a viable subpopulation of voles (Foley and Foley 2016). By 2014, approximately 90 percent of marsh vegetation had been lost. These events provide context to the dramatic reduction in vole density that was documented in the surveys covering this period. In 2014, the culvert was modified, water flow in Marsh 1 was stabilized, and 15 groundwater monitoring wells were installed to monitor water levels. In 2016, intensive restoration activities were implemented, supported by the Service, UC Davis, the Bureau, USGS, the Amargosa Conservancy, and other partners. These activities included removal of plant litter, vegetation outplanting, and intentional flooding of the marsh to restore standing surface water. By 2017, approximately 1 year after restoration of Marsh 1, bulrush density had increased by 500 percent compared to pre-restoration levels and a well-developed litter layer had regenerated (Castle *et al*. 2017).

Population Viability Models

Based on 5 months of data collected in 2012, Klinger *et al.* (2014) was able to derive monthly estimates of abundance, as well as monthly survival and recruitment rates for the survey period. These data were then lumped with data collected in 2013 to develop a population viability analysis for the species (Foley and Foley 2016). The analysis produced two patterns: (1) high spatial and temporal variability in abundance, and (2) low monthly survival rates.

The population viability analysis suggested a mean expected time to extinction in Marsh 1 of 4 years, with a 25 percent probability of population loss within 12 months (Foley and Foley 2016). For the subspecies across its entire range, population viability analysis predicted a time to extinction of 20 to 24 years, with a 4-5 percent probability of extinction within 12 months due to environmental stochasticity. In this study, the more common California vole was used as a surrogate for the Amargosa vole due to a lack of long-term, multi-year demographic data for the latter.

In 2019, Castle *et al*. (in press) developed an additional population viability model that incorporated landscape features, local subpopulation extinction, inter-patch colonization dynamics, and empirical parameter value estimates. This model suggests that no single isolated patch of current marsh is able to support a sustainable vole population, but that when considered in a metapopulation context each marsh patch can be described as having source and sink characteristics. The model further found that voles will move among marsh patches that are adjacent when a corridor protected by vegetation is present, and that larger distance inter-marsh movement is rare but when it does occur voles are able to cross even open playa landscape.

Past research (Neuwald 2010 in Castle *et al*. 2019 in press) has reasoned that voles exist in a metapopulation structure because of marsh habitat patchiness. Castle *et al*. (2019 in press) argue that this may erroneously imply that subpopulations in smaller marsh patches may be somewhat buffered from extirpation by vole migration from larger adjacent marsh patches. These smaller marsh patches serve as sinks, and because connectivity between marsh patches may be further reduced in the future due to increasing demand on local water resources (Zdon *et al*. 2015 in Castle *et al.* 2019 in press). The construction of megamarshes through habitat restoration activities would link separated marsh patches, increase connectivity and overall available habitat, and facilitate movement of voles between marshes, all of which would be beneficial for vole persistence. In their population viability model, Castle *et al*. (2019 in press) find that

megamarshes provide the longest mean time to extinction for the species, and the largest population size, highest proportion of occupied marsh patches, and highest number of colonists 25 years into the future.

The overall value of dedicating resources to constructing megamarshes could vary depending on where megamarshes are located Castle *et al*. (2019 in press). Typically, one marsh may be located at the source of a spring or pump outflow, and subsequent downstream marshes rely on outflow from marshes at the source. This allows for generalized grouping of marshes by water source (Foley *et al*. 2017). Across current marshes, there is natural separation between marsh patches in the northern, central, and southern portions of the range. Northern marshes have moderate to high occupancy rates and connectivity, so a megamarsh there would have a larger beneficial effect on vole persistence. A megamarsh in the central area would have somewhat less value because marshes in this area are already well connected. A megamarsh in the southern area could potentially have very high value because these marshes currently impart negative pressure on vole persistence; however, because of their relatively larger degree of separation this would require more intensive intervention, which brings a higher degree of uncertainty regarding the cost/benefit ratio of resource allocation to construct a megamarsh.

