San Diego County Hermes Copper (*Lycaena hermes*) Habitat Conservation and Management Plan

Prepared for:
San Diego Association of Governments

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Introduction

The Hermes copper (*Lycaena hermes*) is a rare butterfly endemic to San Diego County and northern Baja California. This species is threatened by recent urbanization and wildfires throughout its range in the United States. 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, and it is currently on the USFWS list of candidate species (USFWS 2011).

Within San Diego County, the Hermes copper was historically found within the area addressed by the *Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County*: *A Strategic Habitat Conservation Roadmap* ("MSP Roadmap", San Diego Management and Monitoring Program [SDMMP] 2016), and is designated a Category SL species within this plan. Category SL refers to species determined to be at risk of loss entirely on conserved lands in the MSP area. The MSP area has been divided into 11 management units (MUs) (see Figure 1), and the Hermes copper was historically found in MUs 2, 3, 4, 6, 10, and 11. Most of the historic and recent observations have occurred in MUs 3, 10 and 11.

Purpose

The "MSP Roadmap" is an adaptive management and monitoring framework for prioritized species and vegetation communities in western San Diego County (SDMMP 2016). Large portions of Conserved Lands in western San Diego County are within approved or proposed regional multi-species Habitat Conservation Plans (HCPs)/Natural Communities Conservation Plans (NCCPs). The MSP Roadmap is not limited to species covered under the regional conservation plans, but also includes other sensitive species such as Hermes copper. These conservation plans recognize that biological monitoring and management should extend beyond individual plan boundaries to facilitate regional conservation of an interconnected preserve system for the persistence of rare and sensitive wildlife species and vegetation communities. Management and monitoring of these preserve lands is largely the responsibility of plan participants and varies considerably in methods and timing across the preserve system so that it is not possible to determine the regional status and effectiveness of conservation efforts. The purpose of the MSP Roadmap is to provide a scientifically based strategic plan to determine the status of conserved natural resources across the landscape and to guide regional decision making and funding priorities for managing natural resources on Conserved Lands. The plan prioritizes plant and animal species, vegetation communities, and threats for management. It also provides adaptive management and monitoring goals, objectives, and actions with implementation timelines. It offers a process for coordinated implementation by land managers, conservation groups, and other stakeholders

The MSP Roadmap does not replace the need for preserve resource management plans, daily maintenance activities at existing preserves, or prior obligations negotiated with the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife (CDFW). Rather, the MSP Roadmap provides a framework for the efficient use of funds, to leverage existing funding, and to assist with regional conservation efforts. It does not assign responsibilities for specific management and monitoring objectives, although it identifies "what" and "where" management is needed. Implementation and funding for MSP Roadmap objectives may be accomplished using multiple resources and entities as long as the land owner(s) and entities are in agreement. Management plans prepared as part of MSP

Roadmap objectives may be used to inform the development and implementation of preserve resource management plans, annual work plans, and/or area specific management directives (ASMDs).

This document has been prepared to help meet MSP Roadmap Goals and Objectives for management of the Hermes copper in the MSP area (Appendix A and B). It is based on the information currently available for the species, and can be modified as new information is obtained.

Goal: This plan identifies and prioritizes management and restoration needs over the next five years (2017-2021) for the Hermes copper across the entire United States range. It is intended that implementation of high priority management actions in this plan will help to achieve the MSP Roadmap goal for Hermes copper to: "protect, enhance, and restore Hermes copper occupied habitat and historically occupied habitat and the landscape connections between them to create resilient, self-sustaining populations that provide for persistence over the long term (>100 years)".

This plan fulfills the MSP Roadmap objective: "In 2017, complete a five-year Hermes Copper Management Plan that includes the results from butterfly surveys and habitat assessments and genetic, marking, and translocation studies to develop a management strategy and to identify and prioritize site specific management actions. The plan should employ the modeling results to identify potential fire and climate refugia that may be suitable sites for future translocations and provide specific recommendations for reducing fire risk at occurrences at highest risk."

This iteration of the plan achieves the first part of the MSP Roadmap objective. The identification of fire and climate refugia and specific recommendations to reduce fire risk will be added as an appendix after the modeling is completed.

Specific management objectives and actions identified in this plan are included in the Management Strategies section.

Approach and Planning Area

This plan provides a summary of what is known regarding the Hermes copper, including life history, historic and current distribution, movement patterns, suitable habitat, and threats. A thorough understanding of the species is necessary to make appropriate adaptive management recommendations in an attempt to alleviate the current threats to the species. To develop this plan, we:

1. Reviewed existing data, including historic Hermes copper locations, recent (2010-2016) survey data, property ownership to identify conserved lands for potential surveys, management, and acquisitions, and
2. Consulted with the wildlife agencies (USFWS, CDFW) and other stakeholders to ensure that the most current information regarding Hermes copper biology, management, regulations, conserved lands, and potential acquisitions were included.

Species Description and Life History

Hermes copper males and females are similar in appearance, with a wingspan of 1 to 1 ¼ inches (Opler and Peterson 1999, Faulkner and Klein 2004). Upper forewings are orange with a brown border and brown spots within the orange patch. Hindwings are brown with some orange on the posterior edge, where a tail is present. The underside of both wings is orange to yellow with some dark spots.

Adults emerge in the late spring after overwintering as eggs and spending a short period of time as caterpillars (Thorne 1963, Faulkner and Klein 2004). Adult emergence is fairly consistent, generally beginning in mid to late May, with the flight period extending to late June or mid-July (Faulkner and Klein 2004, Marschalek and Deutschman 2008, Marschalek and Klein 2010). Emergence appears to be influenced by climatic conditions; however, our understanding of this relationship is incomplete.

Hermes copper larvae use only spiny redberry, *Rhamnus crocea*, as a food plant (Thorne 1963, Brown 1991, Faulkner and Klein 2004). Oviposition typically occurs at the intersection of branches on new growth (Marschalek and Deutschman 2009). Although adults gather nectar almost exclusively on California buckwheat, *Eriogonum fasciculatum*, they are rarely found far from spiny redberry plants (Thorne 1963, Brown 1991, Faulkner and Klein 2004, Marschalek 2004). Only a basic understanding of the immature stages exists.

During the flight season, Hermes copper adults become active at around 22°C (72°F) (Marschalek 2004, Marschalek and Deutschman 2008). Adult males have a strong preference for openings in the vegetation, including roads and trails, specifically for the north and west sides of openings (Marschalek 2004, Marschalek and Deutschman 2008). This results in a preference to perch on the south and east sides of plants (Marschalek 2004, Marschalek and Deutschman 2008). They tend to remain inactive or sluggish under conditions of heavy cloud cover and cooler weather (Marschalek 2004, Marschalek and Deutschman 2008).

Hermes copper males typically exhibit short movements with the majority of their displacements well under 50 meters (Marschalek 2004, Marschalek and Klein 2010). This behavior is the result of territoriality in males who generally return to an area after being disturbed. The majority of individuals encountered are males. Hermes copper females display remarkably different behavior, exhibiting no territoriality, and do not return to the area after being disturbed. With the majority of data from males, movements over 100 meters are rare, and the longest movement reported for a Hermes copper is just over 1 kilometer (Marschalek and Klein 2010).

Genetic analyses indicate that individuals from all populations are similar. This suggests that the species was once able to disperse across the landscape so that strong local differences did not develop (Strahm et al. 2012, Marschalek et al. 2016). In contrast, few recolonization events following the recent 2003 and 2007 wildfires have been observed. This may indicate that recent habitat fragmentation is currently restricting dispersal (Marschalek et al. 2016).

Historical and Current Distribution and Abundance

Methods

The historical distribution of Hermes copper was reconstructed using museum specimens, published journal articles, unpublished reports, and personal communications with local biologists. The current distribution has been determined by surveys for Hermes copper adults, starting with Marschalek (2004). This included surveys at historical Hermes copper locations, Hermes copper locations reported by local biologists, and spiny redberry locations present in the San Diego Natural History Museum Plant Atlas. Areas not included in these efforts were private property and those areas that burned in the 2003 or 2007 wildfires. However, surveys have been conducted regularly at historically occupied sites that burned during these fires to document if or when recolonization occurs.

Standardized transects, also referred to as Pollard Walks, are a common butterfly monitoring technique to obtain an annual population index (Pollard 1977). Starting in 2003, standardized transects were established at six sites (Cleveland National Forest- Anderson Road and Wildwood Glen Lane, Crestridge Ecological Reserve, Meadowbrook Ecological Reserve, Rancho Jamul Ecological Reserve, Sycamore Canyon County Park) (Marschalek 2004, Marschalek and Deutschman 2008). In 2007-2016, additional sites were added (Deutschman et al. 2010, 2011; Strahm et al. 2012; Marschalek and Deutschman 2015, 2016A, B, C). From 2003-2007, marking studies at Rancho Jamul Ecological Reserve and Hollenbeck Canyon Wildlife Area were conducted to estimate population sizes (Marschalek 2004, Marschalek and Deutschman 2008, Marschalek and Klein 2010). These marking studies also provided demographic, survival, and movement data.

Repeated sampling during the adult flight season was used to determine occupancy of spiny redberry patches. This involved at least three survey dates, but preferably up to eight survey dates (two surveys per week for four weeks), during a year with near to above average Hermes copper adult counts at known populations. Drought suppresses adult butterfly numbers so failing to detect Hermes copper adults during dry years (e.g. 2015, 2016) are not interpreted as unoccupied/extirpated. It is possible that the species is occupying the habitat in an immature life stage (Marschalek and Deutschman 2015) which are much harder to detect. Some areas have restricted access so the current status could not be determined may be given the designation of “unknown” status. Based on past surveys, occupancy appears to be relatively stable their status does not change unless there is a clear disturbance (e.g. fire, development).

Results

In the United States, Hermes copper is only found within San Diego County, west of the Cuyamaca Mountains (Thorne 1963, Brown 1991, Faulkner and Klein 2004, Marschalek 2004, Marschalek and Klein 2010). The species also occurs in northern Baja California, Mexico; however, very little is known about its status south of the United States-Mexico border (Thorne 1963, Emmel and Emmel 1973, Marschalek and Klein 2010). Hermes copper has been recorded as far north as near the community of Bonsall, in San Diego County and as far south as Ensenada in Mexico. The species has never been recorded immediately along the Pacific coast, and has not been found above 1300 m elevation (Marschalek and Klein 2010).

The current documented distribution of Hermes copper is reduced compared to documented historic locations (Figure 1). Local extirpations in its western most range appear to be due to habitat loss associated with urban development. Wildfires in 2003 and 2007 resulted in the extirpation of several known populations in the eastern portion of its range (Marschalek and Klein 2010, Strahm et al. 2012). Only two recolonization events have been recorded following these fires, both in Cleveland National Forest (Strahm et al. 2012). Most of the known Hermes copper populations are in a small portion of San Diego County, representing about 9% of the county’s area (Deutschman et al. 2010). Some unknown populations likely exist on private property but these are probably within or close to the current known range of the species.

Some historic locations (e.g. “El Cajon”) are too vague to identify a specific property parcel or spiny redberry patch. Therefore, these cases are not informative for site-specific status assessments. However, these data are still useful for county-level scale investigations such as the species distribution.

Many of the largest populations are no longer present (Marschalek and Klein 2010). Museum records and past surveys have recorded 50 to several hundred individuals counted on a single date for several different populations. Despite these large populations, most local populations numbered fewer than 50 adults (Scott 1986). Adult densities vary from year to year (Marschalek and Klein 2010, Strahm et al. 2012), a common pattern observed with butterflies (Pollard 1988).

Recent surveys indicate that occurrence (presence) of this species is relatively consistent from year to year, especially for larger populations (Deutschman et al. 2011, Table 1). However, adults are not always detected for smaller populations across years (Deutschman et al. 2011, Table 1).

