

Hermes Copper Butterfly Surveys and Translocation Efforts

Task 4: 2020 Hermes Copper Adult Surveys
SANDAG Contract #: 5005783



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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 larger populations are found in the southern portion of San Diego County, one large fire could nearly extirpate the species.

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 were similar but occurred during better conditions as the 2018-2019 winter/spring experienced above average rainfall. 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 (2020 surveys) was to further assess the distribution and annual population sizes. We conducted surveys in many of the areas sampled during 2019, but restrictions due to covid-19 did not allow for surveys to be conducted at all of the 2019 sites.

Similar to 2019, vegetation had abundant leaves and flowers in 2020. The 2020 Hermes copper flight season started around 1 June and extended to the end of June. Of the 39 transects surveyed, Hermes copper adults were detected along only three transects. All three transects/sites are along the eastern margin of the Hermes copper's range. Both Boulder Creek and Potrero BLM transects had three or fewer individuals as a maximum daily count. As was the case in 2018 and 2019, the Roberts Ranch South transect (referred to as CNF7 in 2018) had the large majority of observations, with a maximum daily count of 45 adults.

Despite vegetation that appears to be in very good condition in both 2019 and 2020, the distribution of Hermes copper retracted slightly from 2018 to 2019 and from 2019 to 2020. In addition, and most population sizes declined. The distribution is greatly reduced due to drought, with the species only being found on the southeastern margin of its historic range. Based on data from these 2020 surveys and the trajectories based on past sampling, this butterfly species is in risk of being lost from the United States in the near future. Considering that the distribution and population sizes of the species are not increasing when habitat conditions appear to be favorable, translocation and rearing techniques should be explored to increase the number of populations and the spatial extent of those populations.

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 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 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.

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). 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 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 of populations and the geographic extent of populations increases. Long-term viability of this species is dependent on expanding its range, whether natural or assisted, and more urgent that previously known.

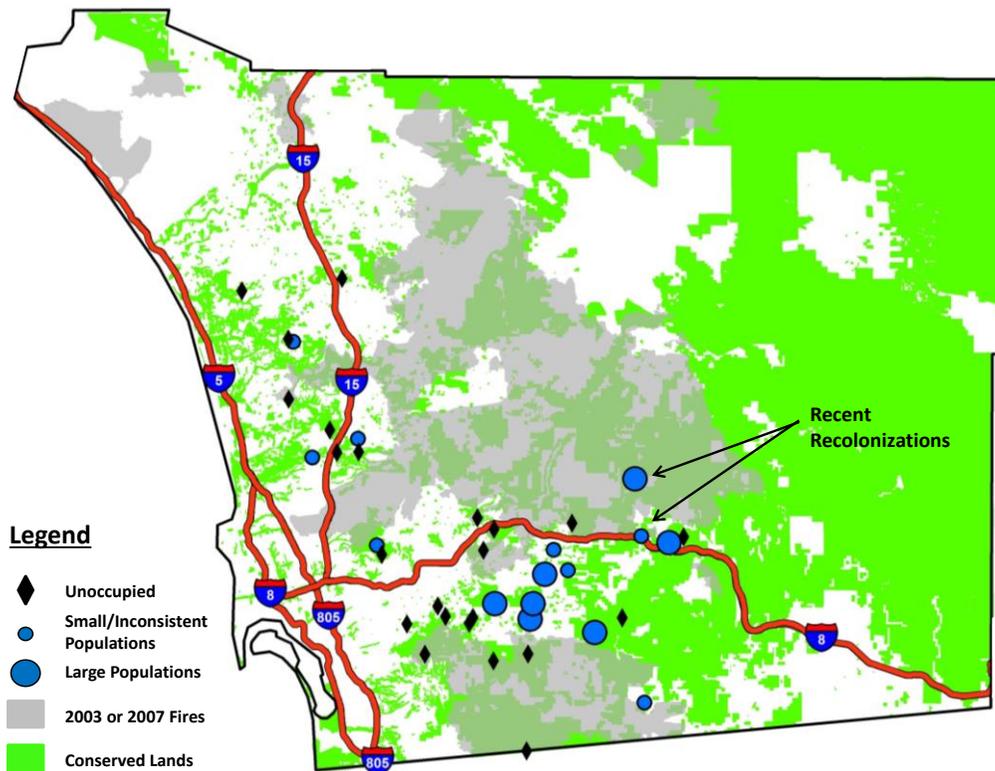


Figure 1. Detections of Hermes copper butterflies on conserved lands, 2010-2013. Sampling locations where Hermes copper was not detected are represented by black diamonds. Small and large Hermes copper populations are indicated by different sized circles.

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, we translocated 11 adults (6 males and 5 females) 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).

The goal of this project was to further assess the distribution and annual population sizes of Hermes copper. In 2020, we conducted surveys in many areas that were sampled during 2019.

Methods

Sentinel Sites

In 2020, 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 21 May at Roberts Ranch North and CNF – Wildwood Glen Lane to assess the flowering phenology of plants and on 29 May at Roberts Ranch South to assess Hermes copper phenology. Roberts Ranch South was chosen because the 2019 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.