Threats

Threats to the Amargosa vole are summarized below as identified in the Listing Rule (Service 1984), Recovery Plan (Service 1997), the most recent 5-year review (Service 2009), and more recent research, monitoring, and general assessment under each of the five factors. In November 2011, the Bureau established an informal ad hoc Amargosa Vole Recovery Team that includes the Federal and State agencies, non-governmental organizations, universities, and private landowners. This group has met regularly to identify and characterize threats, and to discuss, strategize, fund, and implement recovery actions for the species. A captive breeding program was also established in 2014 at UC Davis that serves as a refuge population and provides individuals for release back into the wild.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The final listing rule for the Amargosa vole identified habitat loss due to human activities in the Shoshone and Tecopa Hot Springs areas as one of the factors that contributed to its listing. These activities included livestock grazing, burning of marsh habitat for pasture land, diversion and channelization of springs in the Shoshone area, development of mineral baths and mobile home courts in the Tecopa Hot Springs area, and camping and parking areas adjacent to upland bulrush marshes occupied by voles.

Prior to listing, the Bureau had recognized the importance of the Tecopa, Tecopa Hot Springs, and Amargosa Canyon areas by designating the Amargosa River and Grimshaw Areas of Critical Environmental Concern (ACEC) to specifically manage for wildlife habitat, vegetation, outstanding scenery, and riparian resources (Bureau 1980). The boundaries of the two new ACECs encompassed most known habitat for the Amargosa vole (Bureau 1983a, 1983b). By the time the vole was listed in 1997, land acquisitions by The Nature Conservancy (TNC) and the

Bureau brought most of the vole's preferred habitat under the administration of the Bureau, California State Lands Commission, or TNC (Service 1997).

Since listing, the consolidation of lands within the ACEC has allowed the Bureau to more effectively manage threats to Amargosa vole habitat. The Bureau established control of vehicular access and began implementation of the remaining aspects of its ACEC management plans, although there is evidence of frequent unauthorized vehicle use adjacent to vole habitat (Foley 2019, pers. comm.). While purposeful burning to clear marsh vegetation appears to no longer be a major threat to vole habitat (Service 1997), burning of small patches of bulrush vegetation near Tecopa Hot Springs has occurred on private lands as recently as 2008 and continues to be a localized threat (Scofield 2008, pers. comm.). Structure fires and fires ignited by lightning strike are also continuing threats. Although cattle grazing continued to be a threat through the late 1990s, by the end of the 1990s, the Bureau's Barstow Field Office had removed all livestock from the ACEC and grazing ceased to pose a threat to Amargosa vole habitat (Chavez 2008, pers. comm.).

Since the publication of the 5-year review (Service 2009) there have been multiple legislative and management actions that benefit the vole and its habitat. In 2009, the Amargosa Wild and Scenic River was established, consisting of 26 river miles. The passage of the John D. Dingell Jr. Conservation, Management, and Recreation Act in 2019 expanded this area by 6 river miles. The designation provides protections for the vole and directs the Bureau to manage the area for conservation of the species. In 2016, the Bureau's California Desert Conservation Area Plan was amended by the Desert Renewable Energy Conservation Plan, providing further protections and management directives for the subspecies.

New and/or unresolved threats associated with diversions and other man-made barriers to natural spring flow, groundwater pumping, and salt cedar invasion persist, despite the gains that the Bureau has made in its management of designated areas. Human development, including the diversion of Shoshone Springs to support a high school swimming pool and the development of springs in the Tecopa Hot Springs area for mineral baths were identified as major sources of spring flow modification affecting Amargosa vole habitat (Service 2009). Also, the construction of the Tonopah and Tidewater Railroad line in 1906 has likely altered the historical configuration of marshes in the Tecopa and Tecopa Hot Springs area (Service 1997). Many uncertainties exist with regard to both spring flow diversion and alteration of historical marsh habitat, including 1) whether the persistence of modifications continues to degrade the overall quality and quantity of vole habitat, and 2) whether outflow from mineral bathhouse diversions in the area continues to support Amargosa vole habitat. It is clear that bulrush marshes that generally support voles no longer exist in Shoshone, and while it is not known whether the loss of habitat in this area occurred prior to the diversion of Shoshone Spring, it is likely that diversion of this spring flow has greatly reduced the likelihood of bulrush marsh regeneration at this site.

