Hermes Copper Butterfly Surveys and Translocation Efforts

Task 6: 2021 Hermes Copper Adult Surveys
Task 7: Hermes Copper Translocation

SANDAG Contract #: 5005783

Photo by C Beck

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31 October 2021

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Executive Summary

The Hermes copper (*Lycaena hermes*) is a rare butterfly endemic to San Diego County and northern Baja California. This species is threatened by urbanization, wildfires, and drought throughout its range in the United States. Since most individuals and the single (known) remaining large population are found in the southern portion of San Diego County, one large fire could extirpate the species in this country.

Past efforts have contributed to our understanding of the distribution of the Hermes copper, so it is fairly well understood. This includes wildfires in 2003 and 2007 causing several extirpations with few recolonizations, and more recent droughts further restricting the distribution of this butterfly. We conducted widespread surveys in 2018 with the goal of detecting unknown populations; however, conditions were suboptimal due to below average rainfall. Efforts in 2019 and 2020 followed winters with closer to average precipitation. In 2018, one large population (Roberts Ranch South) was discovered to be larger than previously documented. No new populations were documented and there was no evidence of recolonization within the 2003 or 2007 wildfire at selected sites. The objective of this project (2021 surveys) was to further assess the distribution and annual population sizes. We conducted surveys in many of the areas sampled during 2019-2020.

The 2021 status of the Hermes copper populations is similar to the last couple years, with only three sites being occupied (Boulder Creek, Roberts Ranch South, and Potrero BLM) on conserved lands. It now appears that, after two consecutive years of no observations, Lawson Peak and Roberts Ranch North are extirpated. With more focused attention, the Potrero BLM site may have a larger population than indicated by two observations in 2020 and four in 2021, but more widespread surveys in this area are needed for an accurate description. Since Hermes copper adults were not detected at any sites, the long-term viability of the species appears to be highly dependent on the Robert Ranch South population.

Introduction

The Hermes copper (*Lycaena hermes*) is a rare butterfly endemic to San Diego County and northern Baja California. In April of 2011, the United States Fish and Wildlife Service (USFWS) issued a 12-month finding which concluded that listing the Hermes copper butterfly as threatened or endangered was warranted due to threats of urbanization and wildfires (USFWS 2011). For these reasons, it is currently on the USFWS list of candidate species (USFWS 2011).

Over the years, there have been several efforts to describe the Hermes copper distribution (Figure 1) over large geographic areas (more than one or a few sites/preserves). This started with Thorne (1963) publishing the first distributional map. More recently, since 2002, Marschalek and Deutschman at San Diego State University and now the University of Central Missouri have maintained a research program focusing on this species (e.g. Marschalek and Deutschman 2008, Marschalek and Klein 2010).

Wide-ranging surveys were conducted in 2010 throughout many areas in Cleveland National Forest in preparation for the SDG&E Sunrise Powerlink Project (Chambers Group, Inc. 2011). Considering Chambers Group, Inc. (2011) were able to document several previously unknown large local populations by surveying transects with their locations determined based on infrastructure rather than habitat, there may be other areas occupied by Hermes copper. To investigate further, 2018 surveys were conducted to search for these populations in areas not previously searched. Marschalek and Deutschman (2018b) conducted surveys at 35 transects across a large area of the Hermes copper range. Hermes copper adults were detected at only three of these transects, and only one transect had more than 10 adults.

Although early 2017-2018 winter rainfall was close to long-term averages, there was little to no rainfall in late winter and spring, likely suppressing 2018 summer adult butterfly numbers. If numbers are greatly suppressed, it increases the probability that a particular habitat is occupied, but the population is not detected (false negative). This could be due to the ability of many insects, including butterflies, to diapause. This is a resting phase in development, providing a mechanism to avoid unfavorable environmental conditions and wait until favorable conditions return. During diapause, insects, particularly butterflies, are very difficult to detect.

For these reasons, efforts similar to 2018 were repeated in 2019 with better conditions (Marschalek and Deutschman 2019). The 2018-2019 winter/spring experienced above average rainfall, leading to vegetation with abundant leaves and flowers in 2019. Despite improved habitat conditions, Hermes copper adults were detected at four of five sentinel sites but at no other transects other than along Boulder Creek Road (adjacent to a sentinel site transect). Three of the sentinel sites had two or fewer individuals as a maximum daily count; however, 95 Hermes copper adults were observed at Roberts Ranch South on a single day. Similar efforts in

2020 following what appeared to be suitable winter rainfall. Observations included Hermes copper adults at two of the five sentinel sites and two Hermes copper adults near the Potrero BLM transect (Marschalek 2020).

Initially (2003-2007), wildfires greatly influenced the distribution of Hermes copper, as Wildwood Glen Lane and Boulder Creek are the only documented recolonizations following the large wildfires of 2003 and 2007 (Figure 1). Determination of recolonization was based on multiple adults observed over the period of at least two weeks, including female butterflies. More recently, a several year drought appears to have further reduced the distribution of Hermes copper (Marschalek and Deutschman 2018a, 2018b, 2019). The mortality resulting from wildfires and drought, lack of recolonizations following fire or drought, and evidence of restricted dispersal (Marschalek et al. 2016) places the Hermes copper at increased risk of extinction. Assisted dispersal achieved by translocation of individuals has the potential to mitigate wildfire impacts. The risk of extinction will decrease as the number and spatial extent of populations increase. The long-term viability of this species is dependent on expanding its range, whether natural or assisted, and more urgent that previously known.

