RARE BUTTERFLY MANAGEMENT STUDIES ON CONSERVED LANDS IN SAN DIEGO COUNTY: HERMES COPPER (*LYCAENA HERMES*)

Translocation Final Report

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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 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 is currently on the USFWS list of candidate species (USFWS 2011).

Our research has documented several extirpations due to the 2003 and 2007 wildfires, but few recolonizations despite what appears to be suitable habitat. Although a few small populations exist within and north of the city of San Diego, the majority of Hermes copper individuals are found to the east and southeast of the city between the footprints of 2003 and 2007 fires. Due to the extremely restricted distribution, the species is highly vulnerable since one large fire could push the species to the brink of extinction. Recolonization into post-wildfire habitats is essential for the long-term persistence of Hermes copper; however, it appears that habitat fragmentation is limiting dispersal and preventing recolonizations from occurring.

For these reasons, we initiated a project to evaluate translocation as a management tool for establishing self-sustaining Hermes copper populations. If successful, this could be a potential management tool to mitigate the impacts of wildfire. We translocated 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. Hollenbeck Canyon was selected because it was occupied by Hermes copper prior to a recent (2007) wildfire. In addition, key members of the vegetation community, including spiny redberry and California buckwheat shrubs were still present after the fire. The success of translocation of adults and eggs was 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. Due to a continuing drought that has suppressed adult butterfly numbers, the 2014 release numbers were lower than desired and we were unable to conduct releases in 2015.

During the spring of 2015, nine eggs exhibited signs consistent with larval eclosion (i.e. hatching), 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 the spring of 2016. One was missing at the start of the monitoring period and the second became brown in color and was 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 was our 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. Although one individual is clearly much too small to judge the translocation a success, it is important to note that we only observed a single adult at Sycuan Peak Ecological Reserve during the

2016 flight season. Historically this has been one of the largest populations with 41 adults detected on a single day in 2013.

Many butterfly translocation efforts have occurred around the world, but primarily in the United States and United Kingdom. Most are not successful and lack adequate documentation which limits what others can learn from their efforts. Even well planned reintroduction efforts can fail due to stochastic events like drought or storms. In our case, the drought conditions restricted the translocation effort and hindered our ability to assess its success. Monitoring of a sentinel site demonstrated that few Hermes copper adults emerged in 2014-2016 at most sites.

This project has occurred during two extremely dry years which has suppressed Hermes copper numbers. Despite these challenging conditions, larval emergence and the observation of an adult provide hope that reintroductions could be successful. Translocation efforts should be continued in a year with higher precipitation since this will allow for the translocation of additional adults and eggs.

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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 is currently on the USFWS list of candidate species (USFWS 2011). A proposed rule, including designated critical habitat, will be developed.

In anticipation of this ruling, SANDAG started contracting San Diego State University in 2010 to conduct Hermes copper research with an emphasis on describing its distribution and resolving critical biological uncertainties. In 2010, this project focused on identifying previously unknown populations. This work continued in 2011, providing a multi-year comparison. In 2012 the project shifted to resolving critical uncertainties about the species biology, while also evaluating population size trends at several large "sentinel" sites. Starting with this project in 2014, after sufficient biological data had been collected and analyzed, we began transitioning to a management phase.

Biology and Life History of Hermes Copper

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; see Figure 1). The species also occurs in northern Baja California, Mexico; however, very little is known about the status of the butterfly 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 Fallbrook, in San Diego County and as far south as Ensenada in Mexico. They have never been recorded immediately along the Pacific coast, and have not been found above 1300 meters in elevation (Marschalek and Klein 2010).

Hermes copper larvae emerge in the late spring after overwintering as eggs (Thorne 1963; Faulkner and Klein 2004) while the duration of the larval and pupal stages are unknown. Larvae are able to remain in the egg an additional year and emerge the second spring (Marschalek and Deutschman 2015). The timing of 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). Adult emergence appears to be influenced by climatic conditions. Adults begin flying earlier during years with warmer spring temperatures (Marschalek and Deutschman 2015); however, our understanding of this relationship is incomplete, especially considering the impact of variable precipitation patterns.