The recovery plan identified the potential development and exploitation of subterranean water sources for geothermal energy production and domestic consumption as a new threat to Amargosa vole habitat that the final listing rule and the Bureau's previous management plans had not previously recognized (Service 1997). Since this time, however, reduced groundwater supply has been recognized as a threat as even distant groundwater uses for agriculture or other uses could cause spring outputs to decline. Immediate impacts to spring outflows from

groundwater pumping are unlikely because there is only one groundwater well within the historical range of the Amargosa vole; this well is near Shoshone, California (Moreo *et al.* 2003). However, the potential effect that intense groundwater development in southern Nevada and potentially other areas (i.e., due to urban development and population increase) may have on future spring discharge cannot be currently dismissed given the regional connectivity of groundwater systems in this area, the source of recharge for the groundwater that enters the Shoshone and Tecopa area, and the predicted paths of regional groundwater flow. Although groundwater pumping directly within the range of the vole is not an issue, pumping elsewhere within the same regional carbonate aquifer is a concern.

Extensive groundwater and spring monitoring has been implemented by the Bureau, UC Davis, USGS, and others to capture groundwater and hydrological dynamics both locally and at broader regional scales. For example, Marsh 1 is fed by a large and uncontrolled artesian well that seems to supply enough water to maintain marsh habitat on both sides of Tecopa Hot Springs Road (Marsh 1 to the north and perhaps to a lesser degree may account for some water feeding marshes to the south). The flow rate from this well is high, and it is believed that this may have caused other marshes in the vicinity to dry completely or have significantly less water (Zdon and Parmenter 2014, pers. comm. In Foley *et al*. 2017). In the most recent population viability analysis for the vole (Castle *et* al. 2019 in press), reduction in available water supply was influential in reducing persistence for the species.

Another important source of water for Tecopa marshes comes from gray water in the form of runoff from Tecopa Hot Springs sewage treatment and from overflow from local residences downslope into marshes. This source is believed to supply at least nine (25 percent) marshes, with Marshes 17 and 21 seeming to be particularly dependent on residential gray water overflow (Foley *et al*. 2017). Marshes downstream from The Nature Conservancy's local property have previously dried to some degree when water outflow was turned off. (Foley 2019, pers. comm.).

The recovery plan identified the establishment of salt cedar (*Tamarix* spp.) in the Amargosa River drainage, especially the northern portion of the Amargosa Canyon, as a continuing threat that was likely diminishing Amargosa vole habitat quality through replacement of bulrush marshes (Service 1997). The Bureau has continued efforts to remove salt cedar from the broader Amargosa River drainage, some of which has been adjacent to or upstream of vole marshes (Symons 2019, pers. comm.). As salt cedar generally occurs in riparian areas and is unusual in true wetlands, there is some uncertainty about the level of threat it poses in Tecopa wetlands (Klinger 2019, pers. comm.).

The 5-year review noted that the potential for wildfire at that time continued, although it was believed that the likelihood of a wildfire eliminating large amounts of vole habitat was low because the habitat tends to be narrow and completely disconnected from other habitat patches. While this may still be the case at a large scale, in September 2017 the Service issued an emergency salvage approval for up to 12 voles (4 voles were ultimately captured and removed) following a lightning-caused wildfire in Marshes 17 and 21. Approximately 100 percent of Marsh 17 and approximately 90 percent of Marsh 21 were consumed in this fire (Castle 2017, pers. comm.). In April 2018 another smaller fire was ignited by a suspected transformer malfunction during high winds and burned the portions of Marsh 21 that were unaffected by the 2017 fire, as well as other adjacent marsh habitat. In the most recent population viability analysis

for the vole (Castle *et* al. 2019 in press), habitat destruction from fire was influential in reducing persistence for the species.

The 5-year review identified climate change as a new threat identified since listing that may affect the vole's wetland habitat as a result of prolonged drought. During drought years from 2012 to 2015 the average bulrush cover across the vole's range declined by approximately 37 percent (Foley *et al.* 2017). Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field *et al.* 1999; Cayan *et al.* 2005; IPCC 2007). However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. However, in the most recent population viability analysis for the vole (Castle *et* al. 2019 in press), drought was influential in reducing persistence for the species. When coupled with reduced water availability and habitat destruction from fire, these effects were even more pronounced.

There has been a long-term trend in reduced water availability in the broader Tecopa area as well as increasing temperatures, which has been exacerbated by human water consumption and prolonged drought (Foley *et al*. 2017). Annual variability in water quality and quantity has increased, with direct effects on the quality of marsh habitat available to the Amargosa vole. Vole populations are highly variable year to year, and long-term persistence depends on populations being able to sustain themselves during the poorest marsh conditions, which typically occurs during the winter season when water levels are at their lowest. High variability in habitat quality and population numbers has the potential to lead to local subpopulation extirpation (Foley *et al.* 2017). Regional management of water withdrawal and use is thus critical to ensuring long-term stability for water availability and habitat quality for the vole.