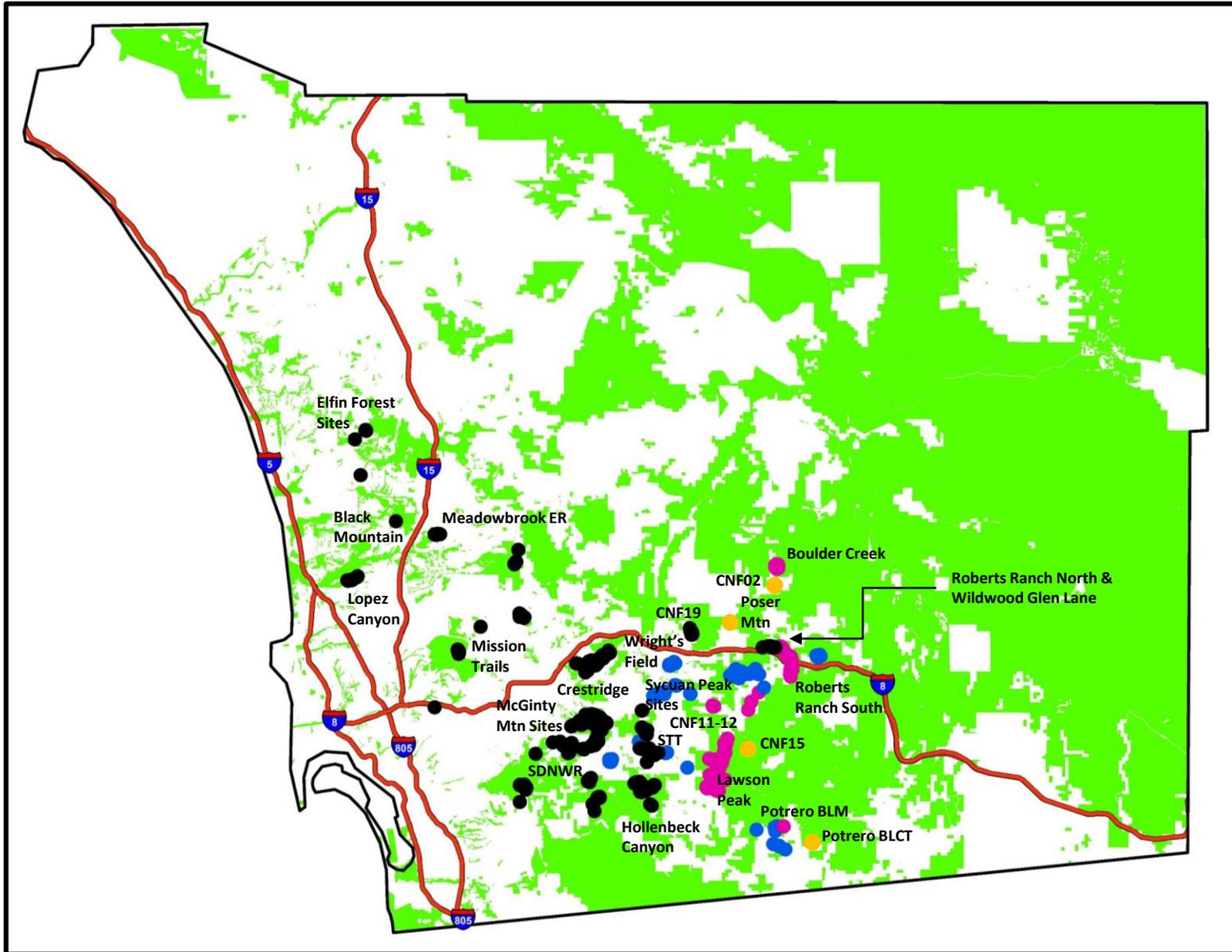


Figure 2. Map of sites that were surveyed for Hermes copper adults in 2020. Purple and black circles represent extant populations and extirpated populations, respectively. Blue circles denote sites of unknown status and orange are sites that have redberry but no historic data regarding Hermes copper occupancy. Status of each site presumed as of August 2019 (see Figure 5 with updated status). Green shading are conserved lands (SANDAG).

Exploratory Sites

In 2020, 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 survey efforts and results (Marschalek and Deutschman 2019). Our goal was to assess 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 2020.

Results

Sentinel Sites

The first Hermes copper adult observed in 2020 was on 1 June 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 2020 (Figure 3, Table 1). This is the fourth consecutive year we did not detect adults at the Sycuan Peak transect, second year out of the last three years with no detections at Lawson Peak, and the first year we did not detect Hermes copper adults at Roberts Ranch North. At the Boulder Creek sentinel transect, we recorded a maximum count of three Hermes copper adults (also see next paragraph for more details regarding this site). Hermes copper adults were present at Roberts Ranch South our entire sampling period (1 – 26 June) so the flight season was likely five to six weeks in length at this site. The flight season started about one week later at Boulder Creek compared to Roberts Ranch South.