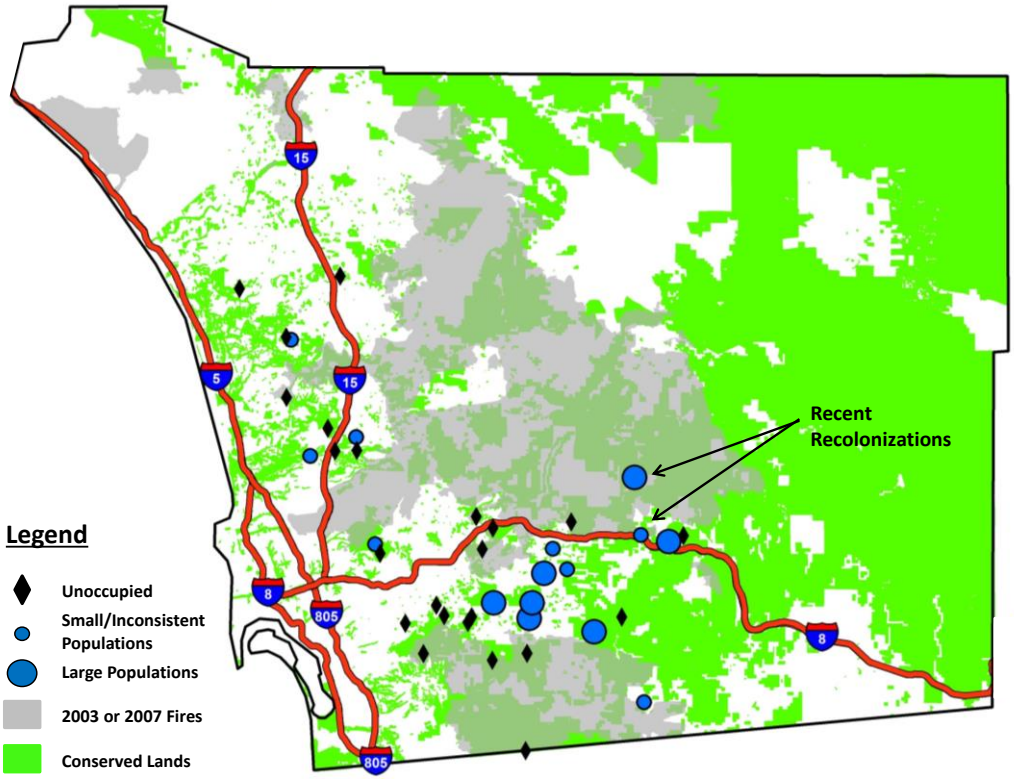

Figure 1. Detections of Hermes copper butterflies on conserved lands, 2010-2013. Sampling locations where Hermes copper was not detected are represented by black diamonds. Small and large Hermes copper populations are indicated by different sized circles.

Recent efforts to translocate Hermes copper from larger populations (San Diego National Wildlife Refuge-McGinty Mountain, a property on Skyline Truck Trail, and Sycuan Peak Ecological Reserve) to an area of suitable habitat at Hollenbeck Canyon Wildlife Area had promising results (Marschalek and Deutschman 2016). In 2014, 11 adults (6 males and 5 females) were translocated to an unoccupied, but suitable patch of habitat. In 2015, of the 14 translocated eggs, 3 were missing from the original clipping and lost prior to the first survey date, 9 eggs exhibited signs consistent with larval eclosion, and 2 eggs remained intact. During the 2015 and 2016 Hermes copper flight season, only one male was detected during surveys at the adult release site and no Hermes copper adults were observed at the egg release site. Continued translocation efforts were attempted but population sizes were too small to capture and move individuals (Marschalek and Deutschman 2016, 2018a, 2019). A recent discovery of a relatively large population near Potrero may be robust enough to support the removal and translocation of eggs although clearing of vegetation may have severely reduced the population size.

The goal of this project was to further assess the distribution and annual population sizes of Hermes copper as well as monitor population sizes for the opportunity to translocate eggs to Crestridge Ecological Reserve. In 2021, we conducted surveys in many areas that were sampled during 2020.

Methods

Sentinel Sites

In 2021, we conducted surveys for Hermes copper adults at five sites we previously designated as sentinel sites (Boulder Creek, Lawson Peak, Roberts Ranch North, Roberts Ranch South, and Sycuan Peak Ecological Reserve) (Figure 2). The sentinel sites are relatively widely spaced across the landscape. This captures a range of climatic conditions throughout much of the Hermes copper range and decreases the likelihood of a single wildfire extirpating all five populations.

Our goal was to record the maximum number of Hermes copper adults present on a single day at each site (***maximum count***). All surveys were conducted during periods of appropriate weather (sunny or partly sunny, 20 to 35 degrees C, and modest wind speeds) unless stated otherwise. The location of each Hermes copper observation was recorded with a handheld GPS unit. Initial surveys occurred on 20 May at Roberts Ranch South to assess the flowering phenology of plants and butterfly community. Roberts Ranch South was chosen because the 2019 and 2020 survey efforts have shown this area to regularly produce the first adults of the season and this site was expected to have Hermes copper adults present due to the relative size of the local population.

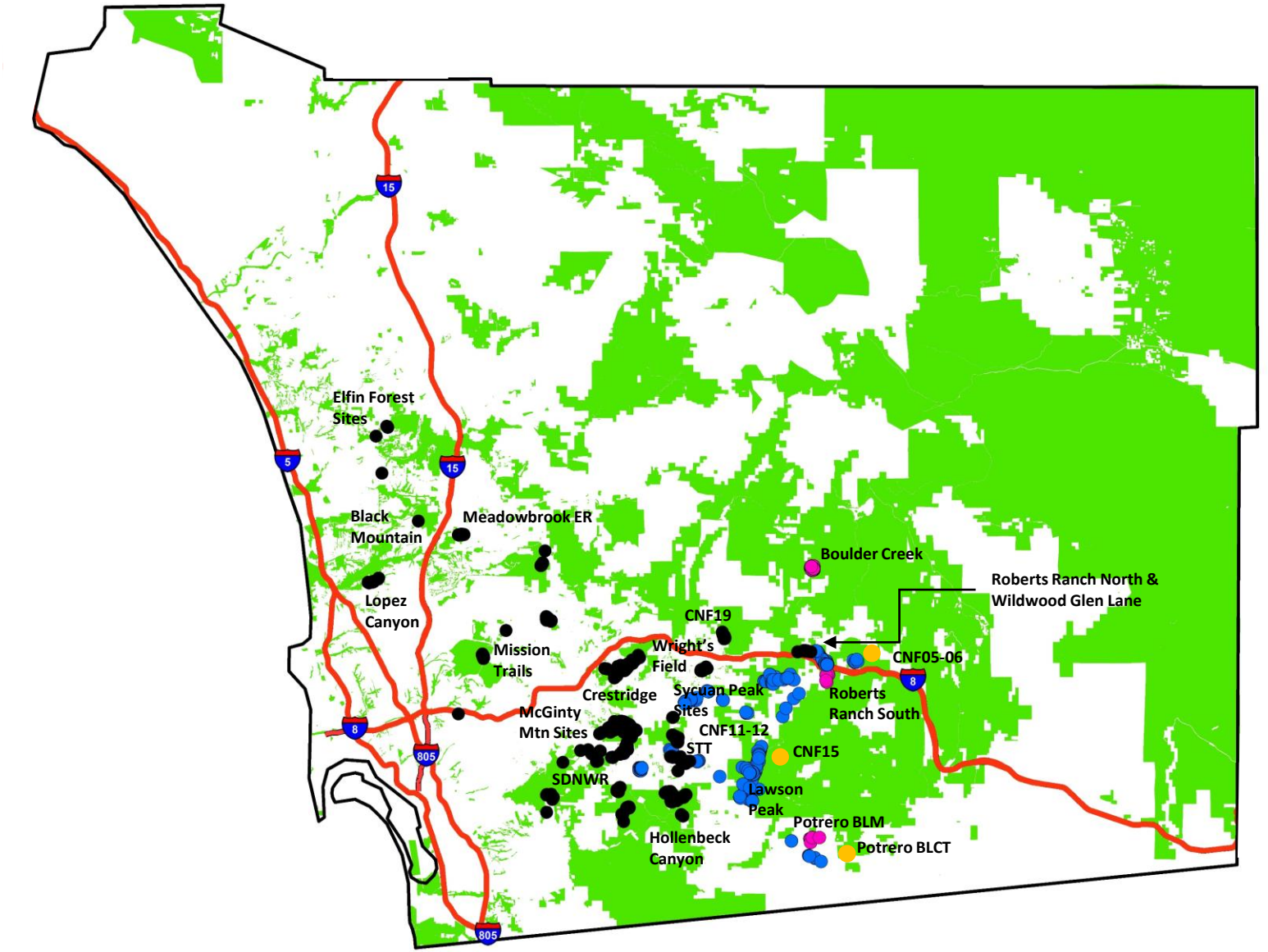

Figure 2. Map of sites that were surveyed for Hermes copper adults in 2021. Purple and black circles represent extant populations and extirpated populations, respectively. Blue circles denote sites of unknown status and orange are sites that have redberry but no historic data regarding Hermes copper occupancy. Status of each site presumed as of August 2020 (see Figure 5 with updated status). Green shading are conserved lands (SANDAG).