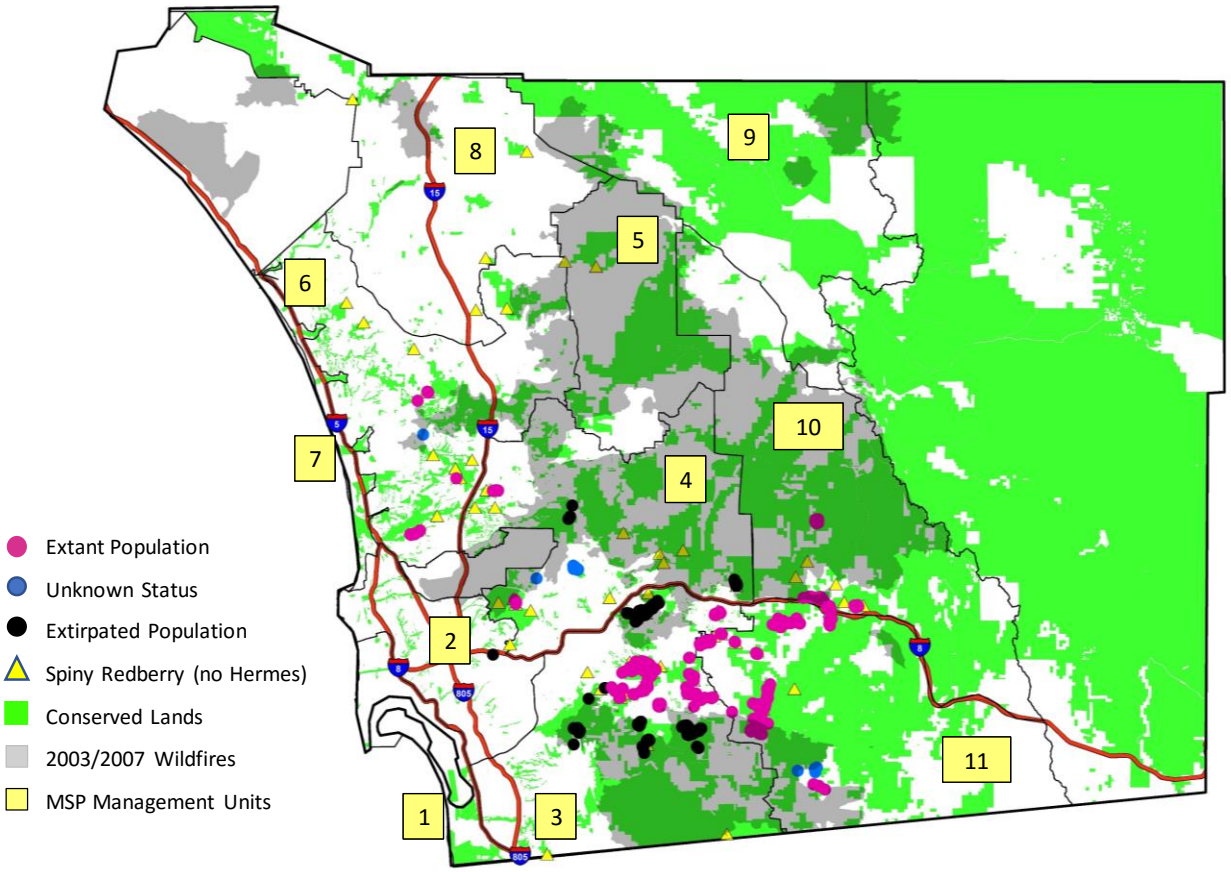

Figure 1. Distribution of the Hermes copper in San Diego County. MSP Management Units are outlined in black and numbered. Only those locations with detailed geographic information are shown as this information is required to assess the status of each population.

Table 1. Daily maximum counts of Hermes copper adult butterflies along a fixed transects.

Populations	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Transect Length (m)	Last Fire
Barrett Lake	---	---	---	---	---	---	---	0	0	---	---	---	---	---	not established	2007 (partial)
Black Mountain	---	P	---	---	---	---	---	0	0	---	---	---	---	0	not established	1943
California Riding & Hiking Trail	---	---	---	---	---	---	---	2	2	1	---	---	---	---	418	1970
Cleveland National Forest	---	---	---	---	---	---	---	P	---	---	---	---	---	---	not established	various
Cleveland National Forest- Anderson Road	73	---	---	---	0	0	0	0	0	0	0	---	---	0	500	2003
Cleveland National Forest- Barber Mountain	---	---	(95)	---	---	(18+)	(1)	P	---	---	---	---	---	---	not established	2007
Cleveland National Forest- Boulder Creek Road	---	---	---	---	---	---	---	P	---	18	29	17	6	11	673	2007
Cleveland National Forest- Lawson Peak	---	---	(30)	---	---	(10+)	---	2	15	5	17	5	4	2	1856	1970
Cleveland National Forest- Roberts Ranch North	---	---	---	---	---	(6)	(3)	4	9	6	8	4	5	3	377	1970
Cleveland National Forest- Roberts Ranch South	---	---	---	---	---	---	(4)	---	---	---	---	---	---	---	not established	1970
Cleveland National Forest- Wildwood Glen Lane	13	---	---	---	1	1 (3)	0 (2)	1	2	0 (3)	0	---	---	---	500/1983	2003
Crestridge Ecological Reserve	49	---	0 (1)	---	0 (1)	0	0	0	0	0	0	---	---	0	750	2003
Crosby National Golf Course	---	(1)	---	---	---	---	---	---	---	---	---	---	---	---	not established	2007
Elfin Forest	---	---	---	---	---	---	---	0	1 (3)	0	---	---	---	---	1440	1943/1989
Flinn Springs County Park	---	---	---	---	---	---	---	0	0	---	---	---	---	---	not established	2003
Hollenbeck Canyon Wildlife Area	---	---	(90)	(13+)	45	---	---	0	0	---	0	---	---	1	3490/4370	2007
Lakeside Downs	---	P	---	---	---	---	---	---	---	---	---	---	---	---	not established	1984/none
Lawson Valley 1 (Skyline Truck Trail 1)*	---	---	---	---	---	(12)	P (7)	9	---	7	6	7	1	0	variable	1970
Lawson Valley 2 (Skyline Truck Trail 2)*	---	---	---	---	---	---	---	(2)	---	12	27	9	2	1	variable	1970
Lopez Canyon	---	---	---	---	---	(2)	---	---	5 (7)	0	---	---	---	---	661	None
Loveland Extension	---	---	---	---	---	---	---	1	1	0	---	---	---	---	714	1970
Loveland Reservior	---	---	---	---	---	---	---	3	10	4	---	---	---	---	2240	1970
Meadowbrook Ecological Reserve	14	---	---	---	---	---	---	0	1	0	---	---	---	---	1225	1967
Mission Trails Regional Park (Kwaay Paay)	---	---	---	---	---	(7)	(1)	1	0	0	---	---	---	---	1439	1981
Potrero	---	---	---	---	---	---	---	(7)	---	---	---	---	---	---	not established	2007/none
Potrero Peak	---	---	---	---	---	---	---	---	---	(6)	---	---	---	---	not established	none
Rancho Jamul Ecological Reserve (2003)	42	---	---	---	0	0	0	0	0	---	0	---	---	0	750	2003
Rancho Jamul Ecological Reserve (2004)	---	10	20	5	4	0	0	0	0	---	0	---	---	0	3300	2007
SDNWR- Las Montanas North	---	---	---	---	---	---	---	3	1	0	---	---	---	---	2471	1970
SDNWR- Las Montanas South	---	(1)	---	---	---	---	---	1	3	0	---	---	---	---	541	1970
SDNWR- McGinty Mountain *	---	---	---	---	---	(3)	(1)	26	27	8	---	1	---	---	variable	1970
SDNWR- San Miguel Mountain	---	P	P	P	P	---	---	0	---	---	0	---	---	0	variable	2007
SDNWR- Steele Canyon	---	---	---	---	---	---	---	P	---	---	---	---	---	---	not established	1970
SDNWR- Sweetwater	---	---	---	P	---	---	---	---	---	---	---	---	---	---	not established	1985
Sycamore Canyon County Park	7	---	---	---	---	---	---	0	---	---	0	---	---	---	250	2003
Sycuan Peak Ecological Reserve	---	---	---	---	---	---	---	12	27	14	41	11	1	1	1628	1970
Sycuaun Peak Ecological Reserve North	---	---	---	---	---	---	(2)	---	---	---	---	---	---	---	not established	2001
Wright's Field	---	---	---	---	---	(3)	---	4	3	0	---	---	---	---	1744	1970

*Differing efforts among years "---" means no survey (#) are observations not from a standardized transect survey
"P" means Hermes copper were present but no numbers reported Fire data from CalFire (2015)

Only two natural recolonizations have been detected following the 2003 or 2007 wildfire extirpations. They are both in Cleveland National Forest, at Boulder Creek Road and Wildwood Glen Lane. The single observation at Hollenbeck Canyon Wildlife Area was likely due to translocation efforts (Marschalek and Deutschman 2016C).

Density of adults, whether it was measured by Pollard Index, Max Count, or number of marked individuals, varied greatly among years at Rancho Jamul Ecological Reserve (Table 2). We encountered difficulties estimating population sizes from the marking studies because of low population sizes and there was little mixing of marked and unmarked individuals. In other words, once an individual was marked, it was always detected until it left the area or died. Only rarely was a marked individual not detected, then observed on a later survey. This mixing is valuable for calculating population estimates generated from marking studies. The population size estimates generated from marking also varied, with the Cormack-Jolly-Seber (CJS) models generally providing estimates two times greater than the Jolly-Seber (JS) estimates. In addition, the JS estimates are consistently lower than the total number of marked individuals (minimum known population size) while the CJS is similar to this value, suggesting that the CJS outperforms JS. The 95% confidence intervals also differed between estimates, as the intervals are quite broad for JS and narrower for the CJS models. Overall, the percent of marked butterflies resighted was relatively high, ranging from 39 to 67%.

Although sample sizes are small, population size estimates are highly correlated (Pollard Index-Max Count, $r_s = 0.956$, $P = 0.025$; Pollard Index-JS, $r_s = 0.931$, $P = 0.047$; Max Count-JS, $r_s = 0.998$, $P < 0.001$). Using estimates only from the Rancho Jamul Ecological Reserve site to exclude the substantially larger Hollenbeck Canyon Wildlife Area population, or replacing JS estimates with CJS estimates produced similar results.

Summary of Historical and Current Distribution and Abundance

The current range of Hermes copper is reduced compared to the historic range, primarily due to habitat loss (urbanization) in the western portion and wildfires in the eastern portion. Historically, some local populations were large, with more than 100 individuals present on a single day. Over the last decade (2008-2016), local populations have been much smaller due to habitat, climate (precipitation), or both. Current populations north of Interstate 8 and west of Alpine are difficult to detect as adults are not observed every year. In addition, the maximum number observed is generally less than five individuals. The largest populations, and therefore the majority of Hermes copper individuals, are located between the 2003/2007 wildfire footprints, east of the San Diego metropolitan area and south of Interstate 8, with the exception of three local populations north of Interstate 8 in Cleveland National Forest. This means the species is essentially restricted to an area of San Diego County less than 350 km^2.

The different monitoring techniques showed a high level of agreement in terms of the relative annual population size. For this reason, any one of the techniques can be used for monitoring, but comparisons among techniques and across years may be complicated. Recent monitoring efforts (Marschalek and Deutschman 2016B) have utilized the Max Count index from transect counts as it is the least time intensive method of those tested.

Table 2. Abundance curve characteristics, population size statistics, and demographic and movement data of the Hermes copper from Rancho Jamul Ecological Reserve (RJER) in 2004-2007 and Hollenbeck Canyon Wildlife Area (HCWA) in 2007. Surveys were infrequent at the end of the 2007 flight seasons.