FACTOR C: Disease or Predation

Although not identified in the final listing rule, the recovery plan and the 5-year review recognized predation by domestic cats (*Felis catus*) in the Tecopa and Tecopa Hot Springs area as a potential source of mortality (Service 2009, McClenaghan and Montgomery 1998); however, there is no evidence that predation of voles by cats is actually occurring. In the revision of the Amargosa River ACEC Plan, the Bureau identified the control of predation as a management priority (Bureau 2007).

Disease threats have not been addressed or identified in the final listing rule, recovery plan, or 5-year review; however, research since 2009 has demonstrated that disease may be a threat that could diminish the health of Amargosa voles. For example, mites that are a larval trombiculid in the genus Neotrombicula are prevalent in wild voles, and can cause severe skin lesions and deformities. Although Ott-Conn *et al.* (2015) found no reduction in fitness associated with infection, broader effects on vole populations may be uncertain and additional research is needed to determine whether infection could lead to diminished body condition (Ott-Conn *et al*. 2015). Additionally, infection by *Toxoplasma gondii*, a protozoal parasite that has been shown to alter host behavior and cause mortality, has been documented in Amargosa voles (Poulsen *et al*. 2017; Ott-Conn *et* al. 2014). Because of these uncertainties and the need for additional information, disease is being included in this addendum to the recovery plan.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms was not identified as a threat in the final listing rule for the Amargosa vole. There are several State and Federal laws and regulations that are pertinent to the Amargosa vole, each of which contributes to the conservation of the vole in varying degrees. These include: 1) the California Endangered Species Act; 2) the Endangered Species Act of 1973, as amended; 3) the National Environmental Policy Act; and 4) the Federal Land Policy and Management Act of 1976.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

The final listing rule identified inbreeding depression as a potential consequence of the small size and disjunct distribution of marsh habitat in the Tecopa Lake Basin. The 5-year review elaborated more on the genetic consequences of small, fragmented populations and low genetic diversity and a limited amount of gene flow among populations as a threat. Loss of genetic diversity in small populations may decrease the potential for persistence in the face of long-term environmental change (Shaffer 1981, Shaffer 1987, Primack 1998). Loss of genetic diversity can also result in declines in fitness from expression of deleterious recessive alleles (Meffe and Carroll 1994). Krohn *et* al. (2018) found that even though Amargosa voles have substantially less genetic diversity than other California vole populations, they still retain moderate population genetic structure. Despite low genetic variation, individual voles still seem to have robust health condition with no evidence of inbreeding depression or reduced fitness observed (Foley 2019, pers. comm.).

Threats Summary:

Threats to the Amargosa vole consist of diversion of spring flows, alteration of historical marsh configuration, human activities, wildfire, grazing, groundwater development, salt cedar establishment, predation, genetic consequences due to small and fragmented populations, interspecific competition, and climate change (Table 2). Partners in the ad hoc Amargosa Vole Recovery Team have made significant progress toward reducing some threats to the vole. The Bureau established an ACEC that encompasses most of the current range of the vole, and in doing so controlled vehicular access, removed grazing, reduced the incidence of marsh burning, removed some salt cedar seed sources, and worked with The Nature Conservancy to acquire private lands to protect vole habitat. Since the Amargosa Wild and Scenic River was established, complimented by passage of the John D. Dingell Jr. Conservation, Management, and Recreation Act in 2019, and since the signing of the Desert Renewable Energy Conservation Plan, the Bureau has implemented numerous actions that help to reduce threats and protect the vole and its habitat.

Although some threats have been reduced, it is difficult to accurately assess the current status of the species with the limited information available on its distribution and abundance. Despite efforts by the ad hoc Amargosa Vole Recovery Team, unresolved threats to the vole persist.

Table 2. Review of past and current threats assessed for the Amargosa vole.