Exploratory Sites

In 2021, in addition to the five sentinel transects, we conducted surveys for Hermes copper adults at 34 transects (Figure 2) determined in consultation with USFWS and USFS biologists and considering 2019 and 2020 survey efforts and results (Marschalek and Deutschman 2019, Marschalek 2020). Our goal was to access presence/absence of Hermes copper at each site and qualitatively determine the relative population size if present. The location of each Hermes copper observation was recorded with a handheld GPS unit. All surveys were conducted during periods of appropriate weather (sunny or partly sunny, 20 to 35 degrees C, and modest wind speeds) between 900 to 1500. Each site was surveyed multiple times during June 2021.

Translocations

Monitoring of a population near Potrero by the landowner, as well as monitoring the population sizes of Hermes copper and other butterfly species at other sites, provided data to determine if the annual adult population would be robust enough to tolerate removal of eggs. If suitable conditions were present, up to three Hermes copper females will be placed in a small cage with a spiny redberry clipping for an oviposition site, and California buckwheat flower clippings to provide a nectar source. Temperature, using natural sunlight, needs to be regulated to keep the female active but not overheated. Past experience suggests that the female will oviposit eggs within one to two hours. Females will be released after obtaining eggs or a couple hours, whichever occurs first. Clippings of spiny redberry with eggs will be attached to living spiny redberry shrubs at Crestridge Ecological Reserve in areas with historic Hermes copper observations.

Results

Sentinel Sites

The first Hermes copper adult observed in 2021 was on 27 May at Roberts Ranch South, when seven adults were observed. Nearly all butterflies were bright orange, consistent with having just emerged. No Hermes copper adults were detected at Lawson Peak, Roberts Ranch North, or Sycuan Peak Ecological Reserve in 2021 (Figure 3, Table 1). This is the fifth consecutive year we did not detect adults at the Sycuan Peak transect, third year out of the last four years with no detections at Lawson Peak, and the second consecutive year we did not detect Hermes copper adults at Roberts Ranch North. At the Boulder Creek sentinel transect, we recorded a maximum count of one Hermes copper adult (also see next paragraph for more details regarding this site). Hermes copper adults were present at Roberts Ranch South for our entire sampling period (27 May – 25 June) so the flight season was likely four to five weeks in length at this site. The flight season started about one week later at Boulder Creek compared to Roberts Ranch South, a similar difference to what was observed in 2020.

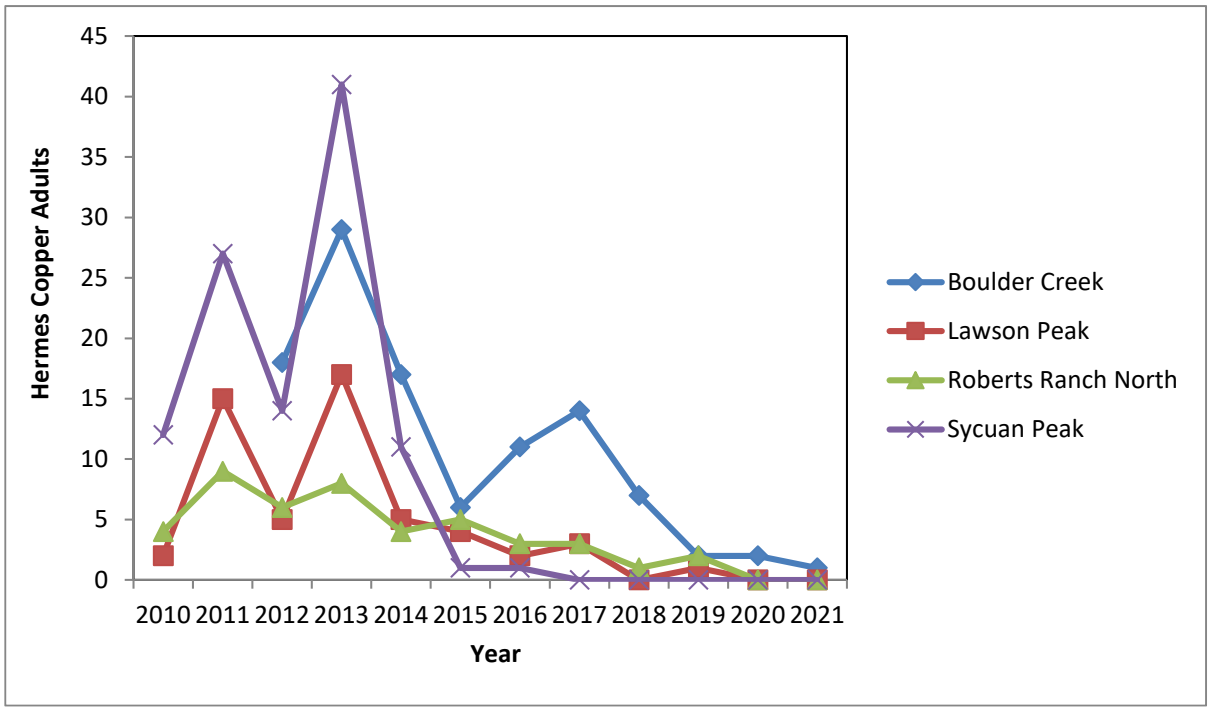

Figure 3. Maximum daily counts of Hermes copper adults at four sentinel sites, 2010-2021 (Roberts Ranch South not shown).

Table 1. Maximum counts of Hermes copper adults at five sentinel sites and an additional site that received frequent visits, 2010-2021. Sampling at sentinel sites consisted of repeated transects to obtain an accurate maximum count. Sampling at the Skyline Truck Trail site was focused on locating females and did not follow a strict protocol for determining the number of Hermes copper present.