Hermes copper larvae use only spiny redberry (*Rhamnus crocea*) as a host 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). 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. It is also unknown why Hermes copper has such a restricted distribution considering both spiny redberry and California buckwheat are found hundreds of miles north of San Diego County.

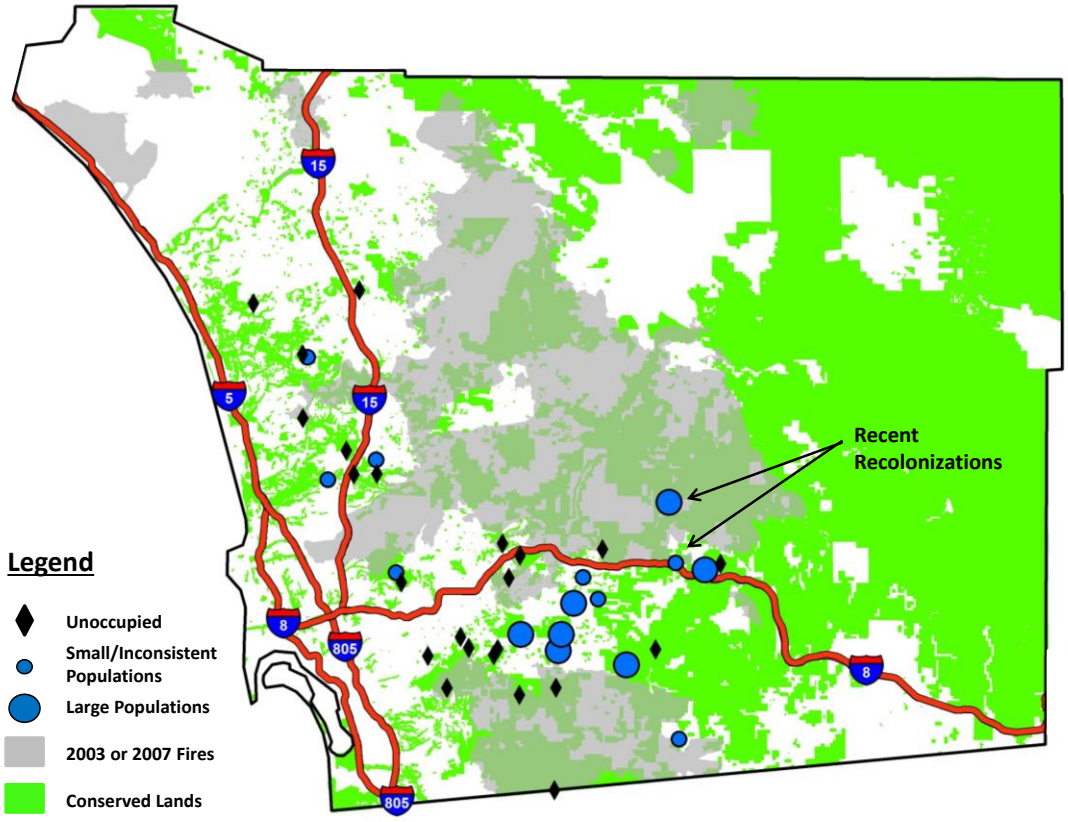

Figure 1. Detection of Hermes copper butterflies on conserved lands, 2010-2013. Fire data from CalFire and Conserved Lands data from SANDAG.

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 spooked. In addition, the majority of individuals encountered are males. Hermes copper females display remarkably different behavior,

exhibiting no territoriality. After being spooked, females do not return to the area. For all individuals, movements rarely exceeded 100 meters, and the longest movement documented for a Hermes copper is just over 1 kilometer (Marschalek and Klein 2010).