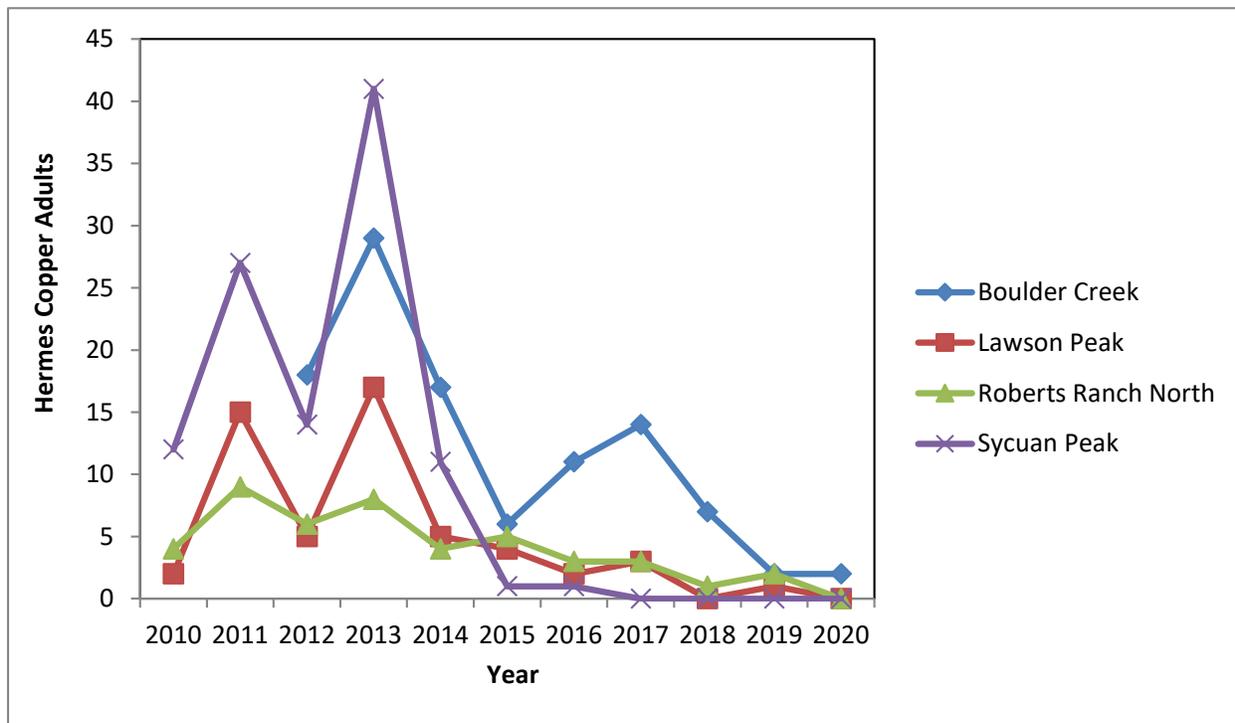


Figure 3. Maximum daily counts of Hermes copper adults at four sentinel sites, 2010-2020 (Roberts Ranch South not shown).

Table 1. Maximum counts of Hermes copper adults at five sentinel sites and an additional site that received frequent visits, 2010-2020. 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
Boulder Creek (routes 2 & 3)	---	---	18	29	17	6	11	14	7	2	2
Boulder Creek (loop- includes routes 2 & 3)*	---	---	---	42	19	10	23	24	26	2	3
Lawson Peak	2	15	5	17	5	4	2	3	0	1	0
Roberts Ranch North	4	9	6	8	4	5	3	3	1	2	0
Sycuan Peak	12	27	14	41	11	1	1	0	0	0	0
Roberts Ranch South (CNF7)**	---	---	---	---	---	---	---	---	54	95	45
Other Visited Site	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Skyline Truck Trail 1	9	---	7	6	7	1	0	3	1	0	0
Skyline Truck Trail 2	---	---	12	27	9	2	1	2	2	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 starting 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.