	RJER				HCWA
	2004	2005	2006	2007	2007
Abundance Curve & Population Estimates					
Date of First Observed	12 May	16 May	12 June	23 May	24 May
Date of Last Observed	14 June	22 June	30 June	15 June	3 July
Date of Peak Abundance	25 May	25 May	22 June	7 June	1 June
Length of Flight (days)	34	38	19	24	41
Pollard Index	59	150	12	18	243
Max Count	10	20	5	4	45
MRR					
Number Marked	29	47	3	8	120
Jolly-Seber Estimate	12.5	28.5	4	3	78.7
(95% CI)	(9-45)	(19-72)	(3-34)	(2-14)	(53-165)
Cormack-Jolly-Seber Estimate	31.5	52.8	3.1	8.5	149.8
(95% CI)	(29-43)	(49-62)	(3-12)	(8-17)	(136-176)
Resighting Rate	43%	67%	67%	57%	39%
(actual count)	(12/28)	(30/45)	(2/3)	(4/7)	(45/116)
Demographic					
Sex Ratio (♂:♀):					
Marked	21:8	40:7	1:1	8:0	107:13
Observed	42:9	125:12	2:2	17:0	187:16
Lifespan (days):					
Average	6.4-9.9	10.5-14.1	5.3-14.3	5.7-9.7	3.9-9.4
Maximum	17-21	23-27	11-22	20-23	23-26
Movement					
Median dispersal range (m)	19.6	34.4	44.5	14.1	11.3
	(1.5-83.8)	(1.5-108.5)	(2.2-86.8)	(3.7-18.5)	(1.3-1132.0)
Median minimum distance traveled (m)	19.6	41.9	44.5	18.4	17.6
	(1.5-86.0)	(1.5-316.3)	(2.2-86.8)	(3.7-35.2)	(1.3-1132.0)

Movement

Methods

Hermes copper movement patterns were quantified using mark-release-recapture techniques and population genetic analyses. Marking studies involved repeated transect surveys at a particular site. All adults were captured and marked with an unique color code using felt-tipped pens. The location of each individual and its unique identity were recorded throughout the flight season. Amplified Fragment Length Polymorphic (AFLP) markers were used to assess genetic differences, and the analyses involved the use of Geneland to assign individuals to genetic clusters and F_{ST} calculations to quantify genetic similarities and differences. A total of 321 individuals from 23 locations were used in the genetic analyses.

Results

Through the use of visual marking techniques, most of the detected movements were short distances. The median minimum distance traveled was 34.4 m at Rancho Jamul Ecological Reserve and 17.6 m at Hollenbeck Canyon Wildlife Area, with 316.3 and 1132.0 m representing the greatest minimum distance, respectively. The median dispersal range was 25.8 m at Rancho Jamul Ecological Reserve and 11.3 m at Hollenbeck Canyon Wildlife Area, with 108.5 m and 1132.0 m representing the largest ranges, respectively. A common trend observed was that the individuals that moved the greater distances did so by single long movements between consecutive observations rather than by several shorter movements. The high frequency of short movements resulted from commonly encountering territorial males, sometimes found perched on the same branch on different sampling occasions.

We detected no movement between Rancho Jamul Ecological Reserve and Hollenbeck Canyon Wildlife Area in 2007, the only year of concurrent marking studies. These two sites are separated by 5.7 km which consists of heavily disturbed sage scrub habitat that includes a type conversion to grassland, small hills, and a two-lane highway. We also did not detect movement between two areas of Hollenbeck Canyon Wildlife Area that were separated by 100 m wide oak riparian community and an adjacent 65 m grassland. Both of the hillsides bordering these riparian/grassland communities had relatively high numbers of Hermes copper adults. The habitat between observation locations for the individual that traveled a minimum of 1,132 m is believed to consist of a nearly or completely continuous patch of coastal sage scrub. Due to a subsequent wildfire, we are unable to confirm the vegetation pattern. At Rancho Jamul Ecological Reserve, 2 of 87 marked individuals were found to have traveled between two spiny redberry patches separated by a grassland of about 90 m in width with sparse California buckwheat and no spiny redberry shrubs.

Using the AFLP data, the majority of Hermes copper individuals were genetically similar to each other, with peripheral portions of the distribution containing most of the differences. This provides evidence that the Hermes copper can disperse across much of the landscape, which was not suggested by Thorne (1963) or detected by small-scale marking studies (Marschalek and Deutschman 2008, Marschalek and Klein 2010). These genetic patterns likely reflect historical processes rather than contemporary influences (e.g. habitat fragmentation) as genetic differences reaching detectable levels would probably require more time to accumulate. Individuals from peripheral populations in the northern and western portion of the Hermes copper distribution generally exhibit increased differentiation compared to populations in the central region of their range (McGinty Mountain, Sycuan Peak, and Lawson Peak areas). The southeastern peripheral populations near Potrero appear to have adequate dispersal with

the central region to prevent genetic differentiation. The overall genetic patterns likely reflect historic processes and it is possible that recent impacts, such as habitat fragmentation resulting in increased isolation, have yet to appear in the genetic composition.

Summary of Movement

The marking studies focused mostly on territorial males and intra-spiny redberry patch movements. Most males remained within an area less than 20 meters across. Genetic techniques were required to assess long-distance movements. The genetic structure of Hermes copper indicated that most of the habitat patches were not isolated from one another historically. Genetic differences among populations require time to accumulate so current connectivity was not assessed through genetic techniques. The lack of recolonization following wildfires, despite vegetation/habitat recovery, suggests that recent habitat loss and fragmentation is limiting or preventing dispersal (connectivity).

Habitat Description

Methods

Previous efforts to describe Hermes copper habitat occurred in 2003 (Marschalek 2004) and 2016 (Marschalek and Deutschman 2016A, B). Hermes copper larvae use only spiny redberry as a food plant (Thorne 1963, Brown 1991, Faulkner and Klein 2004) and adults strongly prefer to obtain nectar from California buckwheat flowers (Thorne 1963, Brown 1991, Faulkner and Klein 2004, Marschalek 2004). For these reasons, spiny redberry and California buckwheat have been a focus for vegetation sampling in regards to describing habitat requirements and preferences.

In 2003, a rapid habitat assessment of butterfly transect areas was conducted at six sites (Cleveland National Forest- Anderson Road and Wildwood Glen Lane, Crestridge Ecological Reserve, Meadowbrook Ecological Reserve, Rancho Jamul Ecological Reserve, Sycamore Canyon County Park) (Marschalek 2004). Aspects of habitat (see Table 3) were measured every 20 m on the 250 m butterfly transects and starting 5 m from transect starting points (Figure 2). Each sampling location was recorded with a GPS unit. Measured characteristics fell into three broad categories: general habitat structure, adult nectar source abundance, and larval host plant abundance. When estimating percent cover, ten percent classes were used (e.g. 0-10%, 10-20%…90-100%). To associate Hermes copper use, or densities, with habitat characteristics, each sighting was registered to the nearest vegetation sampling location using a measuring tool in GIS. All habitat variables were included into the model to predict Hermes copper presence.

In 2016, spiny redberry patches were mapped in the same areas as adult Hermes copper adult surveys (see Figure 3 for list of sites). These sites are currently occupied or had historic records of Hermes copper, with the exception of Bette Bendixen which has no previous Hermes copper observations. For areas with few, discrete spiny redberry patches, all patches at the site were included. Other areas had extensive stands of relatively undisturbed native habitat with spiny redberry shrubs. Due to limitations in field time and funding, only redberry patches closest to the butterfly transects were sampled. Standardized mapping units were not established prior to mapping. Within each spiny redberry patch, the abundance and cover of spiny redberry and California buckwheat were recorded, as well as general vegetation composition (Table 4). The site assessments were designed to be rapid and detect large differences in habitat. Individual spiny redberry shrubs were also recorded but associated habitat data were not collected for single, isolated shrubs.

Table 3. Measurements taken at 20 m intervals on survey transects to determine habitat preference of Hermes copper adults in 2003.

Category	Measurements
General Structure	Slope, aspect, # large shrubs[1]
	% cover: shrubs[1], grasses[2], bare ground[3]
Adult Nectaring Sources	% cover: California buckwheat (*Eriogonum fasciculatum*), chamise (*Adenostoma fasciculatum*)
Larval Host Plant (*Rhamnus crocea*)	# of large plants[4], % cover

[1]Included any woody vegetation.
[2] Included any non-woody vegetation.
[3] Included any non-vegetated area.
[4] Greater than 1.25 meters in height or diameter.

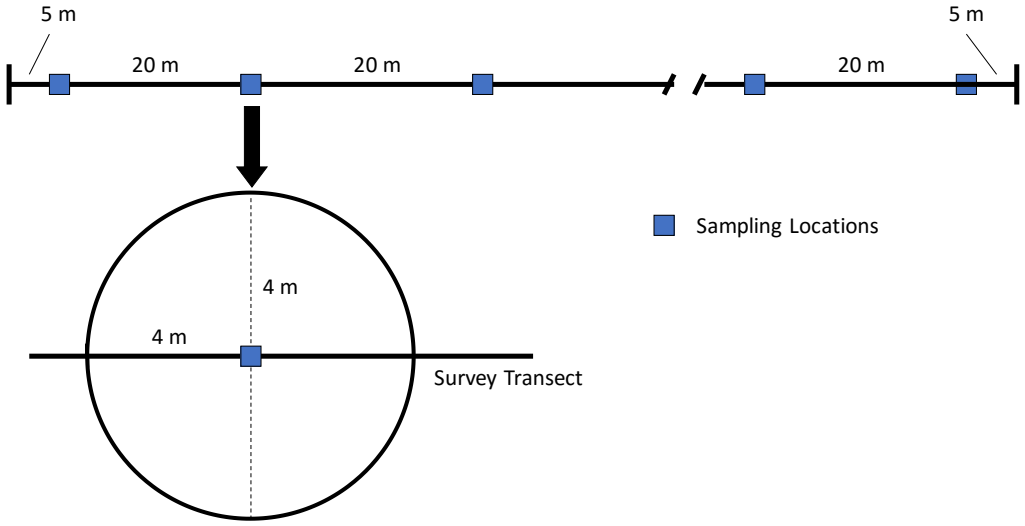

Figure 2. Vegetation sampling locations (blue boxes) along a butterfly survey transect. Each transect was 250 m in length.

Table 4. Habitat assessment variables used in 2016.

Variables	Categories
Spiny Redberry	Number of shrubs, mapped extent
California Buckwheat	Distribution (evenly distributed, most along road, and/or few patches)
Vegetation Composition (% cover)	Spiny redberry, California buckwheat, shrubs (includes redberry and buckwheat), non-native grasses, non-native forbs, bare soil
Trees	Distance to spiny redberry patch, tree species

Results

For the 2003 sampling, the general vegetation structure varied within and among sites (Figure 3). The percent cover of California buckwheat and spiny redberry were relatively low despite sampling in Hermes copper habitat (spiny redberry patches). Habitat was a poor predictor of Hermes copper presence. Site and cover of California buckwheat were the only significant predictors of Hermes copper presence at each sampling location (chi-square = 85.200, $p < 0.001$, 7 df) (Table 5). The addition of percent cover of grasses or presence of spiny redberry increased the predictive power of the model slightly, however neither were significant. Since sites greatly differed in presence of Hermes copper, models were created for each site. Forward stepwise logistic regression models with a $p = 0.15$ cutoff resulted in models with different variables and slopes. This indicates that the habitat characteristics measured do not predict adult presence throughout the range of the species.

In 2016, 108 spiny redberry patches were mapped and 30 single spiny redberry shrubs recorded across the 13 southern sites. Up to 180 spiny redberry shrubs were recorded in a single patch, but more patches were represented by a relatively low number of shrubs. A total of 65 spiny redberry patches were mapped and 11 single redberry shrubs were recorded across the 8 northern sites. Up to 90 redberry shrubs were recorded in a single patch, but more patches were represented by a relatively low number of shrubs. Most of the redberry patches had shrub cover that was at least 60%. The analyses placed the sites into three groups: 1) northern, 2) southern that recently burned (2003 or later), and 3) southern that did not recently burn (the northern sites did not completely burn recently).