Sentinel Sites	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Boulder Creek (routes 2 & 3)	---	---	18	29	17	6	11	14	7	2	2	1
Boulder Creek (loop- includes routes 2 & 3)*	---	---	---	42	19	10	23	24	26	2	3	2
Lawson Peak	2	15	5	17	5	4	2	3	0	1	0	0
Roberts Ranch North	4	9	6	8	4	5	3	3	1	2	0	0
Sycuan Peak	12	27	14	41	11	1	1	0	0	0	0	0
Roberts Ranch South (CNF7)**	---	---	---	---	---	---	---	---	54	95	45	59
Other Visited Site	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Skyline Truck Trail 1	9	---	7	6	7	1	0	3	1	0	0	0
Skyline Truck Trail 2	---	---	12	27	9	2	1	2	2	0	0	0

" --- " indicates no survey

* In 2012, two transects (routes 2 & 3) off of Boulder Creek road were surveyed. Starting in 2013, a longer loop that contains both routes 2 & 3 was surveyed to include butterflies that occupied areas along Boulder Creek Road between the two transects.

** Roberts Ranch South, referred to as CNF7 in 2018, transect was shortened in 2019. The 2018 count in this table reflects the number of Hermes copper adults detected on the shorter transect in 2018 (54 compared to 55 in the 2018 report).

Initial surveys at Boulder Creek in 2012 were restricted to two shorter transects. To more completely cover the area, including the public and maintained road, a new transect was

created to include both shorter transects and the road (Figure 4). To be consistent, summary tables in previous reports have included only those Hermes copper butterflies detected in the areas of the two shorter transects. This report also presents the counts recorded from the full loop transect that started in 2013 (Table 1). Like Sycuan Peak in 2013, it was one of the largest known populations but has also experienced a decline in numbers since that time.

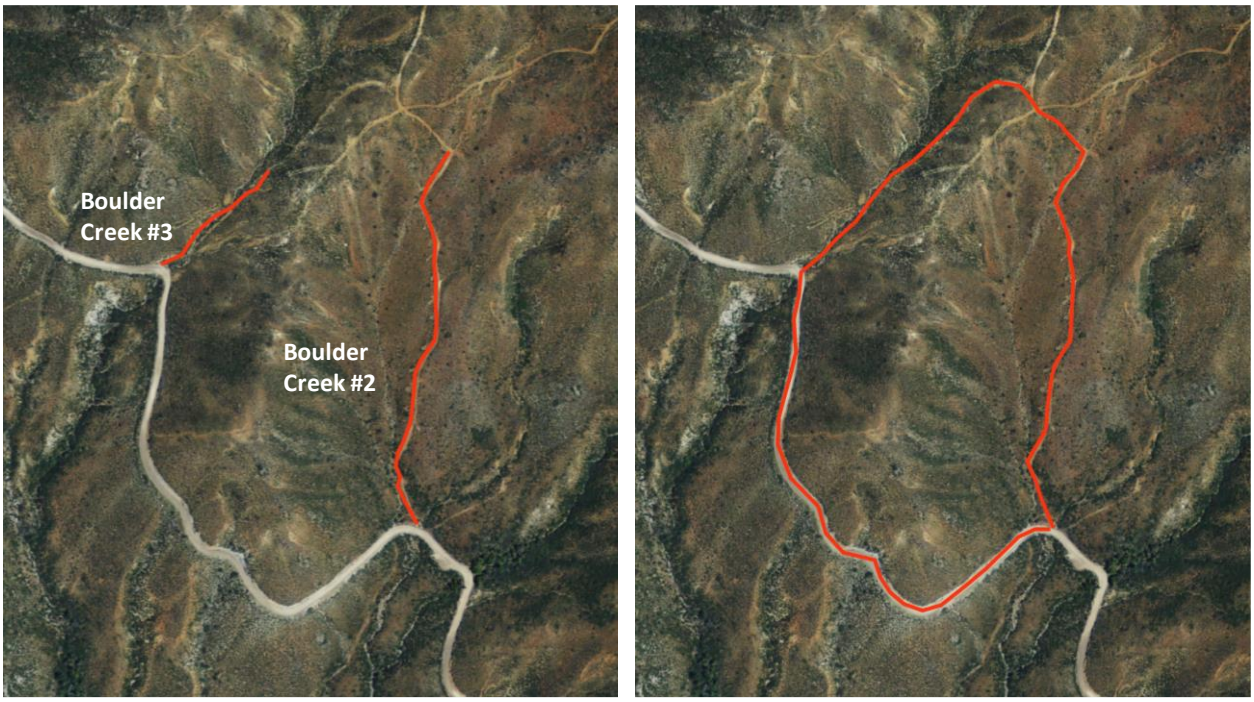

Figure 4. Comparison of survey transects (shown in red) at the Boulder Creek sentinel site. Left: Boulder Creek 2 and Boulder Creek 3 transects were surveyed in 2012. Right: A loop was surveyed in 2013-2020, but only Hermes copper counts from transects 2 and 3 were reported in 2013-2018 report summary tables.

Exploratory Sites

Surveys were conducted 1 – 25 June, with the start date a few days after Hermes copper adults were first observed in 2021. Hermes copper adults were detected at only 1 of the 34 exploratory transects (Table 2), with a maximum count of four Hermes copper adults observed in the vicinity of the Potrero BLM transect on 10 June. The initial sampling transect at this site was restricted to a public road, but since two Hermes copper adults were observed on a trail extending off of that road in 2020, this area was surveyed in 2021. Across all survey sites, the condition of the vegetation looked dry but not as extreme as in 2015-2017. There were fewer flowering plants compared to the last couple years but spiny redberry shrubs had new growth and green leaves, and buckwheat was flowering.

Table 2. Maximum count of Hermes copper adults and dates of surveys for each survey transect.