Threat	Listing-1984	Recovery Plan-1997	5-year Review-2009
Diversion of spring flows	X	X	X
Alteration of historic marsh configuration	X	X	X
Human activities (development, camping, parking)	X	X	X
Localized burning	X		
Wildfire		X	X
Grazing	X		
Groundwater development		X	
Salt cedar establishment		X	X
Predation		X	X
Genetic consequences due to small, fragmented populations			X
Interspecific competition	X	X	X
Climate change/drought			X

AMENDED RECOVERY CRITERIA

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Act are no longer necessary and the species may be delisted. Downlisting is the reclassification of a species from endangered to threatened. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. The term "endangered species" means any species (species, sub-species, or DPS) which is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

We provide downlisting and delisting criteria for the endangered Amargosa vole, which will supersede those included in the Recovery Plan, as follows:

Downlisting Recovery Criteria

The Amargosa vole will be considered for downlisting when**:**

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

A.1: Habitat restoration is completed to create megamarshes that increase connectivity and facilitate movement of voles within and between core areas. Megamarshes in core areas should support a sustainable population for a minimum period of 10 years.

(Defining a "sustainable population" should follow parameters found to have significant influence in population viability analyses, which would likely include future modeling efforts and may evolve as research on status and threats to the vole progresses. A period of 10 years represents an amount of time believed to reasonably include 1-2 drought cycles in the Amargosa River Valley.

Core areas for vole occupancy have been identified based on shared water source, marsh connectivity, and zones of geographic separation. Core areas include (see Figure 1 for marsh locations): 1) the northern portion of the range that includes marshes 1, 17, 21, 54, and other adjacent marshes (core area 1); 2) the central portion of the range that includes marshes 6, 16, 19, 55, 72, and other adjacent marshes (core area 2); and 3) the southern portion of the range that includes marshes 8, 9, 22, and other adjacent marshes (core area 3). These core areas are focal areas within the current vole range for conservation and management initiatives.

A.2: Habitat restoration is implemented to create new marsh habitat in portions of the vole's historical range that are outside of core areas. New habitat locations should be guided by simulation modeling of outcomes and should be geographically and hydrologically separated from core areas to a sufficient degree as to provide a buffer against stochastic threats to the vole (e.g., wildfire and disease). Voles may be translocated from existing marshes to populate new habitat. New habitat should support a sustainable population for a minimum period of 10 years. Translocated populations should be monitored at a minimum of every 5 years to estimate density

and time to extinction, and to ensure that new populations can persist without continual augmentation (i.e., translocation).

(Defining a sustainable translocated population may include influential parameters from population viability analyses as described previously, and may include additional parameters such as assessing the need to continually augment new populations.)

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

No known threats exist under this factor, therefore no criteria are necessary.

Factor C: Disease or Predation

C.1: Disease dynamics and potential effects to the Amargosa vole are well understood at the individual and population scale such that the threat of disease is sufficiently ameliorated through the development of disease management planning.

(Information to inform plan development would be collected through routine monitoring of disease prevalence in marshes and through research activities.)

Factor D: Inadequacy of Existing Regulatory Mechanisms

No known threats exist under this factor, therefore no criteria are necessary.

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

E.1: The mean winter population size is stable or increasing for a period of at least 10 years. A minimum winter (December-January) density of 11.4 voles per hectare in core area 1 and 2.5 voles per hectare in *either* core area 2 or 3 is maintained during this time.

(These density limits are based on survey data from 2012 (see Table 1) that provide information on seasonal population fluctuations in core areas. A period of 10 years represents an amount of time believed to reasonably include 1-2 drought cycles in the Amargosa River Valley. Due to dramatic vole population fluctuations both seasonally and year-to-year it is critical that populations are able to persist at these minimum densities through drought cycles when habitat quality is at its lowest during the winter months.)

Delisting Recovery Criteria

The Amargosa vole will be considered for delisting when**:**

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

A.3: Habitat restoration is implemented to create megamarshes that increase connectivity and facilitate movement of voles within and between core areas. Megamarshes in the core areas should support a sustainable population for a minimum period of 20 years.

("Sustainable population" was previously defined. A period of 20 years represents an amount of time believed to reasonably include more than 2 drought cycles in the Amargosa River Valley.)

A.4: Habitat restoration is implemented to create new marsh habitat in portions of the vole's historical range that are outside of core areas. New habitat locations should be guided by simulation modeling of outcomes and should be geographically and hydrologically separated from core areas to a sufficient degree as to provide a buffer against stochastic threats to the vole metapopulation (e.g., wildfire and disease). Voles may be translocated from existing marshes to populate new habitat. New habitat should support a sustainable population for a minimum period of 20 years. Translocated populations will be monitored at a minimum of every 5 years to estimate density and time to extinction, and to ensure that new populations can persist without continual augmentation (i.e., translocation). This follows the rationale used in A.3 and E.2 for measuring long-term population sustainability.