Previous Results

Wildfires continue to greatly influence the distribution of Hermes copper, as Wildwood Glen Lane and Boulder Creek Road are the only documented recolonizations following the large wildfires of 2003 and 2007. We allocated a relatively large portion of our effort during the 2013 flight season to survey for recolonization events at historic Hermes copper populations. In addition to repeating transects established prior to the 2003 and/or 2007 wildfires, adjacent spiny redberry patches were searched for more complete coverage. No Hermes copper adults were observed in areas impacted by the 2003 and/or 2007 wildfires, and surprisingly we were not able to detect adults at Wildwood Glen Lane which had apparently been recolonized following a 2003 fire (Figure 1, Table 1).

Table 1. Hermes copper survey data from sites that experienced wildfires in 2003 and/or 2007.

Sites	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Crestridge ER	49	---	0 (1)	---	0 (1)	0	0	0	0	0	0
Anderson Road	73	---	---	---	0	0	0	0	0	0	0
Wildwood Glen Lane	13	---	---	---	1	1 (3)	0 (2)	1	2	0 (3)	0
Hollenbeck Canyon WA	---	---	90	13+	45	0	---	0	0	---	0
Rancho Jamul ER (2003)	42	---	---	---	0	0	0	0	0	---	0
Rancho Jamul ER (2004)	---	10	20	5	4	0	0	0	0	---	0
Sycamore Canyon Co Park	7	---	---	---	---	0	---	---	---	---	0
San Diego National Wildlife Refuge*	---	present	present	present	present	---	---	0	---	---	0

Notes:
"---" indicates no survey
(#) Numbers in parentheses include those observed, but not on the historical transect.
* data from John Martin (USFWS)
Survey efforts were similar from 2003-2012 at each site if sampled (see note below)
but efforts (transect length) increased at some sites in 2013.
At Hollenbeck Canyon WA, survey efforts were similar in 2005 and 2007, but not in 2006.

A landscape genetic study (Strahm et al. 2012, Marschalek et al. 2016) complemented the previous marking studies (Marschalek and Deutschman 2008, Marschalek and Klein 2010) by evaluating the dispersal ability of Hermes copper across the landscape of San Diego County. In addition, development and confirmation of a non-lethal genetic sampling protocol allowed for widespread sampling without harming local populations (Strahm et al. 2012, Marschalek et al. 2013). Our analyses indicated very little genetic differentiation among individuals. However, some peripheral populations (Boulder Creek Road, Meadowbrook Ecological Reserve, and Mission Trails Regional Park) exhibited greater increased genetic differentiation when compared to the core area of the Hermes copper distribution. These patterns likely reflect historical processes rather than contemporary influences (e.g., habitat fragmentation) as more pronounced genetic differences would probably require more time to accumulate. Hermes copper was

likely able to move across the landscape (as lack of strong differentiation demonstrates), but dispersal may be more limited now (supported by few post-wildfire recolonizations and slight genetic differentiation of certain peripheral populations).

The mortality resulting from wildfires, lack of post-wildfire recolonizations, 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 wildfires impacts. The risk of extinction will decrease as the number and geographic spread of populations increase.

For this project, we translocated 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. 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 goal of this project is to evaluate translocation as a management tool for establishing self-sustaining Hermes copper populations. The translocation of adults and eggs were assessed separately.

Methods

In 2014, we translocated 11 adults (6 males and 5 females) to an unoccupied, but suitable patch of habitat at Hollenbeck Canyon Wildlife Area (Figure 2). The released adults were uniquely marked with a felt tipped marker on their wings so they could be identified if observed. Male were released in case there are important, but unknown social interactions or if the presence of territorial males would help retain females in the area. Fourteen eggs obtained from females at other sites were also translocated to this preserve, but to a different area. To obtain the eggs, females were caged with redberry clippings. These redberry clippings were cut into smaller sections about 2-3cm on both sides of the egg. This smaller section of branch containing the egg was tied to a living redberry shrub with a twist-tie (which also served as a visual marker for subsequent monitoring) and thread on the other end (Figure 3).