Site	Hermes Copper Maximum Count	Survey Dates				
Black Mountain	0	3-Jun-21	10-Jun-21	15-Jun-21	22-Jun-21	
CNF02	0	2-Jun-21	(no visible redberry)			
CNF05	0	2-Jun-21	24-Jun-21			
CNF06	0	9-Jun-21	17-Jun-21			
CNF11	0	2-Jun-21	9-Jun-21	16-Jun-21	23-Jun-21	
CNF12	0	2-Jun-21	9-Jun-21	16-Jun-21	23-Jun-21	
CNF15	0	2-Jun-21	9-Jun-21	19-Jun-21	25-Jun-21	
CNF19	0	27-May-21	1-Jun-21	11-Jun-21	17-Jun-21	24-Jun-21
CNF- Wildwood Glen Lane	0	24-May-21	2-Jun-21	12-Jun-21	17-Jun-21	24-Jun-21
Crestridge ER (three transects)	0	25-May-21	1-Jun-21	10-Jun-21	14-Jun-21	22-Jun-21
Elfin Forest	0	1-Jun-21	6-Jun-21	14-Jun-21	21-Jun-21	
Elfin Forest West	0	1-Jun-21	6-Jun-21	14-Jun-21	21-Jun-21	
Hollenbeck Canyon WA- egg release site	0	25-May-21	3-Jun-21	11-Jun-21	18-Jun-21	
Hollenbeck Canyon WA- adult release site	0	28-May-21	3-Jun-21	11-Jun-21	18-Jun-21	
Lopez Canyon	0	26-May-21	4-Jun-21	11-Jun-21	15-Jun-21	21-Jun-21
Meadowbrook ER	0	3-Jun-21	10-Jun-21	15-Jun-21	22-Jun-21	
Mission Trails (2 transects)	0	26-May-21	4-Jun-21	11-Jun-21	15-Jun-21	21-Jun-21
Potrero BCLT	0	3-Jun-21	10-Jun-21			
Potrero BLM	**0 (4)***	3-Jun-21	10-Jun-21	16-Jun-21		
SDNWR Interpretive Loop **	0	4-Jun-21				
SDNWR hairpin **	0	2-Jun-21				
SDNWR McGinty Loop **	0	1-Jun-21	9-Jun-21	22-Jun-21		
SDNWR Mother Miguel Saddle Road **	0	2-Jun-21				
SDNWR Par Four Drive **	0	4-Jun-21				
SDNWR Mexican Canyon **	0	10-Jun-21				
Skyline Truck Trail 1	0	27-May-21	1-Jun-21	11-Jun-21	16-Jun-21	23-Jun-21
Skyline Truck Trail 2	0	27-May-21	1-Jun-21	11-Jun-21	16-Jun-21	23-Jun-21
Sycuan 1	0	25-May-21	3-Jun-21	9-Jun-21	17-Jun-21	
Sycuan 2	0	26-May-21	1-Jun-21	10-Jun-21	14-Jun-21	22-Jun-21
Wright's Field (2 transects)	0	27-May-21	1-Jun-21	11-Jun-21	17-Jun-21	24-Jun-21

* Four individuals were observed on a trail off of the original transect

** Surveys conducted by John Martin (USFWS)

Translocations

Only two Hermes copper adults were observed near the private property in the Potrero area so translocations were not possible. Overall, summer butterfly population sizes were low across San Diego County due to below average winter rainfall. It was also reported that vegetation had been cleared in the vicinity of this Potrero Hermes copper population, possibly resulting in a greatly reduced number of observations where the landowner had previously seen this species.

When it was evident that few Hermes copper adults would be found in the Potrero area, the sex of each Hermes copper was recorded during one of the surveys at the Roberts Ranch South sentinel site. This was done to assess the suitability of this site as a *potential* source for translocation efforts. On 6 June 2021, a total of 36 Hermes copper adults were observed, 20 males, 12 females, and 4 unknown/undetermined. Previous marking studies have shown that the daily maximum count represents roughly one-third of the season total (Marschalek and Klein 2010). Based on this proportion, the female population at Roberts Ranch South in 2021 should be at least 36 individuals. If the same calculation is applied to males (which are more reliably detected) and assuming an equal sex ratio, we could assume the female population is closer to 60 individuals. This survey was conducted prior to the peak of flight season so it expected to be an underrepresentation of the actual female and overall population size. Also, our transect counts do not make efforts to locate every individual in the population, just those that are active along the transect.

Discussion

The overall picture of the abundance and distribution of Hermes copper is similar to 2019 and 2020 (Marschalek and Deutschman 2019, Marschalek 2020) but still concerning (Figure 5). Wildfires in 2003 and 2007 greatly reduced the distribution of Hermes copper (Marschalek and Klein 2010). More recently, drought has further reduced the distribution (Marschalek and Deutschman 2017, 2018b, 2019). Based on recent surveys, it appears that the Hermes copper is now restricted to the southeastern margin of its historical range. Still, this species is represented by reasonable numbers at only one site (Roberts Ranch South). Species with restricted geographic ranges, narrow habitat tolerances, and small population sizes are the most vulnerable to extinction (Rabinowitz 1981). The Hermes copper fits all three of these categories, with its range and population sizes being further reduced over the last 15 years.

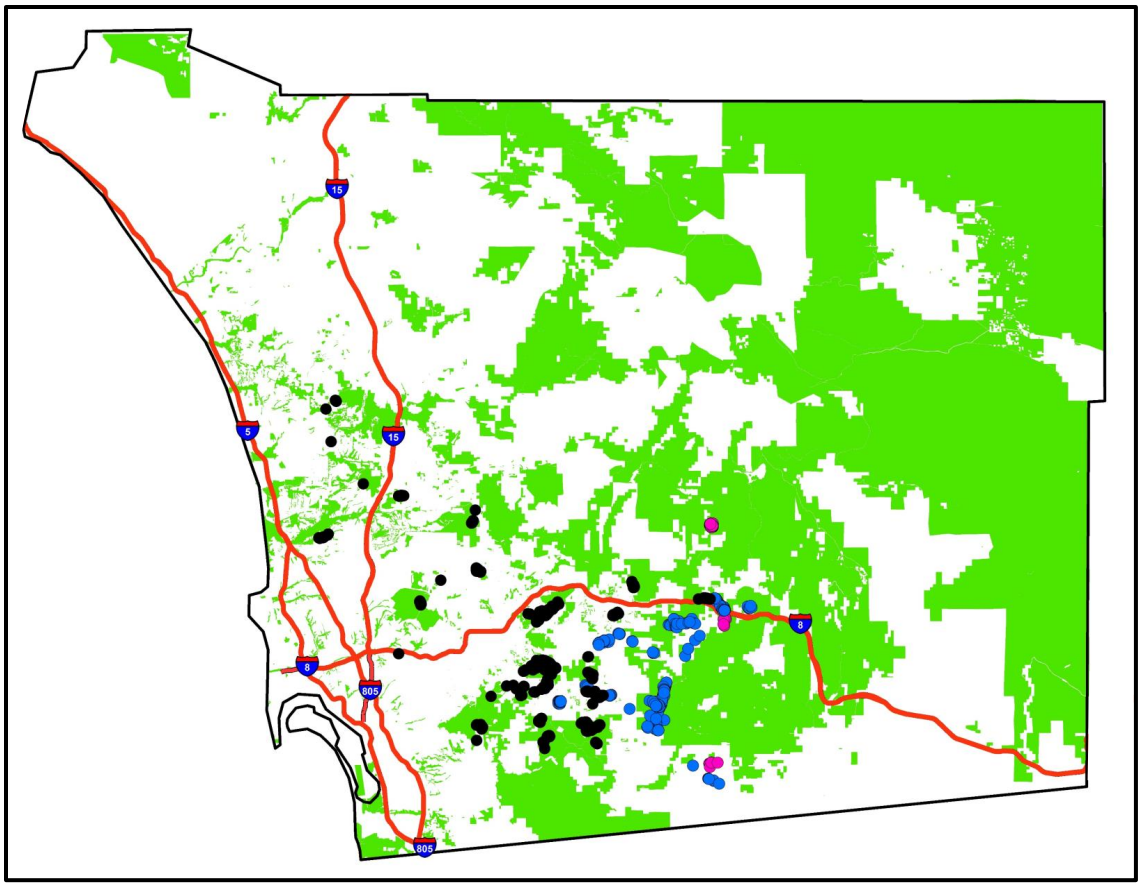

Figure 5. Updated status of local Hermes copper populations based on the most recent survey data. Purple and black circles represent extant populations and extirpated populations, respectively. Blue circles denote sites of unknown status, but most are presumed extirpated. Green shading are conserved lands (SANDAG).