When comparing vegetation structure across the three site groups, the sites varied most in the percent cover of bare ground. The northern sites and southern burned sites had little bare ground compared to the southern unburned sites (Figure 4). Vegetation cover varied among sites and no clear trend beyond the bare ground pattern was observed (Figure 5).

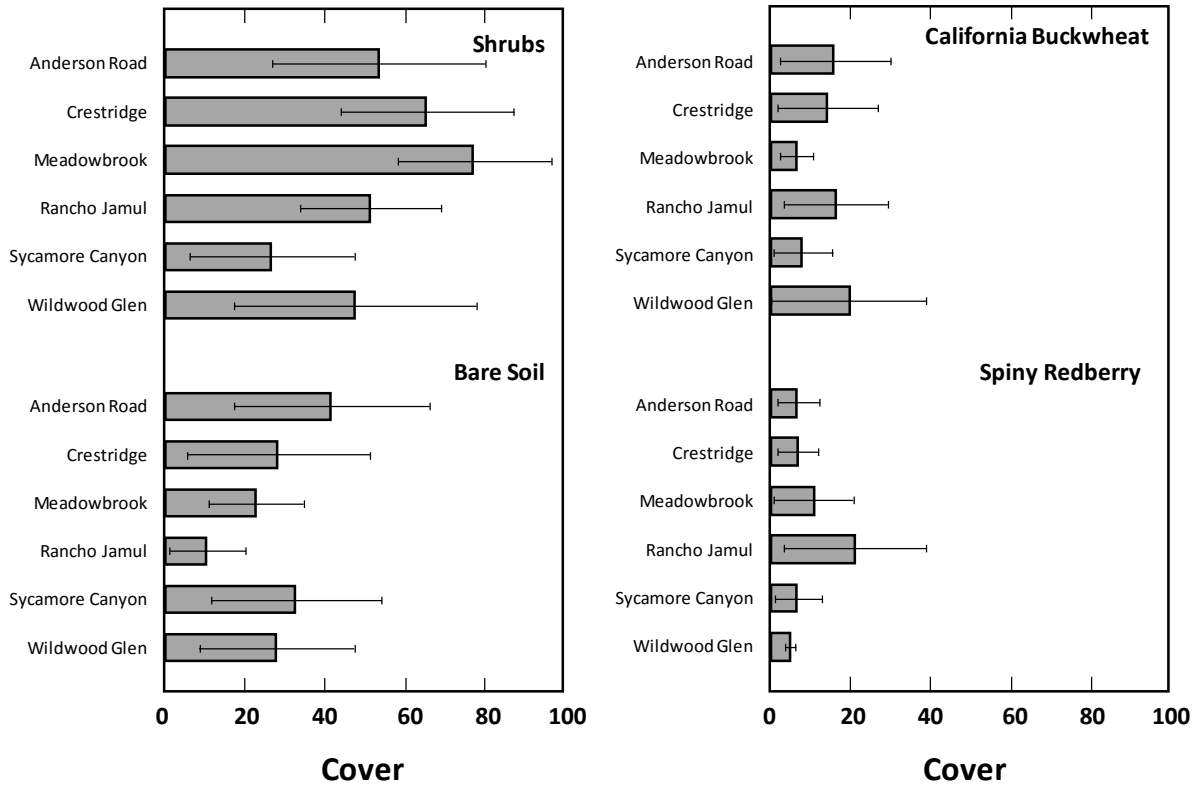

Figure 3. Percent cover at sampling locations along Hermes copper sampling transects. Hermes copper were present at all six sites at the time of sampling.

Table 5. Comparison of logistic regression models determining the presence of Hermes copper adults.

Variable(s)	Deviance (χ^2)	Degrees of Freedom	AIC
Site	72.2	5	62.2
Site, California buckwheat	85.2	7	71.2
Site, California buckwheat, spiny redberry	86.7	8	70.7

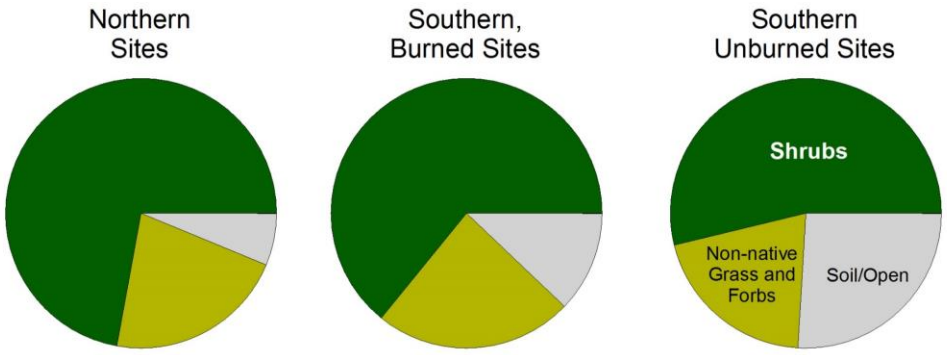

Figure 4. Comparison of vegetation structure at northern and southern Hermes copper sites, including southern sites that did and did not experience recent wildfires.

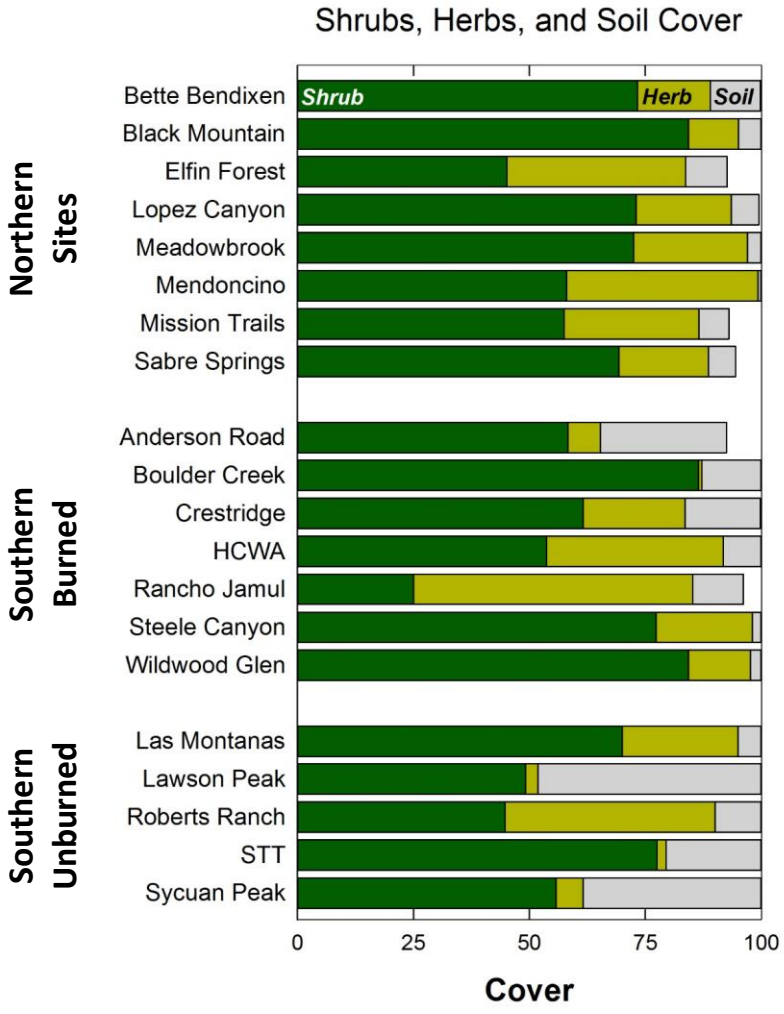

Figure 5. Vegetation structure at each site. Dark green bars represent shrub cover, light green bars represent a combination of grasses and forbs ("Herbs"), and gray bars represent bare ground ("Soil"). All sites, with the exception of Bette Bendixen, have had Hermes copper populations.

Overall, the measured habitat characteristics exhibited a relatively high level of variability. The average number of spiny redberry shrubs in each patch varied, as each of the three site categories had locations with few spiny redberry shrubs and locations with many spiny redberry shrubs (Figure 6). Even though measurements were restricted to redberry patches, the percent cover of spiny redberry for each site generally averaged less than 15 percent. The percent cover of California buckwheat was also generally under 15 percent.

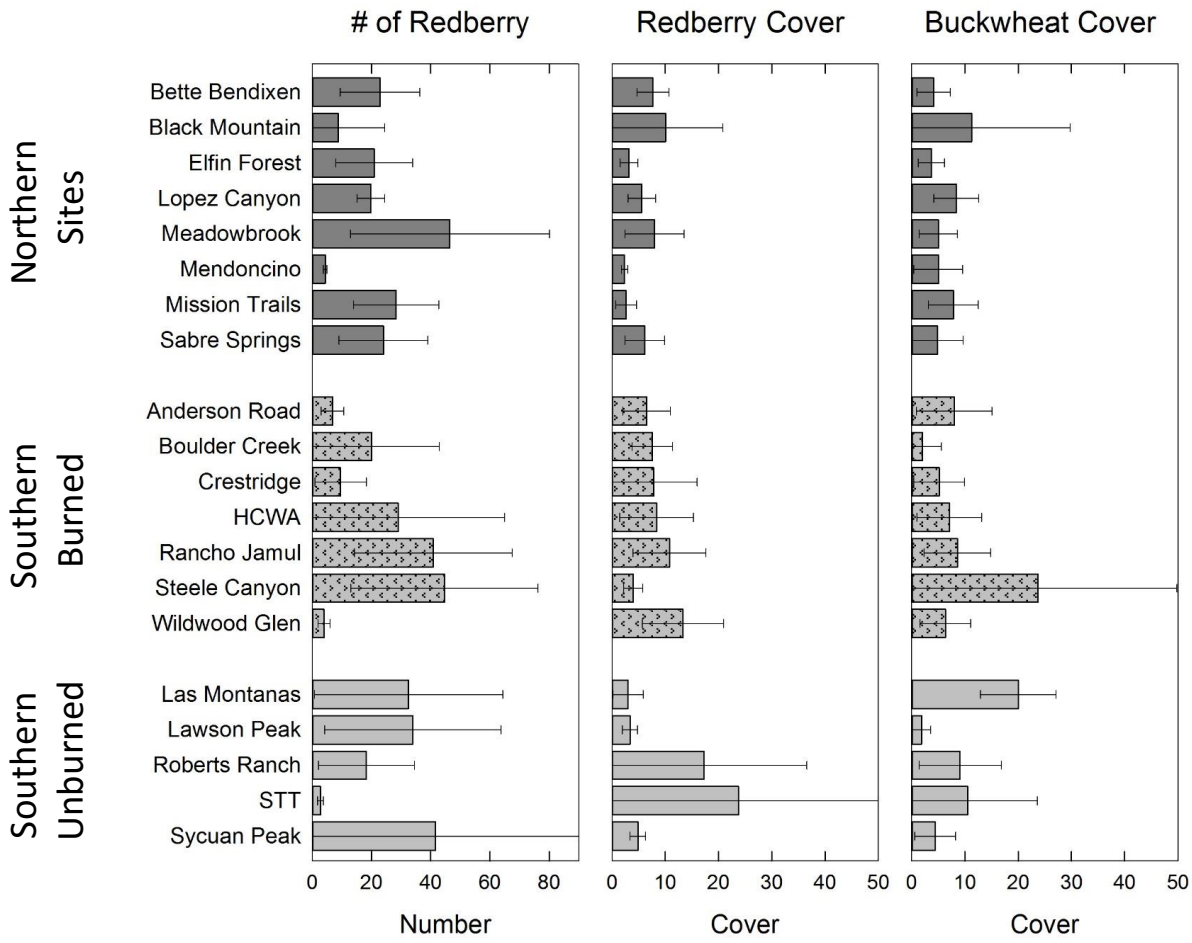

Figure 6. Comparison of spiny redberry and California buckwheat at northern and southern Hermes copper sites, including southern sites that did and did not experience recent wildfires. Site averages are reported with error bars representing 1 standard deviation.