Due to the drought, the source populations had few adults and limited our sample sizes. The continued dry conditions in 2015 resulted in only a few observations of male Hermes copper adults and prevented us from translocating additional adults or eggs. We originally planned to relocate up to 18 males and 18 females, and obtain eggs from up to 6 additional females if population sizes were appropriate. Hermes copper population sizes tend to be small (Scott 1986, Marschalek and Deutschman 2008, Marschalek and Klein 2010, Marschalek et al. 2016), suggesting that fewer translocated individuals would be available and required to reestablish a population.

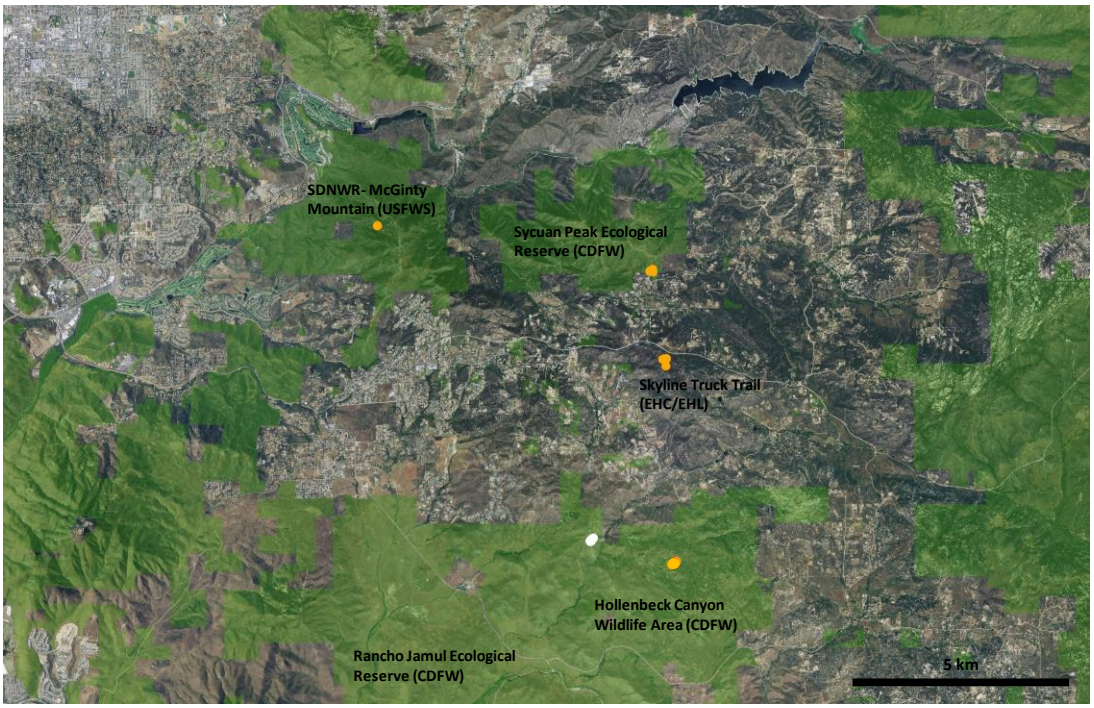

Figure 2. Map showing locations of translocation efforts, with conserved lands represented by the green shading (SANGIS). (The Skyline Truck Trail property is in the process of being purchased for conservation) Orange dots represent Hermes copper adults directly translocated or used to obtain eggs and white dots represent Hermes copper translocated eggs.

Figure 3. Short redberry branch clipping with a Hermes copper egg attached to a living redberry shrub with a green twist tie and thread.

Surveys were conducted during January–April 2015 to monitor the eggs translocated in 2014. When there were signs that a larva had emerged (eclosion) from an egg, that egg was not checked again to avoid any unintended negative impacts to the larva. Because eggs were placed on the underside of branches to mimic natural oviposition, obtaining good view of the eggs required manipulation of the branch. By not revisiting the branches after eclosion, inadvertent disturbance from our activities in the area were minimized. The eggs that exhibited no change were monitored in 2016 using the same protocols.