Based on the last 20 years of surveys, fire and drought have extirpated all populations except for those at the highest elevation (furthest east). This is an area where winter and spring rainfall is more dependable. The apparent loss of the Roberts Ranch North and Lawson Peak local populations demonstrate that not all sites at high elevation are not immune to extirpation.

Recent fires highlight the urgency of translocation efforts. The Valley Fire in September 2020 burned the area between Roberts Ranch South and the Potrero sites (Figure 6). Both locations were included in the evacuation area demonstrating that slightly different wind directions and speeds could have resulted in the loss of one or both populations. Also, a small fire occurred four miles west of Roberts Ranch South in July 2021 (Figure 6). As fires continue to ignite and burn in this part of San Diego County, it is just a matter of time until the Roberts Ranch South population is extirpated.

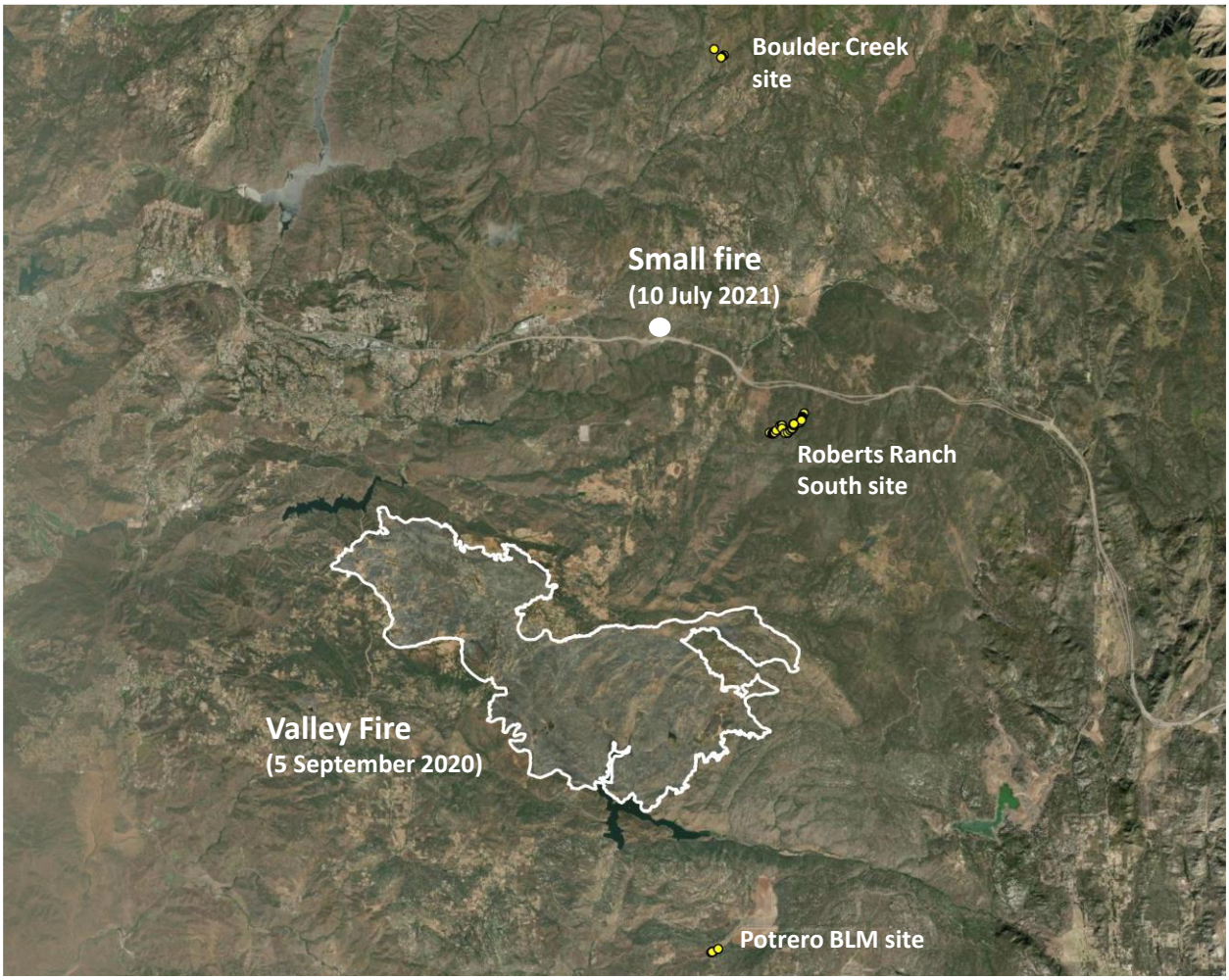

Figure 6. Recent fires in the vicinity of the Roberts Ranch South and Potrero populations.

Recommendations

The area around the Potrero BLM transect should be further explored to more completely describe and delineate that population. Although a maximum count of four individuals does not suggests a large population, it is possible that the surveys are detecting individuals on the periphery of the population and underrepresenting the actual number present. Also, surveys should be conducted at Loveland Reservoir since it has been several years since the last surveys yielded relatively high counts. Unfortunately, terms of an access permit could not be agreed upon by legal representatives from both sides. Considering the decline in annual population sizes and apparent extirpations of other sites in the immediate area, it is suspected that this population has also been extirpated. But the north shore of Loveland Reservoir has several larger ravines that might provide microclimates suitable for surviving drought conditions.

Regarding translocations, Roberts Ranch South offers a potential source population that could be used to expand the Hermes copper distribution before a fire extirpates this last large population. With at least 12 females observed on a single day, survey data suggests that the population size is large enough to be able to tolerate the removal of eggs from two to three females.

Acknowledgments

I would like to thank many people for assistance with this project, including permits, access to reserves, and sharing of data. These include, but are not limited to (alphabetically): Back Country Land Trust, California Department of Fish & Wildlife, City of San Diego, Endangered Habitats League, Escondido Creek Conservancy, San Diego Gas and Electric, Sweetwater Authority, United States Fish & Wildlife Service, and United States Forest Service. Also, much appreciation to Christine Beck, Morgan Cosgrove, David Faulkner, Julia Hoopes, Emily Jones, Korey Klutz, Hannah Ogden, California Department of Fish & Wildlife (Jen Blackhall, Ken Devore, Haley Heesch, Elyse Levy, Amanda McGarry, Kyle Rice, Kasey Skinner, Melissa Stepek), and United States Fish & Wildlife Service (John Martin) for assistance conducting butterfly surveys.

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Appendix. GPS coordinates of Hermes copper adults in 2021.