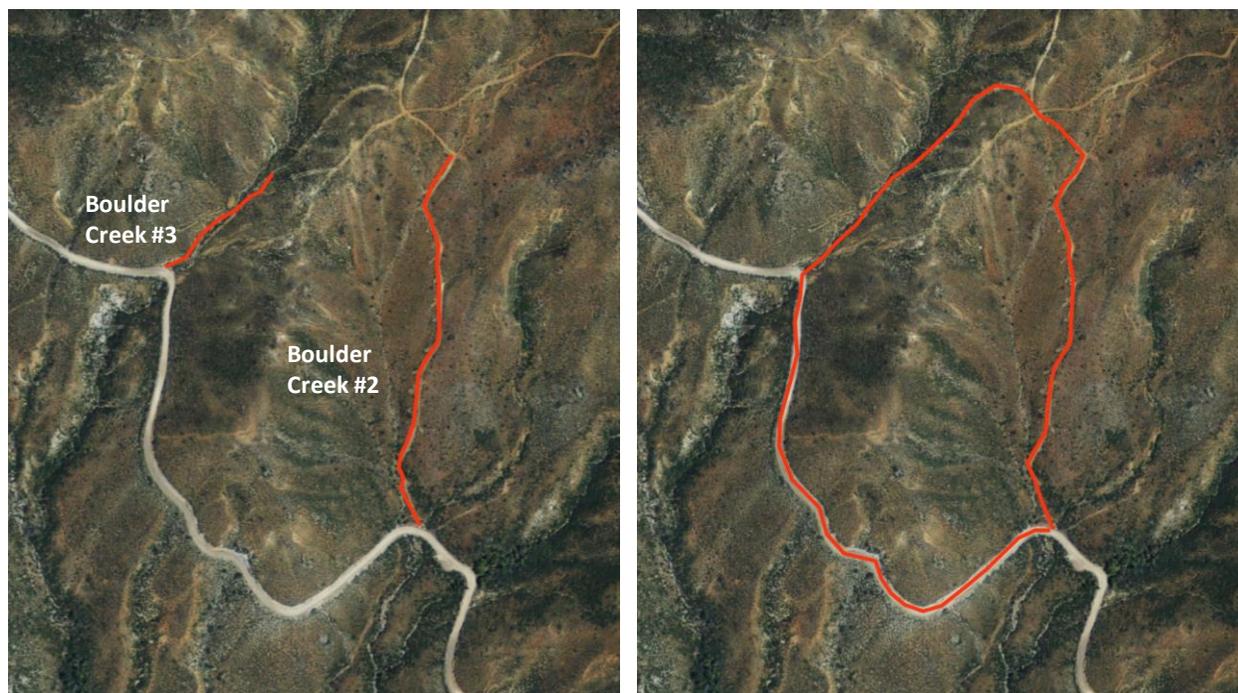


Figure 4. Comparison of survey transects (shown in red) at the Boulder Creek sentinel site. Left: Boulder Creek 2 and Boulder Creek 3 transects were surveyed in 2012. Right: A loop was surveyed in 2013-2020, but only Hermes copper counts from transects 2 and 3 were reported in 2013-2018 report summary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

Exploratory Sites

Surveys were conducted 1 – 26 June, with the start date corresponding to the same date Hermes copper adults were first observed in 2020. Hermes copper adults were detected at only 1 of the 34 exploratory transects (Table 2), with two Hermes copper adults observed in the vicinity of the Potrero BLM transect on 25 June. The sampling transect was restricted to a public road, but both butterflies were observed on a trail extending off of that road. At all sites, the condition of the vegetation looked great. Flowering plants were abundant and the spiny redberry shrubs had lots of leaves and new growth.

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

Site	Hermes Copper		Survey Dates						
	Maximum Count	Survey Dates							
Black Mountain	0	3-Jun-20	11-Jun-20	18-Jun-20	24-Jun-20				
CNF02	0	1-Jun-20	13-Jun-20	22-Jun-20					
CNF11	0	2-Jun-20	10-Jun-20	17-Jun-20	27-Jun-20				
CNF12	0	2-Jun-20	10-Jun-20	17-Jun-20	27-Jun-20				
CNF15	0	2-Jun-20	10-Jun-20	17-Jun-20	27-Jun-20				
CNF19	0	12-Jun-20	20-Jun-20	24-Jun-20					
CNF- Wildwood Glen Lane	0	1-Jun-20	8-Jun-20	12-Jun-20	15-Jun-20	20-Jun-20	24-Jun-20	25-Jun-20	
Crestridge ER (three transects)	0	4-Jun-20	10-Jun-20	17-Jun-20	24-Jun-20				
Elfin Forest	0	2-Jun-20	10-Jun-20	17-Jun-20	22-Jun-20				
Elfin Forest West	0	2-Jun-20	10-Jun-20	17-Jun-20	22-Jun-20				
Hollenbeck Canyon WA- egg release site	0	1-Jun-20	11-Jun-20	18-Jun-20	22-Jun-20				
Hollenbeck Canyon WA- adult release site	0	1-Jun-20	11-Jun-20	18-Jun-20	22-Jun-20				
Lopez Canyon	0	9-Jun-20	16-Jun-20	25-Jun-20					
Meadowbrook ER	0	4-Jun-20	11-Jun-20	18-Jun-20	24-Jun-20				
Mission Trails (2 transects)	0	4-Jun-20	9-Jun-20	16-Jun-20	25-Jun-20				
Poser Mountain	0	12-Jun-20	20-Jun-20	26-Jun-20					
Potrero BCLT	0	9-Jun-20	16-Jun-20	19-Jun-20	25-Jun-20				
Potrero BLM	0 (2)*	9-Jun-20	16-Jun-20	19-Jun-20	25-Jun-20				
SDNWR Interpretive Loop **	0	10-Jun-20							
SDNWR hairpin **	0	12-Jun-20							
SDNWR McGinty Loop **	0	9-Jun-20	17-Jun-20	24-Jun-20					
SDNWR Mother Miguel Saddle Road **	0	12-Jun-20							
SDNWR Par Four Drive **	0	15-Jun-20							
SDNWR Los Montanas South **	0	18-Jun-20							
SDNWR Mexican Canyon **	0	18-Jun-20							
Skyline Truck Trail 1	0	1-Jun-20	11-Jun-20	19-Jun-20	22-Jun-20				
Skyline Truck Trail 2	0	1-Jun-20	11-Jun-20	19-Jun-20	22-Jun-20				
Sycuan 1	0	3-Jun-20	9-Jun-20	11-Jun-20	16-Jun-20	18-Jun-20	23-Jun-20		
Sycuan 2	0	3-Jun-20	11-Jun-20	18-Jun-20	23-Jun-20				
Wright's Field (2 transects)	0	3-Jun-20	18-Jun-20	24-Jun-20					

* Two individuals were observed near the transect area, but not from the transect

** Surveys conducted by John Martin (USFWS)

Discussion

The overall picture of the abundance and distribution of Hermes copper is similar to 2019 (Marschalek and Deutschman 2019) and 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. Confirmation of occupancy in the Potrero area was offset with lack of detection for the first time at Roberts Ranch North. 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.