Surveys for Hermes copper adults were conducted during May –June 2015 and May –June 2016 at the egg and adult release sites. Searches focused on the dirt roads that transverse these two areas as well as areas with dense flowering buckwheat. The egg and adult monitoring was the primary metric of success for the 2014 translocation efforts.

Results

Egg/Larval Surveys

In 2015, of the 14 translocated eggs (Figure 4), 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 (Figure 5, Table 2).

Figure 4. Map showing locations of translocated Hermes copper eggs (white dots) at Hollenbeck Canyon Wildlife Area.

Figure 5. Hermes copper egg with central hole consistent with larval eclosion.
Nine of the translocated eggs had a hole similar to this naturally occurring egg at Sycuan Peak.

Table 2. Results of translocated egg surveys.

	Jan		Feb				Mar	Apr
Egg #	**14**	**21**	**4**	**11**	**17**	**20**	**5**	**8**
1	☐	☐	☐	■				
2	☐	☐	☐	■				
6	☐	☐	☐	■				
9	☐	☐	☐	☐	■			
3	☐	☐	☐	☐	▣	■		
10	☐	☐	☐	☐	☐	■		
5	☐	☐	☐	☐	▣	▣	▣	■
7	☐	☐	☐	☐	☐	☐	☐	■
14	☐	☐	☐	☐	☐	☐	☐	■
8	☐	☐	☐	☐	☐	☐	☐	☐
11	☐	☐	☐	☐	☐	☐	☐	☐
4 12 13	*Missing*							
Legend	☐ Intact and Not Hatched ▣ Partial Exit Hole Present ■ Hatched							

In 2016, we monitored the two remaining eggs (of the original 14) that did not exhibit signs of larval emergence in the previous year. One was not present on the branch clipping and it is unclear if it fell off due to a disturbance, removed by a predator, or some other factor. The second egg became increasingly brown and misshapen over time and is believed to be non-viable.

Adult Surveys

We did not detect Hermes copper adults at the two release sites within Hollenbeck Canyon Wildlife Area during the 2015 flight season. Overall, numbers of all butterfly species were low in abundance.

In 2016, one Hermes copper adult male was observed at the adult release site within Hollenbeck Canyon Wildlife Area during the 2016 flight season (Figure 6, 7). The single male was only observed on one date (19 May 2015). No Hermes copper adults were observed at the egg release sites. Overall, numbers of other butterfly species were higher in abundance compared to 2015.

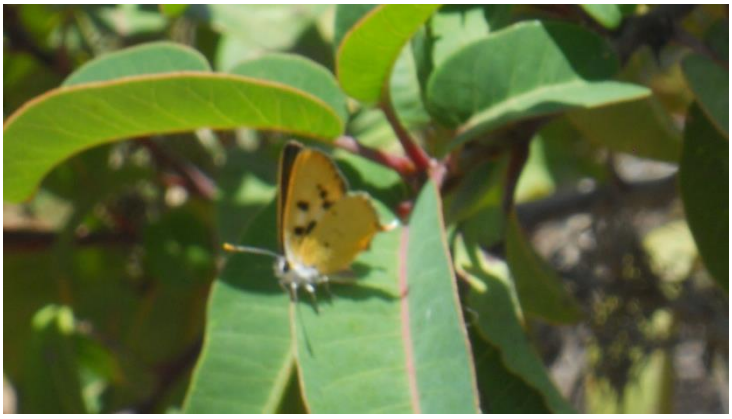

Figure 6. Male Hermes copper observed on 19 May 2016 within the area where adults were released in 2014.

Figure 7. Map showing locations of translocated Hermes copper adults (orange dots) and a post-translocated Hermes copper adult (red dot) at Hollenbeck Canyon Wildlife Area.