Summary of Habitat Description

Hermes copper habitat is variable, with the exception of spiny redberry being a requirement. It also appears that California buckwheat shrubs are required or very beneficial, with buckwheat shrubs more important as the number of native flowering annual plants decreases. A more detailed understanding of suitable habitat is lacking. For example, it is not clear how many spiny redberry and/or California

buckwheat plants are necessary to support a Hermes copper population in a given area, or how abundance and spatial arrangement of plants relate to Hermes copper population sizes.

Threats

Fire

Several local populations were extirpated due to the 2003 and 2007 wildfires but only one (Boulder Creek Road) appears to be recolonized, large, and a self-sustaining population (Marschalek and Klein 2010, Marschalek et al. 2016). Hermes copper adults have been detected at Wildwood Glen Lane, but not since 2012 (Table 1). Wildfires have directly resulted in the loss of populations as well as habitat loss (Marschalek and Klein 2010). This habitat loss may be temporary until the vegetation recovers, or fire may also result in the coastal sage scrub vegetation community being converted into a grassland community (Marschalek and Klein 2010). Many of the extant populations are within an area characterized as having a high risk of fire (USFWS 2011).

Habitat loss or degradation

Hermes copper butterfly is threatened by habitat loss or degradation (USFWS 2011). Historically, habitat loss due to urbanization resulted in the extirpation of several local populations (Wright 1930, Marschalek and Klein 2010). These are generally within the western portion of the Hermes copper distribution. More recently, habitat fragmentation and wildfires have resulted in the loss (type conversion, see "Fire" section) and isolation of the remaining populations throughout the range.

Small populations or lack of connectivity

Further isolation of populations reduces or possibly prevents movement of individuals among these populations which can be a key factor in site occupancy (WallisDeVries 2004). Isolation can also impact the evolutionary pathway of populations and the species by reducing gene flow and subsequently increasing inbreeding (Couvet 2002). Deleterious effects of inbreeding, including reduced survival and fecundity, have been documented in other butterflies (Saccheri et al. 1998, Crnokrak and Roff 1999, Frankham 2005, Vandewoestijne et al. 2008). A restricted range and relatively isolated populations inhibits the species from recovering from stochastic events such as wildfires (USFWS 2011).

Climate change

Although a statistical relationship has not been described, the annual number of Hermes copper adults is greater with more winter/spring precipitation and lower with less precipitation (Marschalek and Deutschman 2016B). From October 2011 to September 2014 represents the driest consecutive three-year period to date (Jones 2015). A reduction in San Diego County precipitation, as predicted with climate change (Li et al. 2014), will likely lead to a reduction in already small annual adult population sizes. This is commonly observed in other butterfly species (Pollard 1988). Climate change has been linked to declines and extinctions in other butterfly species (Forister et al. 2010, Casner et al. 2014, Oliver et al. 2015, Tack et al. 2015).

Management Strategies

MSP Roadmap goal for Hermes copper to: "protect, enhance, and restore Hermes copper occupied habitat and historically occupied habitat and the landscape connections between them to create resilient, self-sustaining populations that provide for persistence over the long term (>100 years)".

Based on our current understanding of Hermes copper, the management strategies listed below are designed to alleviate threats to this species and its habitat.

This can be accomplished by:

1) Protecting current populations from wildfires
2) Enhancing existing populations, particularly those that have the smallest population sizes
3) Expanding the current distribution of populations
4) Protecting habitat

Specific management actions and prioritization of these actions are listed in Appendix A.

Protect current populations from wildfires

Pre-fire

Objective: Protect current Hermes copper occupied spiny redberry patches from fire.

Because fire is a major threat to Hermes copper and it appears that restricted dispersal is limiting recolonization, action should be taken to reduce this threat. This could include reducing the number of fires and/or limiting the size of fires. One of the MSP Roadmap fire objectives is developing a Wildfire Ignition Reduction Plan to reduce risk of wildfires at prioritized Hermes copper sites. Upon completion of fire risk and habitat modeling, specific fire management actions for Hermes copper will be prepared and added as an appendix to this plan.

Post-fire

Objective: Restore California buckwheat populations to at least 1 California buckwheat shrub for every 10 spiny redberry shrubs within and adjacent (within 10 meters) of previously Hermes copper occupied spiny redberry patches following a fire. This may not always be required following a fire.

The two important food plants have different post-fire recovery strategies. Spiny redberry is an obligate resprouter (Keeley 1992), while California buckwheat is a facultative seeder as a high proportion (90%) of plants are killed by fire (Zedler et al. 1983, Keeley 2006). Following the 2003 and 2007 wildfires, a reduction of buckwheat and annual forbs, accompanied by an increase of non-native grasses has been observed at certain sites (Marschalek and Klein 2010, Rochester et al. 2010). It appears that those sites that exhibited signs of type conversion had experienced a certain level of degradation prior to the fires. Restoration of these habitats are necessary for recolonization and support of Hermes copper populations. If non-native grass cover is low, allowing for adequate populations of native annual flowering plants, fewer California buckwheat shrubs may be required. These recommendations, including the ratio of at least 1 California buckwheat shrub for every 10 spiny redberry shrubs, are based on the gestalt of Hermes copper habitat in the absence of quantified data. Sites that experienced high buckwheat loss following these fires and have low counts of buckwheat shrubs include (Figure 7):

Cleveland National Forest- Barber Mountain
Crestridge Ecological Reserve
Rancho Jamul Ecological Reserve
Sycamore Canyon County Park
USFWS- San Miguel Mountain

Relatively large Hermes copper populations have been observed in degraded habitats (e.g. grazing at Rancho Jamul Ecological Reserve, pre-2003 fire data). In addition, habitat assessments have not identified important components other than spiny redberry and California buckwheat. For these reasons, it appears that restoration should focus on the establishment of redberry and buckwheat. Additional benefits may be obtained by removal of grasses around redberry shrubs and establishing/enhancing populations of summer flowering annual plants. Grass removal will provide bare soil under the redberry shrubs which appears to be a preferred condition for oviposition. Hermes copper adults have a preference for nectaring on buckwheat flowers but have been rarely observed feeding from flowers of other plant species as well (e.g. *Adenostoma fasciculatum*, *Deinandra fasciculata*, *Gutierrezia sarothrae*, *Toxicodendron diversilobum*). Other flowering plants during the adult flight season would increase food options.

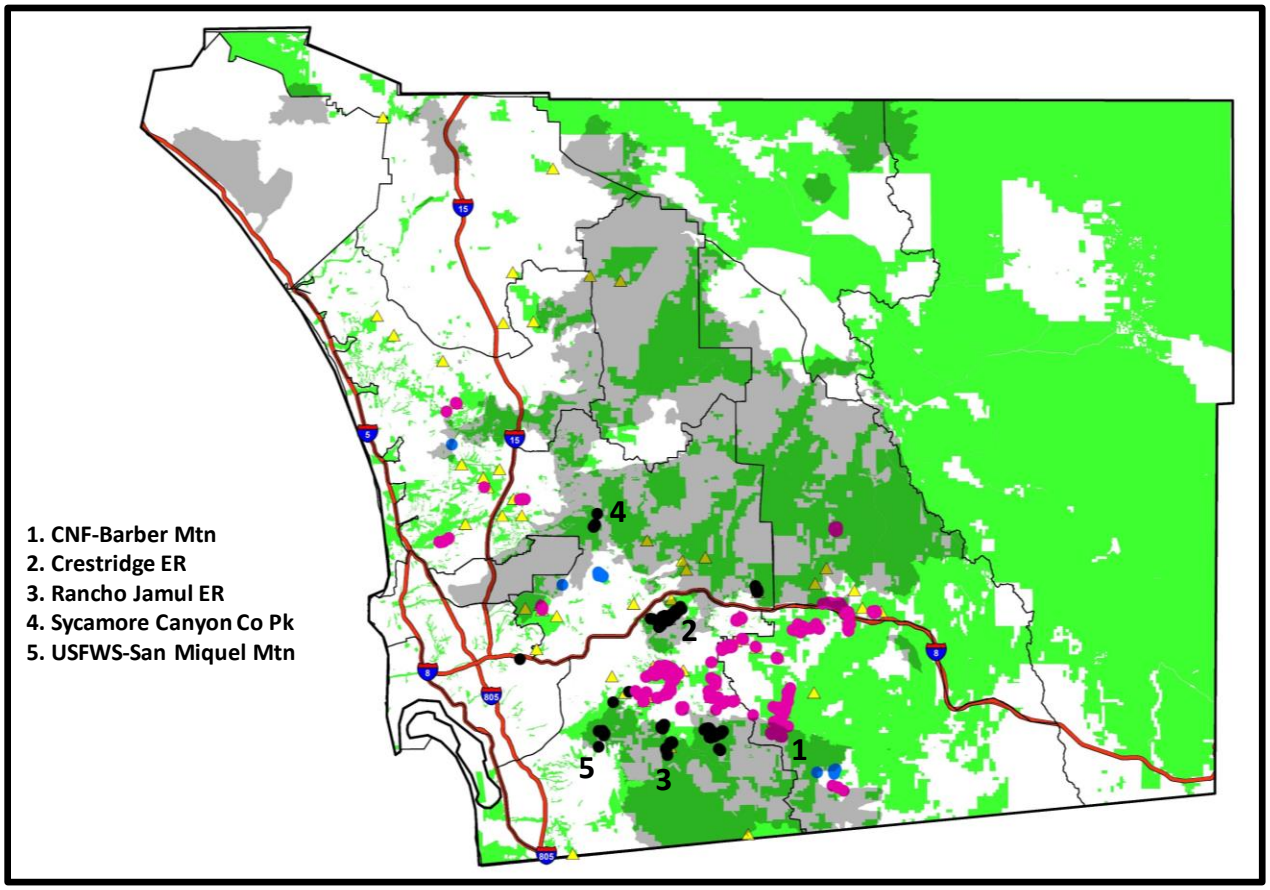

Figure 7. Sites for California buckwheat enhancement.

Enhance existing populations, particularly those that have the smallest population sizes

Objective: Increase the number of spiny redberry shrubs at sites with fewer than 10 Hermes copper adults at peak abundance during a year with average winter precipitation.