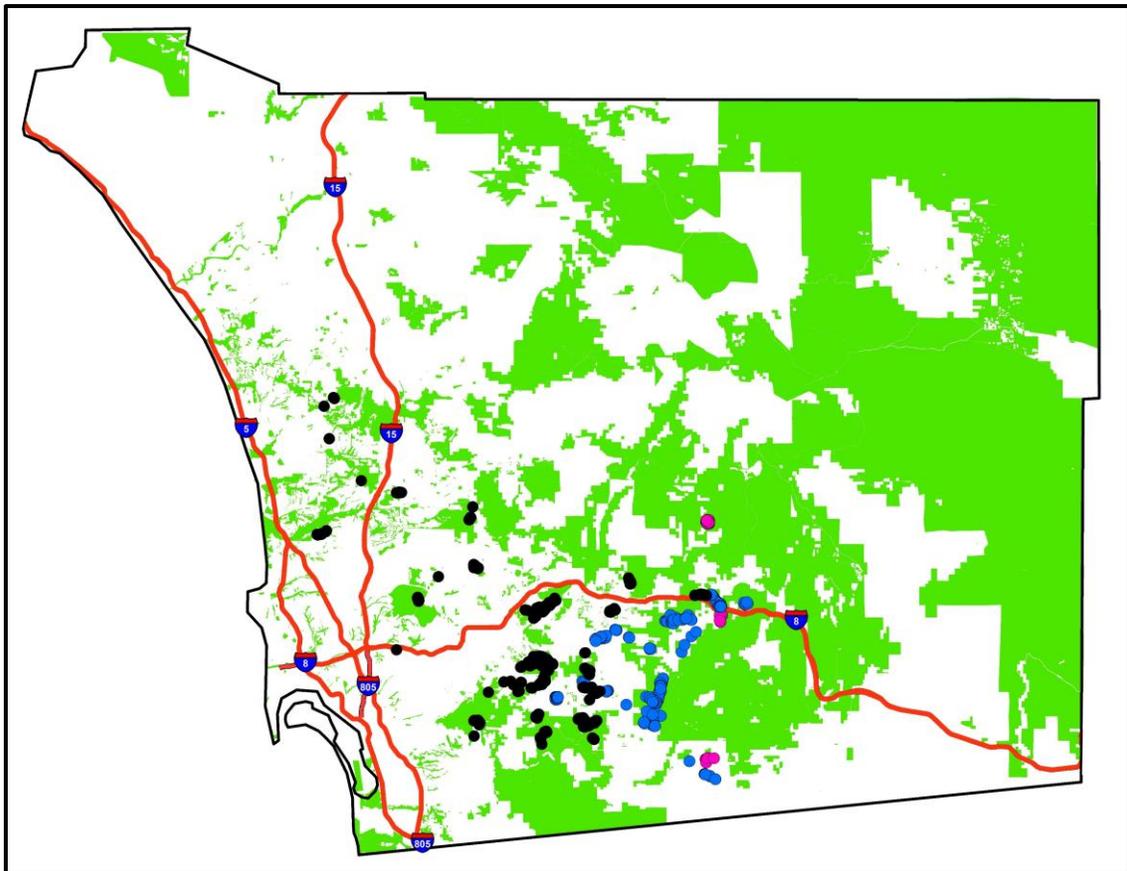


Figure 5. Updated status of local Hermes copper populations based on the most recent survey data. Purple and black circles represent extant populations and extirpated populations, respectively. Blue circles denote sites of unknown status, but most are presumed extirpated. Green shading are conserved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

For the last three years, biologists visiting areas with current or historic Hermes copper populations have reported vegetation growing well and flowering. With vegetation recovering after an extreme drought, the hope was that Hermes copper would start to recolonize unoccupied redberry patches. Unfortunately, this has not occurred. With the existence of Hermes copper largely dependent on one population (Roberts Ranch South), and low recolonization rates after fire or drought (Marschalek and Klein 2010, Marschalek and Deutschman 2019) assisted dispersal expand the geographic extent of the species should be considered. In the dynamic southern California landscape, wildfires are expected and the geographic range of this species needs to expand before the few current populations are lost by future fires.

The Hermes copper butterfly in San Diego County has experienced two substantial stressors in the last 20 years, starting with wildfires in 2003 and 2007, and followed by a drought for most of the last decade. Based on the extirpation and recolonization rates, the current configuration of redberry patches and connectivity of these patches outside of Cleveland National Forest does not appear to be sufficient for a resilient population of Hermes copper considering the dynamic San Diego County environment.

Acknowledgments

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Appendix. GPS coordinates of Hermes copper adults in 2020.