Discussion

Due to the continued drought we were unable to fully assess the success of the initial translocation efforts. We were also unable to augment the translocation efforts as had been originally proposed. Despite these challenging conditions, we have promising results from 2015 and 2016 suggesting that translocations may be an effective management tool. In 2015, larvae emerged from 9 of the 14 translocated eggs. In 2016, a single Hermes copper male was observed within the area where 11 adult butterflies were released in 2014. Given the tremendous difficulties encountered, these results warrant further testing.

Detecting a single individual is clearly too small a number to demonstrate success but this is the same number observed at Sycuan Peak Ecological Reserve, historically one of the larger populations. If the dry conditions suppressed the emergence of adults, as suggested from surveys conducted at Sycuan Peak and other sites, the detection of one individual may be meaningful. Quantitatively, based on Hermes copper adult counts at other sites in 2015 compared to the 2013 and 2014 counts, we would not have expected to observe more than 1 or 2 adults (more likely zero) at the release sites at most. This expectation is based on simple (and fairly crude) calculations of expected numbers given the observed declines from 2013 to 2015.

We cannot conclusively rule out that the individual was a disperser originating from another location. However, this seems unlikely due to the low number of adults present over the last two years as well as the lack of post-wildfire recolonizations across San Diego County. Moreover, several years of surveys at Hollenbeck Canyon Wildlife Area prior to the translocation have failed to detect Hermes copper.

The availability of monitoring data from reference sites has been crucial for interpreting survey data from this translocation study. It shows that the conditions were so unfavorable that the lack of adults detected at our translocation sites cannot be taken as evidence that the methods will not work. It is suspected that Hermes copper individuals (naturally occurring or translocated) entered diapause during 2015 and may emerge when the area receives adequate winter precipitation. Thus it is important to monitor both the translocation and sentinel sites in 2017 in order to document population rebound (or lack thereof). Failure of these sentinel sites to recover following the drought could signify that the chances of survival of the species is even lower than previously thought.

Other butterfly translocation efforts have occurred around the world but most of the peer-reviewed literature is restricted to work in the United States and United Kingdom (Schultz et al. 2008). Unfortunately, most attempt fails, as Oates and Warren (1990) found 29 reintroduction successes out of 226 attempts for 11 different species in Britain and Ireland. For those successful translocation efforts, they tended to utilize more introduction attempts (average of 11.1 introductions compared to 3.5) (Oates and Warren 1990). For British and American attempts, an average of 292 individuals were released per reintroduction and efforts lasted an average of 15 years (Schultz et al. 2008). Schultz et al. (2008) found that translocations often failed due to incomplete knowledge of the species biology, poor habitat conditions at release, poor planning, and limited stock. To make things even more difficult, well planned attempts may fail due to stochastic weather events (e.g. drought, flood) so we should not be quick to assume that failure was the result of poor planning or low-quality habitat (Schultz et al. 2008).

During the 12 years prior to initiating this project, we conducted research to better understand Hermes copper and its habitat (Marschalek and Deutschman 2008, 2009; Marschalek and Klein 2010; Marschalek et al. 2016). We also coordinated planning meetings involving preserve managers, conservation planners, and other butterfly experts prior to implementation. During the project, we have carefully documented efforts and outcomes so that we can learn from failures, and others can learn these lessons without going through all the steps. These efforts are rarely reported from past efforts and are a focus of current translocation projects (Schultz et al. 2008).

Despite suboptimal conditions throughout the duration of this project, signs of larval emergence and the observation of an adult in a release area suggests that translocation may well be a viable management option. A year with more favorable precipitation will likely be required in order to assess the success of these reintroduction efforts. Several consecutive years of average precipitation would be optimal. Improved conditions would support larger source populations, allowing us to translocate more individuals. Improved conditions in the subsequent years would improve the chances that the eggs and larvae would survive to adulthood. Due to these potentially encouraging results, translocation efforts should continue under better weather conditions.

Acknowledgements

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Literature Cited

Ballmer GR and GF Pratt. 1988. A survey of the last instar larvae of the Lycaenidae Lepidoptera of California USA. Journal of Research on the Lepidoptera 27:1-81.