A.5: An integrated vegetation management plan is implemented to address deterioration of bulrush due to self-thinning and for invasive plant control in order to protect vole habitat in core areas and in new habitat (as identified in A.1-A.4).

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

No known threats exist under this factor, therefore no criteria are necessary.

Factor C: Disease or Predation

C.2: Impacts from predators are managed to levels that do not pose a threat to the persistence of the Amargosa vole.

Factor D: Inadequacy of Existing Regulatory Mechanisms

No known threats exist under this factor, therefore no criteria are necessary.

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

E.2: Populations in core areas are naturally reproducing and are sustainable for a period of at least 20 years. A minimum winter (December-January) density of 11.4 voles per hectare in core area 1 and 2.5 voles per hectare in *both* core areas 2 and 3 is maintained during this time.

("Sustainable population" and the significance of a 20-year period was previously described. This demonstrates resiliency of the vole to persist at minimum densities through drought cycles when habitat quality is at its lowest. These density limits are based on survey data from 2012 (see Table 1) that provide information on seasonal population fluctuations in core areas.)

E.3: A regional water conservation management plan is developed and implemented, and the water level in marshes where the Amargosa vole occurs is considered to be stable or increasing for a minimum of 20 years.

RATIONALE FOR AMENDED RECOVERY CRITERIA

The amended criteria provide more updated benchmarks that clearly link and address current threats. The criteria ensure that the underlying causes of decline are addressed and mitigated, providing a valid path to recovery.

Factor A threats are addressed to ensure habitat degradation from past threats (e.g., water diversions, salt cedar establishment) or potential threats (e.g., groundwater withdrawal, prolonged drought, and invasive plant species) are properly ameliorated by utilizing proper management protocols. The expansion of habitat through the construction of megamarshes in core areas will increase connectivity and facilitate movement of voles across marshes, improving resiliency and representation to the range-wide population. The creation of new habitat outside of core areas that are geographically and hydrologically separated from the Tecopa marshes improves redundancy to prevent a single catastrophic event from causing extinction. Because annual variability in vole populations is high, maintaining high quality habitat is critical to survival and for vole persistence through the winter season and for reducing the likelihood of local extirpations. Vole densities in the criteria above are indicative of abundant high quality habitat. Accomplishing this is critical for the resiliency, redundancy, and representation of the species and is important for the long-term success of the recovery goal (delisting).

Managing water use at a regional scale is necessary to sustain water levels in marshes, improve the long-term viability of marsh habitat, address synergistic effects that are coupled with drought and fire, and support the long-term persistence of the subspecies. Because annual population variability for the vole is high, maintaining habitat quality through winter seasons is important for stabilizing year-to-year survival. To ensure the subspecies has the resilience to overcome these negative effects, maintaining long-term (minimum 20 years) stability in water availability in order to provide high quality marsh habitat is necessary before delisting occurs.

Factor C threats are addressed to ensure that predation rates on the vole are low enough as to not affect the persistence of the subspecies. Though predation rates are not well understood, continued management is needed to reduce the likelihood of such events. Research, monitoring, and management that focuses on the role of disease in vole populations will benefit long-term persistence for the subspecies.

Factor E threats are addressed to ensure that populations are viable and will be buffered against the genetic variability issues associated with small population size and fragmentation.

Achieving these recovery criteria will ensure that we meet our recovery goal of delisting the Amargosa vole by confirming that threats are ameliorated, that vole populations have recovered to resilient levels, and that the species has adequate redundancy and representation.

All classification decisions consider the following five factors: (1) is there a present or threatened destruction, modification, or curtailment of the species' habitat or range; (2) is the species subject to overutilization for commercial, recreational scientific or educational purposes; (3) is disease or predation a factor; (4) are there inadequate existing regulatory mechanisms in place outside the ESA (taking into account the efforts by states and other organizations to protect the species or habitat); and (5) are other natural or manmade factors affecting its continued

existence. When delisting or downlisting a species, we first propose the action in the *Federal Register* and seek public comment and peer review. Our final decision is announced in the *Federal Register*.