Date	Site	Latitude	Longitude
1-Jun-20	Roberts Ranch South	32.808761	-116.614392
1-Jun-20	Roberts Ranch South	32.808935	-116.609217
1-Jun-20	Roberts Ranch South	32.808962	-116.609388
1-Jun-20	Roberts Ranch South	32.809537	-116.611887
1-Jun-20	Roberts Ranch South	32.811575	-116.604587
5-Jun-20	Roberts Ranch South	32.80885729	-116.607605
5-Jun-20	Roberts Ranch South	32.80905028	-116.6124517
5-Jun-20	Roberts Ranch South	32.80987857	-116.6060796
5-Jun-20	Roberts Ranch South	32.81109735	-116.6097618
5-Jun-20	Roberts Ranch South	32.81111973	-116.6054382
5-Jun-20	Roberts Ranch South	32.81292504	-116.6024549
8-Jun-20	Boulder Creek	32.92579	-116.631314
9-Jun-20	Roberts Ranch South	32.80845	-116.608598
9-Jun-20	Roberts Ranch South	32.808479	-116.613806
9-Jun-20	Roberts Ranch South	32.808614	-116.614162
9-Jun-20	Roberts Ranch South	32.80876	-116.614447
9-Jun-20	Roberts Ranch South	32.808767	-116.614764
9-Jun-20	Roberts Ranch South	32.808778	-116.614608
9-Jun-20	Roberts Ranch South	32.808818	-116.608841
9-Jun-20	Roberts Ranch South	32.808936	-116.609361
9-Jun-20	Roberts Ranch South	32.808996	-116.612471
9-Jun-20	Roberts Ranch South	32.809715	-116.610067
9-Jun-20	Roberts Ranch South	32.810317	-116.605633
9-Jun-20	Roberts Ranch South	32.810996	-116.605508
9-Jun-20	Roberts Ranch South	32.811029	-116.609632
9-Jun-20	Roberts Ranch South	32.811069	-116.609761
9-Jun-20	Roberts Ranch South	32.81108	-116.609731
9-Jun-20	Roberts Ranch South	32.811089	-116.60551
9-Jun-20	Roberts Ranch South	32.811124	-116.610252
9-Jun-20	Roberts Ranch South	32.811328	-116.605528
9-Jun-20	Roberts Ranch South	32.811333	-116.605538
9-Jun-20	Roberts Ranch South	32.811388	-116.604966
9-Jun-20	Roberts Ranch South	32.811431	-116.605625
9-Jun-20	Roberts Ranch South	32.811443	-116.605611
9-Jun-20	Roberts Ranch South	32.811452	-116.605621
9-Jun-20	Roberts Ranch South	32.811487	-116.605636
9-Jun-20	Roberts Ranch South	32.811501	-116.605622
9-Jun-20	Roberts Ranch South	32.811552	-116.604121
9-Jun-20	Roberts Ranch South	32.811557	-116.605569

Appendix. GPS coordinates of Hermes copper adults in 2020 continued.

Date	Site	Latitude	Longitude
9-Jun-20	Roberts Ranch South	32.811571	-116.605568
9-Jun-20	Roberts Ranch South	32.811624	-116.604189
9-Jun-20	Roberts Ranch South	32.811655	-116.604158
9-Jun-20	Roberts Ranch South	32.811711	-116.604203
9-Jun-20	Roberts Ranch South	32.811745	-116.604458
9-Jun-20	Roberts Ranch South	32.811781	-116.60431
9-Jun-20	Roberts Ranch South	32.811786	-116.603935
9-Jun-20	Roberts Ranch South	32.811789	-116.604311
9-Jun-20	Roberts Ranch South	32.811863	-116.603908
9-Jun-20	Roberts Ranch South	32.81188	-116.603854
9-Jun-20	Roberts Ranch South	32.811901	-116.603839
9-Jun-20	Roberts Ranch South	32.81191	-116.603916
9-Jun-20	Roberts Ranch South	32.811939	-116.603764
9-Jun-20	Roberts Ranch South	32.811947	-116.603413
9-Jun-20	Roberts Ranch South	32.812045	-116.603048
9-Jun-20	Roberts Ranch South	32.812144	-116.602959
9-Jun-20	Roberts Ranch South	32.812177	-116.602917
9-Jun-20	Roberts Ranch South	32.813359	-116.602404
12-Jun-20	Boulder Creek	32.926393	-116.631655
12-Jun-20	Boulder Creek	32.927202	-116.631635
12-Jun-20	Boulder Creek	32.929254	-116.630914
12-Jun-20	Roberts Ranch South	32.80827696	-116.6081177
12-Jun-20	Roberts Ranch South	32.80830807	-116.608209
12-Jun-20	Roberts Ranch South	32.80851752	-116.6138584
12-Jun-20	Roberts Ranch South	32.80857348	-116.6085765
12-Jun-20	Roberts Ranch South	32.80866872	-116.6142282
12-Jun-20	Roberts Ranch South	32.80880311	-116.6146479
12-Jun-20	Roberts Ranch South	32.80886584	-116.6086333
12-Jun-20	Roberts Ranch South	32.8090389	-116.6124878
12-Jun-20	Roberts Ranch South	32.80912198	-116.6073919
12-Jun-20	Roberts Ranch South	32.80951692	-116.6100148
12-Jun-20	Roberts Ranch South	32.8095451	-116.6119072
12-Jun-20	Roberts Ranch South	32.80963744	-116.6117757
12-Jun-20	Roberts Ranch South	32.81038297	-116.6055618
12-Jun-20	Roberts Ranch South	32.81042925	-116.6098323
12-Jun-20	Roberts Ranch South	32.81049978	-116.6112676
12-Jun-20	Roberts Ranch South	32.81052159	-116.6055458
12-Jun-20	Roberts Ranch South	32.81064738	-116.6097343
12-Jun-20	Roberts Ranch South	32.81088561	-116.6109247

Appendix. GPS coordinates of Hermes copper adults in 2020 continued.