Brown J. 1991. Sensitive and declining butterfly species (Insecta: Lepidoptera) in San Diego County, California. Draft report prepared for Dudek and Associates. 27 pages.

Comstock JA and CM Dammers. 1935. Notes on the early stages of three butterflies and six moths from California. Bulletin of the Southern California Academy of Science 34:124-126.

Deutschman DH, ME Berres, DA Marschalek and SL Strahm. 2010. Initial evaluation of the status of Hermes copper (*Lycaena hermes*) on conserved lands in San Diego County. Final Report for San Diego Association of Governments Contract: MOU # 5001442. 41 pages.

Deutschman DH, ME Berres, DA Marschalek and SL Strahm. 2011. Two-year evaluation of Hermes copper (*Lycaena hermes*) on conserved lands in San Diego County. Final Report for San Diego Association of Governments Contract: MOU # 5001442. 53 pages.

Emmel TC and JF Emmel. 1973. The butterflies of southern California. Natural History Museum of Los Angeles County, Science Series. 26:1-148.

Faulkner D and M Klein. 2004. San Diego's sensitive butterflies: a workshop focusing on 10 local species, San Diego, CA.

Johnson J, T Longcore, A Clause, A Lansing, D Renner, A Romero, B Messerschmidt, B Pickett, P Kores, K Courtney. 2010. Captive rearing of Laguna Mountain skipper (*Pyrgus ruralis lagunae*). Cooperative Agreement No. 814307J024. The Urban Wildlands Group, Inc.

Marschalek DA. 2004. Factors influencing population viability of Hermes copper (*Lycaena hermes*). Master's Thesis. San Diego State University. 58 pages.

Marschalek DA and DH Deutschman. 2008. Hermes copper (*Lycaena* [*Hermelycaena*] *hermes*: Lycaenidae): life history and population estimation of a rare butterfly. Journal of Insect Conservation 12(2): 97-105.

Marschalek DA and DH Deutschman. 2009. Larvae and Oviposition of Hermes Copper (Lepidoptera: Lycaenidae). Journal of Entomological Science 44: 400-401.

Marschalek, D.A. and D.H. Deutschman. 2015. Rare butterfly management studies on conserved lands in San Diego County: Hermes copper (*Lycaena hermes*). Final Report for San Diego Association of Governments. 61 pp.

Marschalek, D.A., D.H. Deutschman, S. Strahm and M.E. Berres. 2016. Dynamic landscapes shape post-wildfire recolonization and genetic structure of the endangered Hermes copper (*Lycaena hermes*) butterfly. Ecological Entomology. 41:327-337.

Marschalek, D.A., J.A. Jesu and M.E. Berres. 2013. Impact of non-lethal genetic sampling on the survival, longevity and behavior of the Hermes copper (*Lycaena hermes*) butterfly. Insect Conservation and Diversity. 6:658-662. (online 20 February 2013)

Marschalek D.A. and M.W. Klein. 2010. Distribution, ecology, and conservation of Hermes copper (Lycaenidae: *Lycaena* [*Hermelycaena*] *hermes*). Journal of Insect Conservation 14:721-730.

Oates, M.R. and M.S Warren. 1990. A review of butterfly introductions in Britain and Ireland. Report for the Joint Committee for the Conservation of British Insects. World Wide Fund for Nature, Godalming, Surrey, UK.

Schultz C., C. Russell and L. Wynn. 2008. Restoration, reintroduction, and captive propagation for at-risk butterflies: a review of British and American conservation efforts. Israel Journal of Ecology and Evolution. 54:41-61.

Scott, J. A. 1986. The butterflies of North America: A natural history and field guide. Stanford University Press. 583 pp.

Strahm S.L., D.A. Marschalek, D.H. Deutschman and M.E. Berres. 2012. Monitoring the status of Hermes copper (*Lycaena hermes*) on conserved lands in San Diego County. Final Report for San Diego Association of Governments Contract: MOU # 5001442. 61 pages.