ADDITIONAL RECOVERY ACTIONS

To better address these recovery criteria we have included additional Priority 1 actions that identify current needs that we believe to be critical to the recovery of the Amargosa vole, and that supplement the actions contained in the recovery plan. Priority 1 actions are those actions that are identified to prevent extinction or to prevent the Amargosa vole from declining irreversibly in the foreseeable future. These additional Priority 1 actions include:

1. More effectively use and distribute water from spring and well outflows to increase their utility in supporting marsh habitat quantity and quality;
2. Construct megamarshes within the vole's historical range to provide additional habitat for voles;
3. Develop a regional water use management plan;
4. Conduct rangewide monitoring at least every 5 years for vole density in existing marshes, water availability, and habitat quality;
5. Implement population augmentation in existing and new marsh habitat.
6. Enhance habitat quality in existing marshes;
7. Conduct environmental education and public outreach;
8. Secure local water sources;
9. Proceed in land acquisition and/or development of conservation easements with key, willing landowners that have critical marshes, spring sources, or flow paths; and
10. Maintain a captive breeding colony to assist with vole recovery.

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APPENDIX A – SUMMARY OF PUBLIC, PEER, AND PARTNER REVIEW COMMENTS RECEIVED

Summary of Public Comments

We published a notice of availability in the *Federal Register* on August 6, 2019 (84 FR 38284-38287) to announce that the draft recovery plan revision for the Amargosa vole was available for public review, and to solicit comments by the scientific community, State and Federal agencies, Tribal governments, and other interested parties on the general information base, assumptions, and conclusions presented in the draft revision. An electronic version of the draft recovery plan revision was posted on the Service's Species Profile website (Amargosa vole draft recovery plan addendum). We also developed and implemented an outreach plan that included (1) publishing a news release on our national webpage (USFWS News) on August 5, 2019, (2) sending specific notifications to Congressional contacts in California Districts 1, 2, 8, 10, and 11, and (3) sending specific notifications to key stakeholders in conservation and recovery efforts. These outreach efforts were conducted in advance of the *Federal Register* publication to ensure that we provided adequate notification to all potentially interested audiences of the opportunity to review and comment on the draft recovery plan revision.

We received one response during the public comment period from the Bureau of Land Management.

Public comments ranged from providing minor editorial suggestions to specific recommendations on plan content. We have considered all substantive comments; we thank the reviewers for these comments and to the extent appropriate, we have incorporated the applicable information or suggested changes into the final revised recovery plan. In general, these comments supplement and update the current status and the threats to the Amargosa vole that are addressed in the draft plan. We also provided copies of all comments received during the formal public comment period to all relevant Federal agencies for their consideration prior to implementation of the revised final recovery plan in accordance with section 4(f)(5) of the Endangered Species Act (Act).

Public comment (1): The commenter indicated that the recovery plan addendum relied on the listing rule (1984), recovery plan (1997), and the most recent 5-year review (2009). They stated that the threats discussion in this revision is not reflective of current conditions for the Amargosa vole because there have been numerous actions completed to assist in recovery for the species. They provided an extensive list of actions that have been completed that improve protections for the vole and its habitat.

Response: The comments provided by the BLM were very useful in providing broader context and in highlighting the beneficial actions that the BLM and other partners have taken in protecting the vole and its habitat. Though we have incorporated information from the reviewer, the primary purpose of this addendum is to provide quantitative delisting criteria. Therefore, a more thorough review of recovery activities will be summarized and discussed in the future when a species status assessment is completed.

Public comment (2): This comment relates to ongoing support of marsh restoration in Shoshone that would expand vole habitat to historical portions of the range outside of the Tecopa marshes.

Response: The general concept of creating megamarshes in historical portions of the range outside of the Tecopa marshes is addressed in the revised recovery plan; however, we did not specify where these marshes may occur. Any translocation of voles to restored marshes (i.e. Shoshone) would only occur following coordination with our partners and the completion of any necessary agreements/permits (i.e. Safe Harbor Agreement with the landowner).

Summary of Peer and Partner Review Comments

We solicited independent peer review during the development of the draft recovery plan addendum in accordance with the requirements of the Act from researchers from the California Department of Fish and Wildlife, the University of California at Davis, California State University at Sacramento, and the University of California at Berkeley. Criteria used for selecting peer reviewers included their demonstrated expertise and specialized knowledge related to the Amargosa vole and its marsh habitat in the Amargosa River Basin in California. The qualifications of the peer reviewers are in the decision file for this recovery plan revision.