Date	Site	Latitude	Longitude
12-Jun-20	Roberts Ranch South	32.81106521	-116.609913
12-Jun-20	Roberts Ranch South	32.81107399	-116.6097444
12-Jun-20	Roberts Ranch South	32.81107399	-116.6096852
12-Jun-20	Roberts Ranch South	32.8113344	-116.6054629
12-Jun-20	Roberts Ranch South	32.81139604	-116.6038974
12-Jun-20	Roberts Ranch South	32.81149235	-116.605531
12-Jun-20	Roberts Ranch South	32.8115015	-116.6055773
12-Jun-20	Roberts Ranch South	32.8115368	-116.6051368
12-Jun-20	Roberts Ranch South	32.81156102	-116.6054221
12-Jun-20	Roberts Ranch South	32.81158162	-116.6055065
12-Jun-20	Roberts Ranch South	32.81166517	-116.6044578
12-Jun-20	Roberts Ranch South	32.8116669	-116.6044789
12-Jun-20	Roberts Ranch South	32.8116935	-116.6043967
12-Jun-20	Roberts Ranch South	32.81171298	-116.6041839
12-Jun-20	Roberts Ranch South	32.81186702	-116.6038721
12-Jun-20	Roberts Ranch South	32.81190774	-116.6038215
12-Jun-20	Roberts Ranch South	32.81192722	-116.6037899
12-Jun-20	Roberts Ranch South	32.81195378	-116.6033243
12-Jun-20	Roberts Ranch South	32.81197502	-116.6036783
12-Jun-20	Roberts Ranch South	32.81198742	-116.6031685
12-Jun-20	Roberts Ranch South	32.81199273	-116.6031685
12-Jun-20	Roberts Ranch South	32.8120069	-116.60312
12-Jun-20	Roberts Ranch South	32.81261962	-116.6025666
12-Jun-20	Roberts Ranch South	32.81332918	-116.6023439
12-Jun-20	Roberts Ranch South	32.81334314	-116.6023306
12-Jun-20	Roberts Ranch South	32.81335152	-116.6023173
12-Jun-20	Roberts Ranch South	32.81355266	-116.6021844
15-Jun-20	Boulder Creek	32.926011	-116.632038
15-Jun-20	Boulder Creek	32.926441	-116.634471
16-Jun-20	Roberts Ranch South	32.808779	-116.614433
16-Jun-20	Roberts Ranch South	32.80883	-116.608834
16-Jun-20	Roberts Ranch South	32.808851	-116.607621
16-Jun-20	Roberts Ranch South	32.808872	-116.614763
16-Jun-20	Roberts Ranch South	32.808877	-116.614988
16-Jun-20	Roberts Ranch South	32.808887	-116.612459
16-Jun-20	Roberts Ranch South	32.808918	-116.609214
16-Jun-20	Roberts Ranch South	32.809124	-116.607273
16-Jun-20	Roberts Ranch South	32.809132	-116.607472
16-Jun-20	Roberts Ranch South	32.809295	-116.606866

Appendix. GPS coordinates of Hermes copper adults in 2020 continued.

Date	Site	Latitude	Longitude
16-Jun-20	Roberts Ranch South	32.809343	-116.609877
16-Jun-20	Roberts Ranch South	32.809353	-116.609933
16-Jun-20	Roberts Ranch South	32.809512	-116.611896
16-Jun-20	Roberts Ranch South	32.810303	-116.611348
16-Jun-20	Roberts Ranch South	32.810339	-116.605588
16-Jun-20	Roberts Ranch South	32.810511	-116.605535
16-Jun-20	Roberts Ranch South	32.810671	-116.605526
16-Jun-20	Roberts Ranch South	32.810836	-116.605508
16-Jun-20	Roberts Ranch South	32.810844	-116.610697
16-Jun-20	Roberts Ranch South	32.810973	-116.61057
16-Jun-20	Roberts Ranch South	32.811026	-116.611393
16-Jun-20	Roberts Ranch South	32.81107	-116.609777
16-Jun-20	Roberts Ranch South	32.811094	-116.605484
16-Jun-20	Roberts Ranch South	32.811333	-116.605497
16-Jun-20	Roberts Ranch South	32.811417	-116.605102
16-Jun-20	Roberts Ranch South	32.811572	-116.605455
16-Jun-20	Roberts Ranch South	32.811634	-116.604512
16-Jun-20	Roberts Ranch South	32.811667	-116.604477
16-Jun-20	Roberts Ranch South	32.811945	-116.603877
16-Jun-20	Roberts Ranch South	32.81197	-116.603282
16-Jun-20	Roberts Ranch South	32.811992	-116.603177
16-Jun-20	Roberts Ranch South	32.81241	-116.602709
16-Jun-20	Roberts Ranch South	32.812589	-116.602608
16-Jun-20	Roberts Ranch South	32.81302	-116.602478
16-Jun-20	Roberts Ranch South	32.813542	-116.602229
16-Jun-20	Roberts Ranch South	32.813685	-116.602158
16-Jun-20	Roberts Ranch South	32.814033	-116.60206
19-Jun-20	Boulder Creek	32.9290443	-116.6347785
19-Jun-20	Boulder Creek	32.92914954	-116.6347439
19-Jun-20	Roberts Ranch South	32.80860834	-116.6131162
19-Jun-20	Roberts Ranch South	32.80862533	-116.6140257
19-Jun-20	Roberts Ranch South	32.80883447	-116.6146464
19-Jun-20	Roberts Ranch South	32.80893109	-116.612328
19-Jun-20	Roberts Ranch South	32.80902865	-116.6091706
19-Jun-20	Roberts Ranch South	32.80903301	-116.6125301
19-Jun-20	Roberts Ranch South	32.80987649	-116.6061191
19-Jun-20	Roberts Ranch South	32.80988355	-116.6061107
19-Jun-20	Roberts Ranch South	32.81002486	-116.6100112
19-Jun-20	Roberts Ranch South	32.81018736	-116.6057744