The distribution of Hermes copper is geographically limited, so each population is important for their long-term persistence. Having numerous, robust populations spread out across the landscape is important considering the regular occurrence of wildfires. The largest populations exist in the southern portion of San Diego County, from the Jamul area east into Cleveland National Forest. Smaller populations also exist within this region. However, only small populations are currently known from sites at Mission Trails Regional Park and further north. The small populations in the northern portion of the Hermes copper distribution that warrant enhancing include (Figure 8):

Black Mountain
Crosby National Golf Course
Elfin Forest
Los Penasquitos Canyon Preserve- Lopez Canyon
Meadowbrook Ecological Reserve
Mission Trails Regional Park
Onyx Ridge

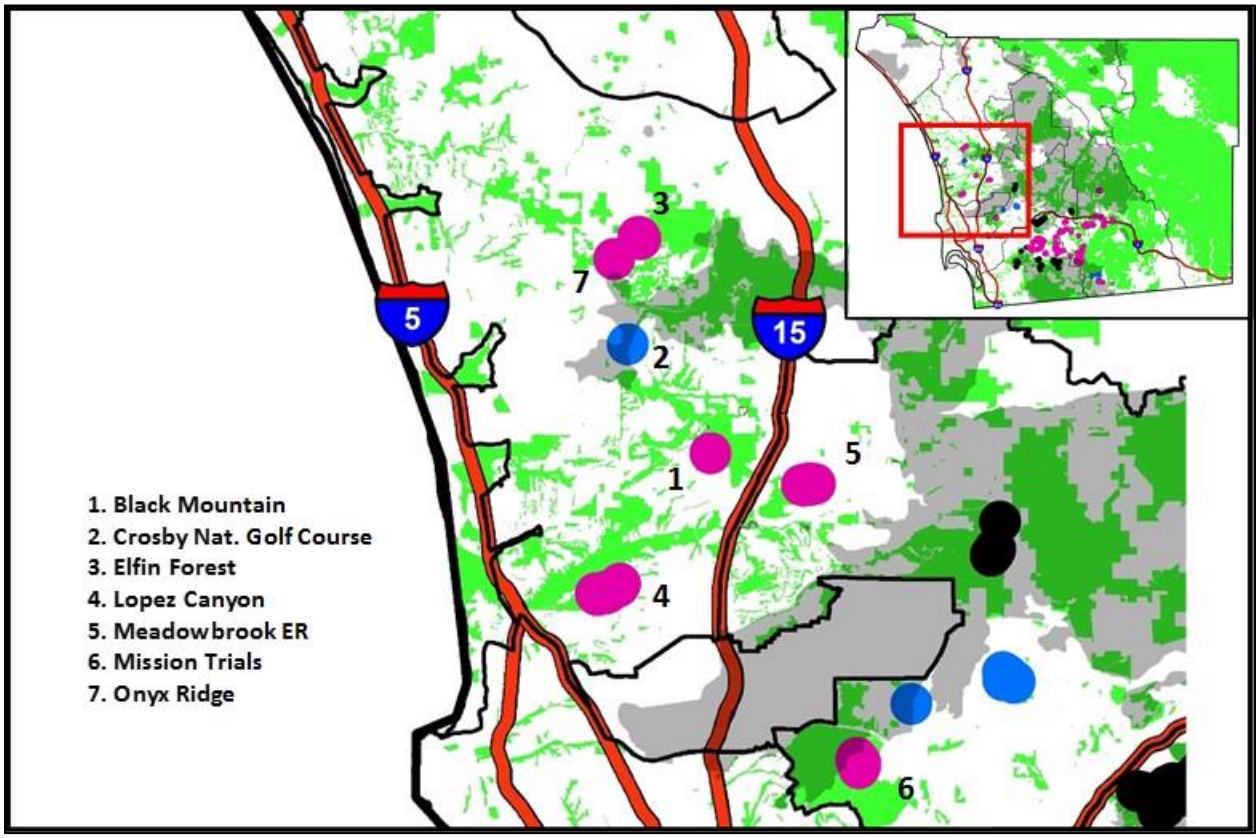

Figure 8. Sites with small populations that should be enhanced.

It appears that Hermes copper populations are generally positively correlated with the amount of larval food resources. Results from egg surveys suggest that eggs are not deposited on each shrub, and that eggs are sparsely distributed (only once was a redberry shrub found with more than one Hermes copper egg). Increasing the number of spiny redberry shrubs and expanding the extent of these plants should increase the local Hermes copper population size. This increases larval resources and expands suitable habitat.

Topographic variation should be considered when expanding current spiny redberry patches to provide different microhabitat conditions (e.g. hillsides, ravines, aspect). This has been shown to be important for butterflies (Weiss et al. 1988) and is an important consideration considering climate change. North-facing hillsides with cooler temperatures and increased moisture will likely be of increased importance in the future. Furthermore, spiny redberry tends to grow in deeper soils in with increased moisture (Thorne 1963).

Expand the distribution of populations

Objective: Translocate Hermes copper (eggs or adults) to reestablish or create (when the historical occupancy status is unknown) populations so that the butterfly is as widely distributed as historic conditions.

Wildfires have reduced the number of Hermes copper populations as well as the spatial extent to which this species is reliably found. Habitat loss and fragmentation may be restricting dispersal, therefore limiting recolonization. Dispersal (natural or assisted) to recolonize post-wildfire habitat before other fires extirpate extant populations is a critical need for the conservation of this species. However, assisted dispersal following wildfires may be required to maintain a wide geographic extent to reduce the risk of extinction due to one major catastrophe (e.g. wildfire).

Translocation of individuals to a post-wildfire recovery habitat is currently being explored to determine the efficacy of this method for re-establishing a population (Marschalek and Deutschman 2016C). Not only could this technique mitigate the impacts of fire, but also reduce the risk of extinction due to future fires by expanding the already reduced distribution. The following sites have experienced recent extirpations and are potential candidates for translocations (habitat restoration may be required prior to natural or assisted dispersal for recolonization) (Figure 9):

Cleveland National Forest- Anderson Road
Crestridge Ecological Reserve
Hollenbeck Canyon Wildlife Area (translocations efforts occurring)
Rancho Jamul Ecological Reserve
Sycamore Canyon County Park
USFWS- San Miguel Mountain
USFWS- Steele Canyon
USFWS- Sweetwater

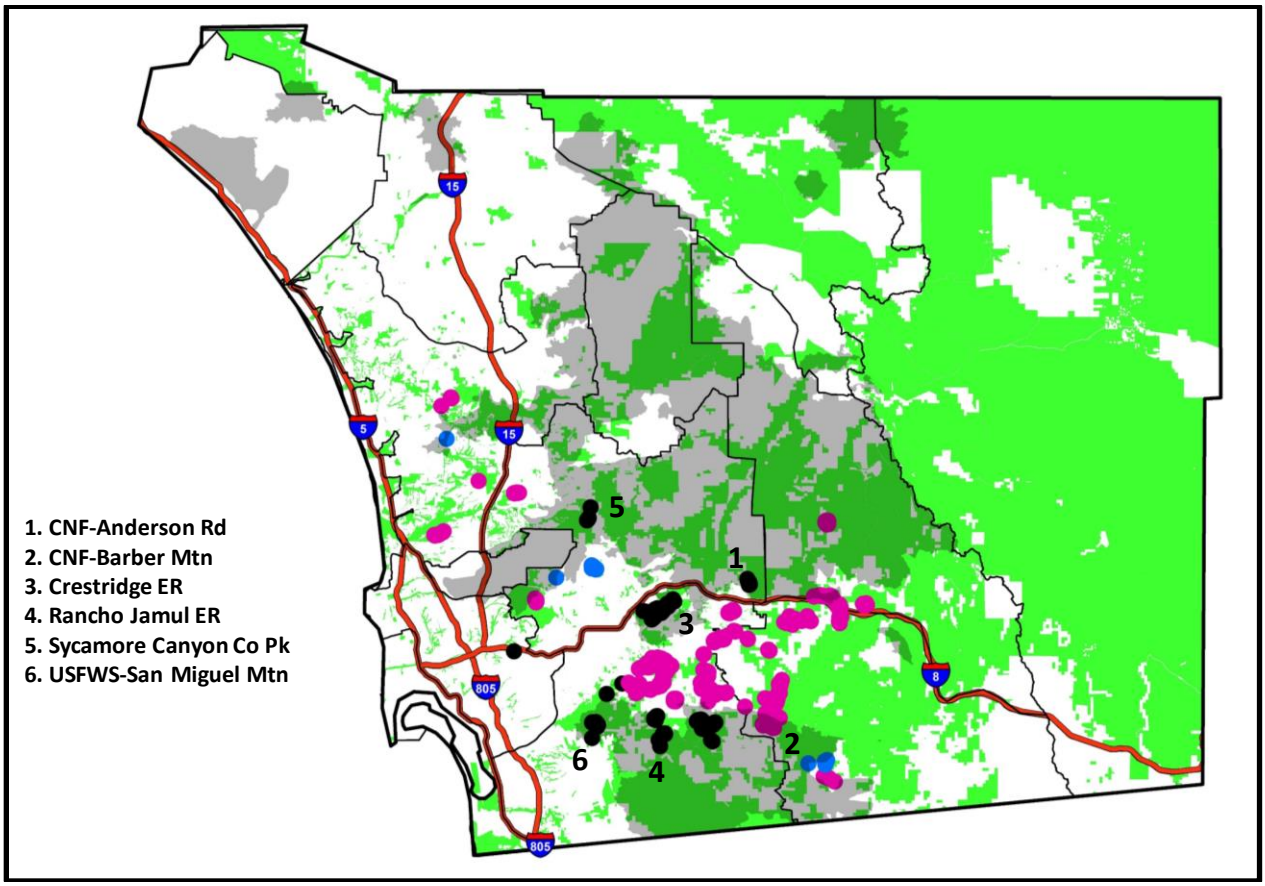

Figure 9. Potential sites for translocations to expand the Hermes copper distribution by reestablishing populations following wildfires.

For the southern portion of the Hermes copper range, reestablishment of populations at Cleveland National Forest- Anderson Road (north), Rancho Jamul Ecological Reserve (south), and USFWS- San Miguel Mountain (west) would extend the distribution to the maximum extent of the known historic range. Spiny redberry is found adjacent to the US-Mexico border so Hermes copper could be introduced further south. These areas were likely occupied historically. For the northern populations, fire has impacted Sycamore Canyon County Park and possibility other spiny redberry patches as well. Other locations, within or between (e.g. Lakeside, Santee) the north and south regions could also represent opportunities for translocations provided appropriate habitat is present or restored.

Currently, large source populations exist from McGinty Mountain east through Sycuan Peak, Lawson Peak and north towards Descanso. These populations exhibit a high degree of genetic similarity so they should be appropriate for most translocation efforts. The Cleveland National Forest- Boulder Creek Road population is the only large population that exhibited significant genetic differentiation. For this reason, it may not be an ideal source but should not be precluded due to differences in neutral genetic markers. Sites to the north were also genetically different from other sampled sites. No sites north of Interstate 8

and west of Hwy 67 appear to be large enough to support translocation efforts (i.e. source populations) at this time.

Protect Habitat

Objective: Protect habitat from future development or alteration through land acquisition and conservation, and include newly conserved lands into the San Diego County preserve system.

Due to the naturally restricted distribution of Hermes copper and the increasingly fragmented San Diego County landscape, protecting current habitat is important for the long-term persistence of this species. This should include protecting occupied or suspected occupied habitats, but also maintaining or restoring connectivity of spiny redberry patches. Currently, Hermes copper populations are known to occur at several locations on private property and others are likely. The following areas should be considered for acquisition to protect Hermes copper populations, habitats, and connectivity (Figure 9):

Adjacent to Meadowbrook Ecological Reserve in Poway
Adjacent to Wright's Field in Alpine
South of South Crest Preserve and northwest of McGinty Mountain
Between McGinty Mountain and Sycuan Peak
Southeast of Sycuan Peak
Sycuan Peak Ecological Reserve inholding
Area around Loveland Reservoir
Between Hollenbeck Canyon Wildlife Area and Cleveland National Forest
North of Potrero and Potrero Peak
Southwest and Southeast of Descanso