Thorne F. 1963. The distribution of an endemic butterfly *Lycaena hermes*. Journal of Research on the Lepidoptera 2:143-150.

United States Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-Month finding on a petition to list Hermes copper butterfly as endangered or threatened. Federal Register 50 CFR(17): 20918-20939. http://federalregister.gov/a/2011-9028.

Appendix 1: Hermes copper eggs and adults at Hollenbeck Canyon Wildlife Area.

Locations of 14 eggs translocated to Hollenbeck Canyon Wildlife Area in 2014.

Site of Female	Egg Location on Redberry Shrub	Latitude	Longitude
Skyline Truck Trail II	South side of redberry shrub	32.694005	-116.814998
Skyline Truck Trail II	North side of redberry shrub	32.694079	-116.815026
Skyline Truck Trail II	West side of redberry shrub	32.694053	-116.814846
Sycuan Peak	South side of redberry shrub	32.694071	-116.814769
Skyline Truck Trail II	South side of redberry shrub	32.694259	-116.814727
Skyline Truck Trail II	South-east side of redberry shrub	32.69429	-116.814666
Skyline Truck Trail II	West side of redberry shrub	32.694338	-116.8147
Skyline Truck Trail II	North side of redberry shrub	32.694348	-116.814864
Skyline Truck Trail II	West side of redberry shrub	32.694301	-116.814924
Skyline Truck Trail II	North-east side of redberry shrub	32.694545	-116.814377
Skyline Truck Trail II	North side of redberry shrub	32.694642	-116.814449
Skyline Truck Trail II	East side of redberry shrub	32.69463	-116.814468
Skyline Truck Trail II	South-east side of redberry shrub	32.694714	-116.814256
Skyline Truck Trail II	East side of redberry shrub	32.694719	-116.81427

Datum is WGS 84

Capture and release locations of 11 Hermes copper adults.

Sex	Date	Capture Site	Capture Location		Release Site	Release Location	
Male	3-Jun-14	Sycuan Peak Ecological Reserve	32.748872	-116.800033	Hollenbeck Canyon Wildlife Area	32.689307	-116.795592
Female	3-Jun-14	Sycuan Peak Ecological Reserve	32.748872	-116.800033	Hollenbeck Canyon Wildlife Area	32.689307	-116.795592
Male	4-Jun-14	Skyline Truck Trail	32.730661	-116.797563	Hollenbeck Canyon Wildlife Area	32.689295	-116.795684
Male	3-Jun-14	Sycuan Peak Ecological Reserve	32.748485	-116.80066	Hollenbeck Canyon Wildlife Area	32.689658	-116.795081
Male	3-Jun-14	Sycuan Peak Ecological Reserve	32.748332	-116.800022	Hollenbeck Canyon Wildlife Area	32.689401	-116.795368
Female	4-Jun-14	Skyline Truck Trail	32.730761	-116.797202	Hollenbeck Canyon Wildlife Area	32.689295	-116.795684
Male	4-Jun-14	Skyline Truck Trail	32.729402	-116.79689	Hollenbeck Canyon Wildlife Area	32.689295	-116.795684
Female	11-Jun-14	Skyline Truck Trail	32.730837	-116.796798	Hollenbeck Canyon Wildlife Area	32.689968	-116.794556
Female	4-Jun-14	Skyline Truck Trail	32.730804	-116.796988	Hollenbeck Canyon Wildlife Area	32.689295	-116.795684
Male	10-Jun-14	McGinty Mountain	32.757725	-116.865623	Hollenbeck Canyon Wildlife Area	32.689718	-116.794758
Female	11-Jun-14	Skyline Truck Trail	32.730675	-116.797621	Hollenbeck Canyon Wildlife Area	32.689969	-116.794556

Hermes copper male observed on May 19, 2016: N32.689711° W116.794959°.

Datum is WGS 84