Appendix. GPS coordinates of Hermes copper adults in 2020 continued.

Date	Site	Latitude	Longitude
19-Jun-20	Roberts Ranch South	32.81028627	-116.6056736
19-Jun-20	Roberts Ranch South	32.81067486	-116.6097758
19-Jun-20	Roberts Ranch South	32.81075257	-116.6054886
19-Jun-20	Roberts Ranch South	32.81107757	-116.6097254
19-Jun-20	Roberts Ranch South	32.81144496	-116.6039755
19-Jun-20	Roberts Ranch South	32.81153681	-116.6053373
19-Jun-20	Roberts Ranch South	32.81154387	-116.6053289
19-Jun-20	Roberts Ranch South	32.81168517	-116.6041688
19-Jun-20	Roberts Ranch South	32.81195365	-116.6031769
19-Jun-20	Roberts Ranch South	32.81199604	-116.6031769
19-Jun-20	Roberts Ranch South	32.81208082	-116.6029667
19-Jun-20	Roberts Ranch South	32.81208788	-116.6029499
19-Jun-20	Roberts Ranch South	32.81332155	-116.6023633
22-Jun-20	Boulder Creek	32.925516	-116.632781
22-Jun-20	Boulder Creek	32.928099	-116.634861
23-Jun-20	Roberts Ranch South	32.808742	-116.614337
23-Jun-20	Roberts Ranch South	32.808834	-116.6145
23-Jun-20	Roberts Ranch South	32.809329	-116.606893
23-Jun-20	Roberts Ranch South	32.809557	-116.611832
23-Jun-20	Roberts Ranch South	32.810085	-116.611455
23-Jun-20	Roberts Ranch South	32.810671	-116.60975
23-Jun-20	Roberts Ranch South	32.810812	-116.610776
23-Jun-20	Roberts Ranch South	32.811098	-116.609718
23-Jun-20	Roberts Ranch South	32.811553	-116.605618
23-Jun-20	Roberts Ranch South	32.811615	-116.605013
23-Jun-20	Roberts Ranch South	32.811871	-116.604267
23-Jun-20	Roberts Ranch South	32.813044	-116.602446
23-Jun-20	Roberts Ranch South	32.813592	-116.60216
23-Jun-20	Roberts Ranch South	32.813976	-116.602076
25-Jun-20	Boulder Creek	32.92635678	-116.6344923
25-Jun-20	Boulder Creek	32.926881	-116.631165
25-Jun-20	Boulder Creek	32.927442	-116.634738
25-Jun-20	Potrero BLM	32.64678	-116.63572
25-Jun-20	Potrero BLM	32.64682	-116.63571
26-Jun-20	Roberts Ranch South	32.80886543	-116.6147462
26-Jun-20	Roberts Ranch South	32.80915251	-116.607424
26-Jun-20	Roberts Ranch South	32.80942164	-116.6119496
26-Jun-20	Roberts Ranch South	32.80942164	-116.6119496

Appendix. GPS coordinates of Hermes copper adults in 2020 continued.

Date	Site	Latitude	Longitude
26-Jun-20	Roberts Ranch South	32.81109023	-116.6097509
26-Jun-20	Roberts Ranch South	32.81137729	-116.6054814
26-Jun-20	Roberts Ranch South	32.81139524	-116.6054814
26-Jun-20	Roberts Ranch South	32.81155671	-116.6053319
26-Jun-20	Roberts Ranch South	32.81157465	-116.6053746
26-Jun-20	Roberts Ranch South	32.81191554	-116.603859
26-Jun-20	Roberts Ranch South	32.81191554	-116.603859
26-Jun-20	Roberts Ranch South	32.81196937	-116.6033253
26-Jun-20	Roberts Ranch South	32.81204113	-116.6032186
26-Jun-20	Roberts Ranch South	32.81363756	-116.6021537
26-Jun-20	Roberts Ranch South	32.81490346	-116.6160303