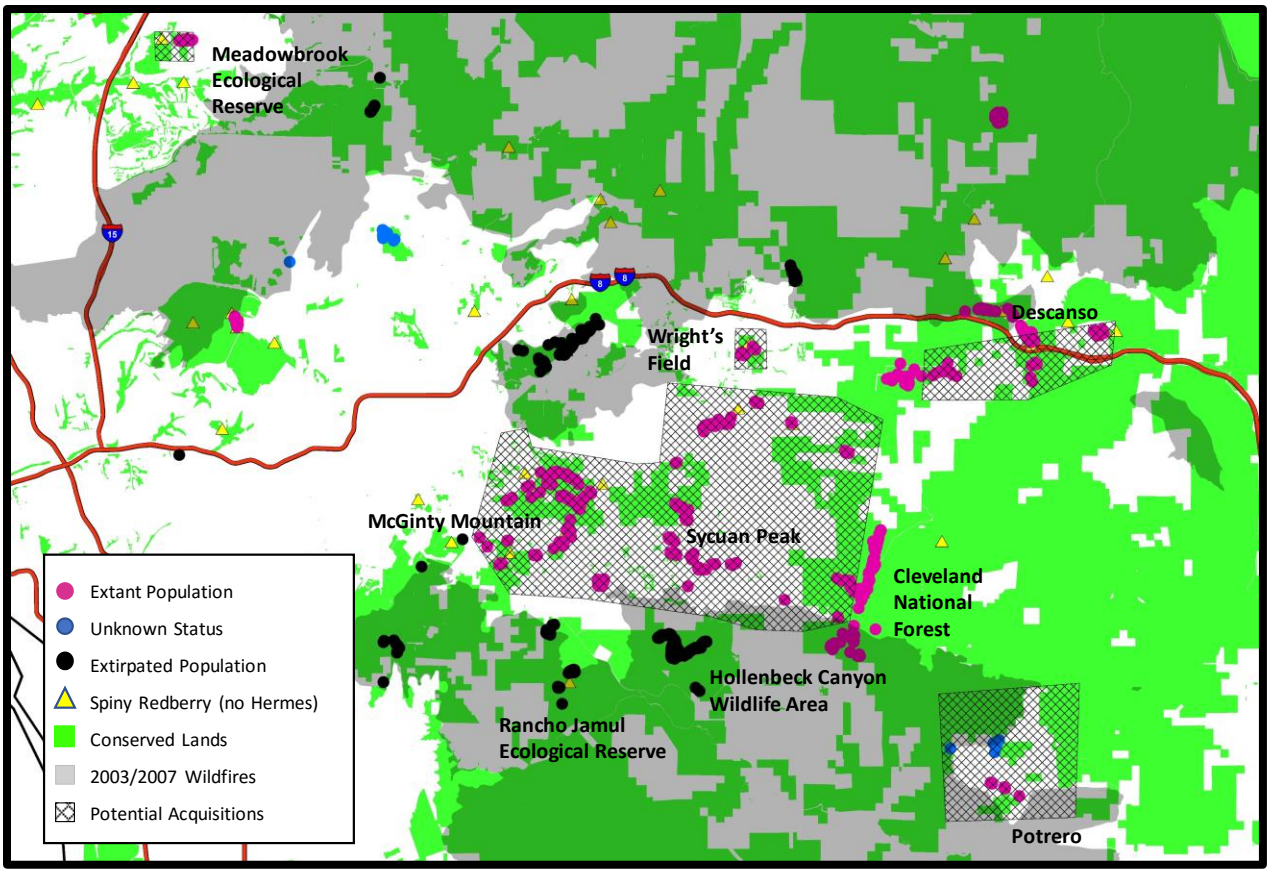

Figure 10. Areas to be considered for land acquisitions.

Research Needs

Research needs were developed from the current conceptual model for Hermes copper, as biological uncertainties and future research topics were listed (Lewison et al. 2012):

Biological Uncertainties

How the spatial distribution of spiny redberry affects occupancy
Female behavior including oviposition preferences and dispersal abilities
Major predators and parasitoids
Mortality factors including predators, parasitoids, roadkill, and others
Overall species dispersal behavior and ability, including impacts on gene flow
Distribution of buckwheat

Future Research Topics

Dispersal, including potential factors influencing dispersal
- Wind or directed flight
- Male vs. female
- Trigger to dispersal flight
- Landscape features impact to movement

Larval requirements

Habitat requirements

Physiological requirements (light, temperature, etc.)

Since development of the conceptual model, some aspects of current distribution (through landscape genetics techniques) and female oviposition sites have been addressed, but new questions about occupancy of northern sites have arisen. For example, following the 2012 adult flight season, no Hermes copper adults have been detected at the northern sites, which are west of Alpine and north of Interstate 8. To reduce the risk of extirpation due to wildfires, it is important that this portion of the county supports Hermes copper populations. In addition, severe drought conditions suppressed Hermes copper adult emergence at all sites in 2015 and 2016 and likely contributed to the lack of observations. Lastly, work with immature stages continues to be problematic, either due to lack of knowledge for these stages and/or the inability to obtain specimens to work with. Therefore, addressing larval requirements and parasitoids will be difficult until we have a better understanding of immature stages. As with the management strategies, research needs are prioritized (Appendix B).

Translocation

Currently, the translocation of adults or eggs has not conclusively resulted in the reestablishment of a Hermes copper population; however, this may be related to drought conditions. Signs of larval eclosion (emerging from eggs) in 2015 and one adult in the release site in 2016 are promising. Since Hermes copper adult numbers have been suppressed during the recent drought, particularly in the vicinity of the translocation project, a year with greater precipitation is required to fully assess the success of the previous translocations. Additional translocations to supplement the 2014 efforts are also warranted. If successful, translocations can be used to reestablish populations extirpated from wildfires and expand the geographic extent of the species, both reducing the risk of extinction.

Surveys for relatively large spiny redberry patches (greater than 200 shrubs) closer to the United States-Mexico border should be conducted. These habitats could be chosen for future translocations with the goal of establishing a large population and expanding the Hermes copper distribution as far south as possible in the United States. A large population should have a higher probability of long-term persistence compared to a smaller population (due to stochastic factors) and would be able to provide individuals for management and research activities. This area is in the region of Otay Mountain, directly south of SDNWR- San Miguel Mountain, Rancho Jamul Ecological Reserve, and Hollenbeck Canyon Wildlife Area.

Document and Describe Smaller, Northern Populations

The northern Hermes copper populations west of Alpine and north of Interstate 8 represent important populations for the persistence of the species by reducing the chances of extinction due to wildfire in the southern portion of the range. Initial data indicates these populations are small and hard to detect

(Deutschman et al. 2011, Strahm et al. 2012, Marschalek and Deutschman 2016A), and the landscape suggests they are highly isolated. In 2016, habitat and threat assessments were made in these areas but Hermes copper adults were not detected due to drought conditions suppressing butterfly emergence. Adult observations are required to better understand which spiny redberry patches are occupied, as well as determining the local population size. This is a first step before being able to enhance populations (habitat), address connectivity of populations, and assess potential sites for reintroductions.

Habitat Requirements (Population Size, Connectivity)

For prioritized and effective landscape conservation planning and habitat restoration, a better understanding of habitat is necessary. This relates to characteristics that drive population sizes and connectivity of spiny redberry patches. The number and spatial arrangement of spiny redberry, California buckwheat, and possibly other variables could be influential. Landscape scale mapping of redberry is required. It is possible that aerial imagery and/or remote sensing technologies could be used to detect spiny redberry shrubs when the plants have small, shiny leaves in the early spring (February) and buckwheat shrubs when flowering in the summer (June).

Increasing connectivity between habitat patches is important for natural dispersal. However, little is known about how most insect species move across complex landscapes so more work is needed before species-specific management can be implemented for Hermes copper.

Assessing Ability to Survive Drought

Monitoring of Hermes copper adults at regularly surveyed sites should continue so that we can assess the ability of the species to recover following multiple years of drought. Populations that are less sensitive to drought are more likely to survive and increasingly important considering climate change projections for less precipitation (Li et al. 2014).

Assessing Ability to Recolonize Following Fire

Monitoring of Hermes copper adults at historically occupied sites which were extirpated by recent wildfires will inform about natural recolonization ability. Conditions of both the post-wildfire habitats and dispersal corridors are likely to influence recolonization rates. If recolonization events continue to be rare, the importance of translocations and captive populations will be elevated. Likewise, if future fires result in loss of additional population, the importance of these activities will be elevated.

Survey for Unknown/Additional Populations

It is likely that the Hermes copper occupies spiny redberry patches that have not been previously discovered and documented. Initial San Diego County-wide surveys (Deutschman et al. 2010, 2011) covered much of the conserved lands, but were unable to survey all areas. Other areas have been recently acquired and incorporated in the regional preserve system. For this reason, surveys for spiny redberry and Hermes copper should be conducted to more completely describe the butterfly's distribution. However, based on the rich butterfly collecting history of San Diego County, San Diego State University's surveys, wildfire extirpations, and landscape topography (and associated redberry elevational restrictions), discovering new populations outside of the current extent is unlikely.

There are three areas that are more likely to result in the discovery of new Hermes copper populations (Figure 11). One is Cleveland National Forest and adjacent lands. Recent work in Cleveland National Forest found several areas with Hermes copper with relatively limited and survey linear transects

(Chambers Group, Inc 2011). A second area is near Jamul, CA and immediately east as several surveys required for development projects have resulted in Hermes copper observations. The third area is in the vicinity of Poway and Escondido. This region has experienced less intensive surveys, but that maybe due to less conserved lands and appropriate habitat.

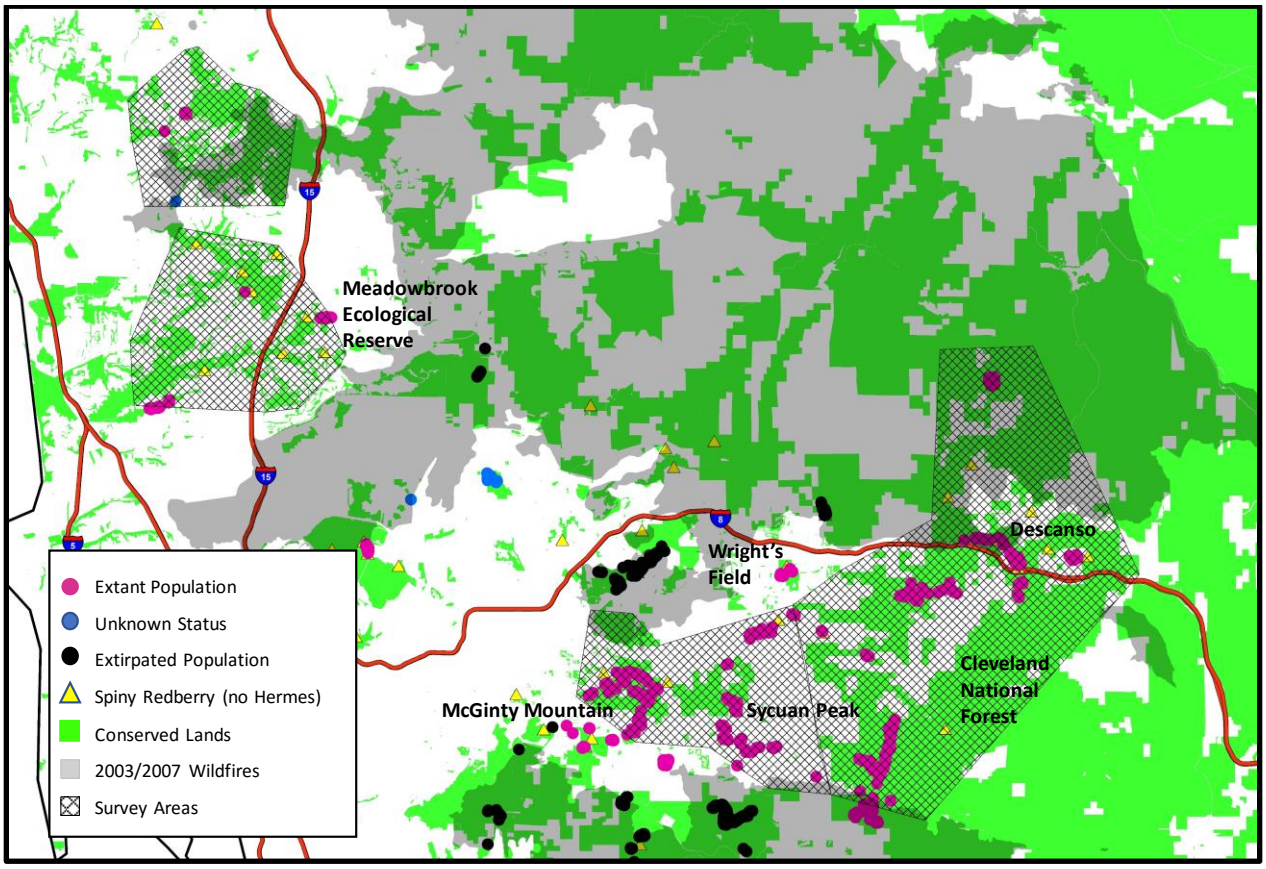

Figure 11. Areas to be considered for future spiny redberry and Hermes copper surveys to discover undocumented Hermes copper populations. These areas are mostly likely to have unknown populations.