Date	Site	Latitude	Longitude
27-May-21	Roberts Ranch South	32.80949	-116.60670
27-May-21	Roberts Ranch South	32.81144	-116.60560
28-May-21	Roberts Ranch South	32.81189	-116.60390
31-May-21	Roberts Ranch South	32.80864	-116.61279
31-May-21	Roberts Ranch South	32.80897	-116.61248
31-May-21	Roberts Ranch South	32.81016	-116.60597
31-May-21	Roberts Ranch South	32.81090	-116.60551
31-May-21	Roberts Ranch South	32.81090	-116.60551
3-Jun-21	Potrero BLM	32.64669	-116.63588
3-Jun-21	Potrero BLM	32.64683	-116.63565
4-Jun-21	Roberts Ranch South	32.80877	-116.61443
4-Jun-21	Roberts Ranch South	32.80877	-116.61442
4-Jun-21	Roberts Ranch South	32.80852	-116.61342
4-Jun-21	Roberts Ranch South	32.80852	-116.61307
4-Jun-21	Roberts Ranch South	32.80864	-116.61281
4-Jun-21	Roberts Ranch South	32.80864	-116.61281
4-Jun-21	Roberts Ranch South	32.80881	-116.61250
4-Jun-21	Roberts Ranch South	32.80954	-116.61188
4-Jun-21	Roberts Ranch South	32.81099	-116.61052
4-Jun-21	Roberts Ranch South	32.81107	-116.60990
4-Jun-21	Roberts Ranch South	32.81110	-116.60983
4-Jun-21	Roberts Ranch South	32.81014	-116.60979
4-Jun-21	Roberts Ranch South	32.80865	-116.60863
4-Jun-21	Roberts Ranch South	32.80865	-116.60863
4-Jun-21	Roberts Ranch South	32.80890	-116.60765
4-Jun-21	Roberts Ranch South	32.80948	-116.60673
4-Jun-21	Roberts Ranch South	32.80991	-116.60609
4-Jun-21	Roberts Ranch South	32.81014	-116.60601
4-Jun-21	Roberts Ranch South	32.81106	-116.60551
4-Jun-21	Roberts Ranch South	32.81175	-116.60441
4-Jun-21	Roberts Ranch South	32.81175	-116.60442
4-Jun-21	Roberts Ranch South	32.81192	-116.60389
4-Jun-21	Roberts Ranch South	32.81194	-116.60377
4-Jun-21	Roberts Ranch South	32.81201	-116.60314
4-Jun-21	Roberts Ranch South	32.81215	-116.60296
4-Jun-21	Roberts Ranch South	32.81268	-116.60258
6-Jun-21	Roberts Ranch South	32.81412	-116.60205
6-Jun-21	Roberts Ranch South	32.81404	-116.60211
6-Jun-21	Roberts Ranch South	32.81385	-116.60212

Appendix. GPS coordinates of Hermes copper adults in 2021 continued.

Date	Site	Latitude	Longitude
6-Jun-21	Roberts Ranch South	32.81378	-116.60216
6-Jun-21	Roberts Ranch South	32.81359	-116.60224
6-Jun-21	Roberts Ranch South	32.81359	-116.60224
6-Jun-21	Roberts Ranch South	32.81300	-116.60253
6-Jun-21	Roberts Ranch South	32.81275	-116.60259
6-Jun-21	Roberts Ranch South	32.81274	-116.60257
6-Jun-21	Roberts Ranch South	32.81218	-116.60294
6-Jun-21	Roberts Ranch South	32.81199	-116.60321
6-Jun-21	Roberts Ranch South	32.81198	-116.60318
6-Jun-21	Roberts Ranch South	32.81196	-116.60350
6-Jun-21	Roberts Ranch South	32.81190	-116.60388
6-Jun-21	Roberts Ranch South	32.81189	-116.60389
6-Jun-21	Roberts Ranch South	32.81169	-116.60448
6-Jun-21	Roberts Ranch South	32.81169	-116.60448
6-Jun-21	Roberts Ranch South	32.81169	-116.60448
6-Jun-21	Roberts Ranch South	32.81169	-116.60448
6-Jun-21	Roberts Ranch South	32.81156	-116.60539
6-Jun-21	Roberts Ranch South	32.81156	-116.60550
6-Jun-21	Roberts Ranch South	32.81129	-116.60551
6-Jun-21	Roberts Ranch South	32.81113	-116.60546
6-Jun-21	Roberts Ranch South	32.81113	-116.60545
6-Jun-21	Roberts Ranch South	32.81100	-116.60551
6-Jun-21	Roberts Ranch South	32.81092	-116.60552
6-Jun-21	Roberts Ranch South	32.81054	-116.60559
6-Jun-21	Roberts Ranch South	32.81017	-116.60593
6-Jun-21	Roberts Ranch South	32.81017	-116.60594
6-Jun-21	Roberts Ranch South	32.80911	-116.60757
6-Jun-21	Roberts Ranch South	32.81028	-116.60979
6-Jun-21	Roberts Ranch South	32.81112	-116.60978
6-Jun-21	Roberts Ranch South	32.81112	-116.60978
6-Jun-21	Roberts Ranch South	32.81112	-116.60978
6-Jun-21	Roberts Ranch South	32.81100	-116.61055
6-Jun-21	Roberts Ranch South	32.80941	-116.61194
6-Jun-21	Roberts Ranch South	32.80939	-116.61231
6-Jun-21	Roberts Ranch South	32.80901	-116.61249
6-Jun-21	Roberts Ranch South	32.80856	-116.61386
7-Jun-21	Boulder Creek	32.92567	-116.63238
9-Jun-21	Roberts Ranch South	32.81482	-116.60163
9-Jun-21	Roberts Ranch South	32.81381	-116.60216

Appendix. GPS coordinates of Hermes copper adults in 2021 continued.