In total, we solicited review and comment from 4 peer reviewers and 3 partner agencies. We received comments from 2 peer reviewers and 1 partner reviewer. Peer reviewers that responded included representatives from the California Department of Fish and Wildlife and the University of California at Davis. Partner reviewers that responded included representatives from the U.S. Geological Survey. In general, the draft recovery plan revision was well-received by the peer and partner reviewers and garnered positive comments, some considered to be substantive. Several reviewers provided additional specific information, including documents and citations; we thank the reviewers for these data and we have added the information where appropriate.

We considered all substantive comments, and to the extent appropriate, we incorporated the applicable information or suggested changes into the revised recovery plan. Below, we provide a summary of specific comments received from peer and partner reviewers with our responses; however, we addressed many of the reviewers' specific critiques and incorporated their suggestions as changes to the revised recovery plan. Such comments did not warrant an explicit response, and as such, are not addressed here. We appreciate the input from all commenters, which helped us to consider and incorporate the best available scientific and commercial information during development and approval of the revised recovery plan.

Summary of Peer Review Comments:

Peer Review Comment (1): Commenter noted the need for construction of megamarshes in order to connect marsh habitat, increase marsh size, and facilitate movement of voles between marshes in core areas.

Response: We agree this concept addresses an extremely important recovery action that has been recently discussed with vole partners and is supported by the recent population viability model developed by UC Davis partners. This information was incorporated in the revised plan and recovery criteria as applicable.

Peer Review Comment (2): Commenter noted relevant literature indicating that at an ecosystem scale, water flow to marshes is likely from a single source and not multiple sources.

Response: We thank the commenter. This was an extremely useful information that helped redefine core areas in the plan more accurately. This information also provides useful context to the various scales at which habitat quality and threats to the vole operate.

Peer Review Comment (3): Commenter clarified that not all springs may be getting constant water flow.

Response: Thanks to the reviewer. This information is important for providing context to threats and recovery actions and was incorporated in the revisions to the plan.

Peer Review Comment (4): Commenter noted robust health in individual voles in UC Davis captive breeding colony despite low genetic variability; cited research from vole partners.

Response: We thank the reviewer for this useful information. It was incorporated into the revised plan.

Peer Review Comment (5): Commenter de-emphasized the potential for competition between voles and house mice based on recent observations by vole research partners.

Response: Information from the commenter was useful and was incorporated into the revised plan.

Peer Review Comment (6): Commenter requested additional recommended recovery actions as discussed in more recent planning meetings with vole partners.

Response: We thank the reviewer for discussion of additional recovery actions to benefit vole recovery. As a result, we made changes to the list of additional actions in the revised plan.

Peer Review Comment (7): Commenter recommended emphasizing the Marsh 1 collapse to provide additional context to decline in vole density.

Response: This was a very useful comment. We have incorporated a history of the Marsh 1 issues into the revised plan.

Summary of Partner Review Comments

Partner Review Comment (1): Commenter recommended including information on habitat condition from partner range-wide assessment for vole in 2017. Provided important points about decline in bulrush cover during 2012-2015 drought years.

Response: This is a critical piece of context when planning for recovery actions and was included in the revised plan. Additional information from the range-wide assessment was also incorporated to improve the discussion.

Partner Review Comment (2): Commenter recommended omitting discussion of predation by domestic cats because no real evidence exists that would indicate it is happening.

Response: Thanks for the information. We agree with this assessment and incorporated the information into the revised plan.

Partner Review Comment (3): Two commenters recommended omitting discussion about potential competition with house mice.

Response: We agree with this assessment and removed this issue from the revised plan.

Partner Review Comment (4): Two comments suggested the need to develop actual plans for addressing disease in vole populations and vegetation management for marshes.

Response: We agree with these useful recommendations and incorporated information into the revised recovery criteria. Developing plans to manage these threats will provide an important recovery framework.

Partner Review Comment (5): Commenter recommended including a "softer" version of the 20-year regional water management plan as a downlisting criterion.

Response: The revised criteria for Factor A threats focuses on the development of megamarshes, which in itself requires that water sources be stabilized. This criterion covers a 10-year time span and is considered to include water management by default in order to achieve improved habitat quality and a sustainable megamarsh population over the time period. It was not included as a specific downlisting criterion but its significance to recovery is reflected in the overall revised criteria.