Captive Rearing

Captive rearing should also be explored. This could be used to maintain a captive refugia population as insurance against a large catastrophic event. Rearing may also be a valuable tool to assist in translocation as described above. Hermes copper larvae are extremely difficult to rear in captivity. This was noted as early as the 1930s (Comstock and Dammers 1935, Thorne 1963) and continues to be problematic today (Marschalek and Deutschman 2015). To our knowledge, no one has successfully reared a Hermes copper from egg to adult. This is a critical barrier to several management approaches that are available for other butterfly species.

Current Management Actions

Translocation

San Diego State University initiated a project to evaluate translocation as a management tool for establishing self-sustaining Hermes copper populations (Marschalek and Deutschman 2016C). If successful, this could be a potential management tool to mitigate the impacts of wildfire. Hermes copper were translocated 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. Hollenbeck Canyon was selected because it had a historic Hermes copper population prior to a recent (2007) wildfire and the vegetation community, including spiny redberry and California buckwheat shrubs, were still present after the fire. The translocation of adults and eggs were assessed separately.

In 2014, 14 eggs and 11 adults (5 females and 6 males) were released in two different areas at Hollenbeck Canyon Wildlife Area. Initial plans included releasing more individuals in 2014 as well as supplementing these releases with similar numbers in 2015 and 2016. Due to a continuing drought that has suppressed adult butterfly numbers, the 2014 release numbers were lower than desired and releases in 2015 and 2016 were not possible.

During the spring of 2015, nine eggs exhibited signs consistent with larval eclosion, three were missing from the original clipping and lost prior to the first survey date, and two eggs remained intact. The two intact eggs were monitored in spring of 2016. One was missing at the start of the monitoring period and the second became brown in color and assumed to be non-viable.

Surveys for Hermes copper adults occurred during the 2015 and 2016 flight seasons at both the egg and adult release sites. The presence of adults is a primary indicator of success. No adults were observed at either site during 2015, but one male was observed in the area where adults were released in 2016. One individual is a low number but equal to the number observed at Sycuan Peak Ecological Reserve, recently one of the largest populations.

Post-fire Restoration

The Harris Fire of October 2007 burned most of the chaparral at Barber and Elena Mountains. A few small unburned patches remained, and the Hermes copper population persisted at low numbers after the fire (Faulkner 2008). Spiny redberry resprouted vigorously after the fire but the fire completely killed a number of California buckwheat shrubs which is not typical. The US Forest Service planned a restoration effort to enhance the buckwheat population to enhance Hermes copper habitat.

The Forest Service contracted for collection of 100 lbs of buckwheat seed from the local area. This was collected in 2009 and was used to seed key areas in February of 2010. Seeding was accomplished by hand-spreading the seed and raking it in. Seeded areas are shown on the map below. Subsequently, recruitment was observed from seed which occurred concurrently with natural recovery and re-sprouting of buckwheat at the site. Buckwheat is typically very successful when introduced as seed (White et al. 1995) so this would appear to be a good restoration method. However, in this instance natural recovery of buckwheat was also occurring, so the seeding was likely not a significant factor in the restoration of the Hermes copper habitat.

Prioritization of Activities

All activities listed in this document are expected to benefit the Hermes copper and help ensure the persistence of this species over the next 100 years in San Diego County. Due to the restricted distribution and relatively small population sizes, protecting the few large populations and working towards reestablishing additional populations (particularly large populations) are most important. Activities of highest priority are assigned a rank of 1, followed by 2 and 3. The prioritized management actions and research needs are listed in Appendix A and B, respectively.

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Appendix A: Site assessments and prioritized management actions

Site Name	Manager	MU	Hermes Copper Status	Summary of Habitat Conditions	Management Options*	Priority
Black Mountain	City of San Diego	6	Possibly extant		Protect from fire, enhance redberry population	2, 3
Cleveland National Forest	USFS	10, 11	Extant	Redberry is common throughout portions of Cleveland National Forest, as recorded for the SDGE Sunrise Powerlink Project. Non-native plant cover appears to be low in general.	Protect from fire	1
Cleveland National Forest- Anderson Road	USFS	4	Extirpated (2003)	This area burned in 2003 and the native vegetation (little non-native vegetation) appears to have recovered. Redberry is extensive on the western side of the mountain, buckwheat shrubs are present almost exclusively adjacent to the road).	Translocation	1
Cleveland National Forest- Barber Mountain	USFS	11	Extant		Enhance buckwheat (in progress)	3
Cleveland National Forest- Boulder Creek Road	USFS	10	Extant	This area burned in 2007 and the native vegetation appears to have recovered (little non-native vegetation). Redberry is extensive on the lower western side of the mountain near the road. Few buckwheat shrubs are present, primarily near the road.	Protect from fire	1
Cleveland National Forest- Lawson Peak	USFS	11	Extant	This area has more chamise present than most other Hermes copper locations. Redberry is scattered throughout, with few non-native plants.	Protect from fire	1
Cleveland National Forest- Roberts Ranch North	USFS	10	Extant	This area has more chamise present than most other Hermes copper locations. Redberry appears to be confined to a certain area with more shrubs and fewer grasses. However, there are several smaller patches with non-native grasses.	Protect from fire	1
Cleveland National Forest- Roberts Ranch South	USFS	11	Extant	This area has more chamise present than most other Hermes copper locations. Redberry appears to be confined to a certain area with more shrubs and fewer grasses. However, there are several smaller patches with non-native grasses.	Protect from fire	1
Cleveland National Forest- Wildwood Glen	USFS	10	Extant	Redberry is relatively sparse but scattered throughout this area, with chamise as a common shrub. Much of the buckwheat is near the road. This area burned in 2003 and most of the native plants have recovered. A non-native broom is present and this site and has been treated in the past.	Protect from fire	1
Crestridge Ecological Reserve	EHL	3	Extirpated (2003)	This area burned in 2003 and the native vegetation (little non-native vegetation) appears to have recovered. Redberry is found throughout much of the reserve. Buckwheat is less common but also scattered throughout the reserve.	Protect from fire, enhance buckwheat population, translocation	2, 3, 1
Crosby National Golf Course	County of San Diego	6	Likely extirpated (2007)		Enhance redberry population	3
Elfin Forest	ECC	6	Extant	Several patches of redberry are present, interspersed by areas of non-native grasses. Most of the redberry patches are small.	Protect from fire, enhance redberry population	1, 2
Hollenbeck Canyon Wildlife Area	CDFW	3	Reintroduced	This area burned in 2007 and both native and non-native vegetation returned. There are several dense and numerous redberry patches with buckwheat shrubs.	Protect from fire, translocation (in progress)	1, 1
Lakeside Downs	EHL	4	Unknown	Unknown (may be surveyed in 2017)	Surveys to determine Hermes copper occupancy	1

Appendix A: Site assessments and prioritized management actions, continued.

Site Name	Manager	MU	Hermes Copper Status	Summary of Habitat Conditions	Management Options*	Priority
Lawson Valley (Skyline Truck Trail)	EHL	3	Extant	Surprisingly few redberry shrubs have been observed considering the number of Hermes copper adults. Non-native grasses are present but most of the vegetation is composed of shrubs.	Protect from fire	1
Los Penasquitos Canyon Preserve- Lopez Canyon	City of San Diego	6	Extant	This area has a high cover of non-native grasses, while the area with redberry and buckwheat is relatively discrete	Protect from fire, enhance redberry population	1, 1
Loveland Reservoir	Sweetwater Authority	11	Extant	Most of the redberry shrubs are found in several ravines along the north side of the reservoir. Shrubs represent a relatively high percent cover, while non-native vegetation is a low percent cover.	Protect from fire	1
Meadowbrook Ecological Reserve	CDFW	4	Possibly extant	The redberry and buckwheat are bordered by non-native grasses (fuel break) on two sides. Black sage is relatively common, more so than other Hermes copper locations.	Protect from fire, enhance redberry population	1, 3
Mission Trails Regional Park	City of San Diego	4	Possibly extant	Most of the redberry is found within non-native grasslands, while some extends up Kwaay Paay Peak into shrub dominated vegetation. A portion of the redberry burned in 2003.	Protect from fire, enhance redberry population	1, 3
Onyx Ridge	ECC	6	Possibly extant	This is a dry southern facing hillside with redberry in a drainage.	Protect from fire, enhance redberry population	1, 3
Potrero	BLM & Private	11	Unknown	A portion burned in 2007.	Protect from fire, acquire property adjacent to BLM	1, 1
Rancho Jamul Ecological Reserve	CDFW	3	Extirpated (2003)	Hermes copper was extirpated from at least four redberry patches in 2003 and at least two patches in 2007. Some areas burned in both 2003 and 2007. The redberry shrubs have recovered following the fires, but most of the other shrubs have not. Non-native grassland is the common vegetation community.	Enhance buckwheat population, translocation	2, 2
Sycamore Canyon County Park	County of San Diego	4	Extirpated (2003)	The vegetation is a mixture of shrubs and grassland, both before and after the 2003 fire.	Enhance buckwheat population, translocation	3, 3
Sycuan Peak Ecological Reserve	CDFW	3	Extant	The southeastern portion of the hill has 1000s of redberry shrubs, which are also likely present throughout the entire southern aspect of the peak. Redberry is also present on the northern side but the density and extent is unknown. Non-native plant cover is very low, with areas of bare soil common.	Protect from fire	1
USFWS- Las Montanas	USFWS	3	Extant	Lower areas are represented by non-native grasslands but the majority is composed of sage scrub on the upper portions of the hillsides.	Protect from fire, enhance redberry population	2, 2
USFWS- McGinty Mountain	USFWS	3	Extant	Over this large area, non-native grasslands, mesic dense sage scrub, and more xeric open sage scrub are present with redberry shrubs.	Protect from fire	1
USFWS- San Miguel Mountain	USFWS	3	Extirpated (2007)	This area burned in 2007 and has a mixture of non-native grassland and sage scrub habitats.	Enhance buckwheat population, translocation	2, 2
USFWS- Steele Canyon	USFWS	3	Possibly extirpated	A portion of this area burned in the last 20 years (too small to show up in the state-fire map?). Lower areas are represented by non-native grasslands and the upper portions of the hillsides are represented by sage scrub.	Enhance buckwheat population, translocation	2, 3
USFWS- Sweetwater	USFWS	3	Extirpated (2007)		Enhance buckwheat population, translocation	2, 3

Appendix A: Site assessments and prioritized management actions, continued.

Site Name	Manager	MU	Hermes Copper Status	Summary of Habitat Conditions	Management Options*	Priority
Wright's Field	BCLT	3	Extant	This area is mostly a grassland, but there are redberry shrubs north of the grassland where there is a relatively high amount of bare soil. This redberry patch is adjacent and interspersed with a Eucalyptus grove.	Protect from fire, enhance redberry population	1, 2

* See "Management Strategies" section for more details.

Appendix B: Research needs prioritization

Research Needs	Priority	Status
Develop Translocation Protocols	1	Positive preliminary results and translocation efforts are planned for 2017
Document and Describe Northern Populations	1	Surveys planned for 2017.
Assessing Habitat Requirements	1	Work conducted in 2003 & 2016, but future large scale efforts are warranted.
Assess Ability to Survive Drought	1	Surveys planned for 2017.
Assess Ability to Recolonize Following Fire	1	Work conducted in 2016 but future work warranted.
Survey for Unknown/Additional Populations	2	Populations are mapped as they are discovered, but other occpuied redberry patches likely exist.
Captive Rearing	3	Previous work had limited success.