Date	Site	Latitude	Longitude
9-Jun-21	Roberts Ranch South	32.81372	-116.60219
9-Jun-21	Roberts Ranch South	32.81346	-116.60230
9-Jun-21	Roberts Ranch South	32.81339	-116.60239
9-Jun-21	Roberts Ranch South	32.81323	-116.60246
9-Jun-21	Roberts Ranch South	32.81323	-116.60246
9-Jun-21	Roberts Ranch South	32.81303	-116.60252
9-Jun-21	Roberts Ranch South	32.81273	-116.60257
9-Jun-21	Roberts Ranch South	32.81235	-116.60280
9-Jun-21	Roberts Ranch South	32.81218	-116.60295
9-Jun-21	Roberts Ranch South	32.81218	-116.60295
9-Jun-21	Roberts Ranch South	32.81198	-116.60322
9-Jun-21	Roberts Ranch South	32.81198	-116.60322
9-Jun-21	Roberts Ranch South	32.81195	-116.60339
9-Jun-21	Roberts Ranch South	32.81195	-116.60354
9-Jun-21	Roberts Ranch South	32.81196	-116.60374
9-Jun-21	Roberts Ranch South	32.81196	-116.60373
9-Jun-21	Roberts Ranch South	32.81194	-116.60376
9-Jun-21	Roberts Ranch South	32.81193	-116.60377
9-Jun-21	Roberts Ranch South	32.81169	-116.60448
9-Jun-21	Roberts Ranch South	32.81167	-116.60451
9-Jun-21	Roberts Ranch South	32.81158	-116.60461
9-Jun-21	Roberts Ranch South	32.81154	-116.60536
9-Jun-21	Roberts Ranch South	32.81154	-116.60535
9-Jun-21	Roberts Ranch South	32.81153	-116.60558
9-Jun-21	Roberts Ranch South	32.81146	-116.60559
9-Jun-21	Roberts Ranch South	32.81135	-116.60556
9-Jun-21	Roberts Ranch South	32.81129	-116.60554
9-Jun-21	Roberts Ranch South	32.81128	-116.60554
9-Jun-21	Roberts Ranch South	32.81117	-116.60547
9-Jun-21	Roberts Ranch South	32.81096	-116.60553
9-Jun-21	Roberts Ranch South	32.81096	-116.60553
9-Jun-21	Roberts Ranch South	32.81067	-116.60557
9-Jun-21	Roberts Ranch South	32.81058	-116.60561
9-Jun-21	Roberts Ranch South	32.81035	-116.60563
9-Jun-21	Roberts Ranch South	32.81016	-116.60596
9-Jun-21	Roberts Ranch South	32.81006	-116.60606
9-Jun-21	Roberts Ranch South	32.80932	-116.60690
9-Jun-21	Roberts Ranch South	32.80916	-116.60724
9-Jun-21	Roberts Ranch South	32.80869	-116.60766

Appendix. GPS coordinates of Hermes copper adults in 2021 continued.

Date	Site	Latitude	Longitude
9-Jun-21	Roberts Ranch South	32.80990	-116.60995
9-Jun-21	Roberts Ranch South	32.81012	-116.60977
9-Jun-21	Roberts Ranch South	32.81012	-116.60977
9-Jun-21	Roberts Ranch South	32.81067	-116.60974
9-Jun-21	Roberts Ranch South	32.81107	-116.60961
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81111	-116.60980
9-Jun-21	Roberts Ranch South	32.81108	-116.60988
9-Jun-21	Roberts Ranch South	32.81108	-116.61022
9-Jun-21	Roberts Ranch South	32.80943	-116.61194
9-Jun-21	Roberts Ranch South	32.80938	-116.61234
9-Jun-21	Roberts Ranch South	32.80938	-116.61234
9-Jun-21	Roberts Ranch South	32.80898	-116.61250
9-Jun-21	Roberts Ranch South	32.80898	-116.61249
9-Jun-21	Roberts Ranch South	32.80871	-116.61426
10-Jun-21	Potrero BLM	32.64693	-116.63524
10-Jun-21	Potrero BLM	32.64697	-116.63559
10-Jun-21	Potrero BLM	32.64678	-116.63579
10-Jun-21	Potrero BLM	32.64670	-116.63596
12-Jun-21	Roberts Ranch South	32.80876	-116.61439
12-Jun-21	Roberts Ranch South	32.80878	-116.61445
12-Jun-21	Roberts Ranch South	32.80886	-116.61462
12-Jun-21	Roberts Ranch South	32.80928	-116.60689
12-Jun-21	Roberts Ranch South	32.80948	-116.60665
12-Jun-21	Roberts Ranch South	32.80958	-116.61004
12-Jun-21	Roberts Ranch South	32.81011	-116.60600
12-Jun-21	Roberts Ranch South	32.81019	-116.60588
12-Jun-21	Roberts Ranch South	32.81034	-116.60561
12-Jun-21	Roberts Ranch South	32.81087	-116.60550
12-Jun-21	Roberts Ranch South	32.81095	-116.60552
12-Jun-21	Roberts Ranch South	32.81100	-116.61058
12-Jun-21	Roberts Ranch South	32.81105	-116.61051
12-Jun-21	Roberts Ranch South	32.81109	-116.60983
12-Jun-21	Roberts Ranch South	32.81110	-116.61031
12-Jun-21	Roberts Ranch South	32.81144	-116.60560

Appendix. GPS coordinates of Hermes copper adults in 2021 continued.

Date	Site	Latitude	Longitude
12-Jun-21	Roberts Ranch South	32.81147	-116.60517
12-Jun-21	Roberts Ranch South	32.81155	-116.60540
12-Jun-21	Roberts Ranch South	32.81155	-116.60543
12-Jun-21	Roberts Ranch South	32.81156	-116.60458
12-Jun-21	Roberts Ranch South	32.81168	-116.60447
12-Jun-21	Roberts Ranch South	32.81192	-116.60339
12-Jun-21	Roberts Ranch South	32.81192	-116.60380
12-Jun-21	Roberts Ranch South	32.81206	-116.60305
12-Jun-21	Roberts Ranch South	32.81214	-116.60293
12-Jun-21	Roberts Ranch South	32.81477	-116.60164
12-Jun-21	Roberts Ranch South	32.81493	-116.60153
14-Jun-21	Boulder Creek	32.92830	-116.63489
14-Jun-21	Boulder Creek	32.92637	-116.63130
15-Jun-21	Roberts Ranch South	32.81114	-116.60548
15-Jun-21	Roberts Ranch South	32.81134	-116.60553
15-Jun-21	Roberts Ranch South	32.81143	-116.60559
15-Jun-21	Roberts Ranch South	32.81155	-116.60557
15-Jun-21	Roberts Ranch South	32.81154	-116.60543
16-Jun-21	Potrero BLM	32.64773	-116.63342
16-Jun-21	Potrero BLM	32.64663	-116.63601
16-Jun-21	Potrero BLM	32.64664	-116.63601
18-Jun-21	Roberts Ranch South	32.80852	-116.61362
18-Jun-21	Roberts Ranch South	32.80853	-116.61363
18-Jun-21	Roberts Ranch South	32.80871	-116.61448
18-Jun-21	Roberts Ranch South	32.81119	-116.60550
18-Jun-21	Roberts Ranch South	32.81144	-116.60562
18-Jun-21	Roberts Ranch South	32.81150	-116.60560
18-Jun-21	Roberts Ranch South	32.81185	-116.60332
18-Jun-21	Roberts Ranch South	32.81189	-116.60381
18-Jun-21	Roberts Ranch South	32.81191	-116.60392
18-Jun-21	Roberts Ranch South	32.81192	-116.60385
18-Jun-21	Roberts Ranch South	32.81193	-116.60391
18-Jun-21	Roberts Ranch South	32.81194	-116.60380
18-Jun-21	Roberts Ranch South	32.81196	-116.60327
18-Jun-21	Roberts Ranch South	32.81198	-116.60324
18-Jun-21	Roberts Ranch South	32.81488	-116.60144
18-Jun-21	Boulder Creek	32.92579	-116.63221
18-Jun-21	Boulder Creek	32.92597	-116.63198