Species Status Assessment for the Hermes copper butterfly
(*Lycaena [Hermelycaena] hermes*)
Version 1.0

Hermes copper butterfly. Photo credit Mike Couffer (used with permission).

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U.S. Fish and Wildlife Service
Region 8
Carlsbad, CA
Chapter 1. Introduction, Data, and Analytical Framework

Introduction

The Hermes copper butterfly is a medium-sized butterfly currently found in San Diego County, California, and Baja California, Mexico. The Hermes copper butterfly has been a candidate for listing under the Endangered Species Act of 1973, as amended (Act), since the 12-month finding published in 2011 (Service 2011). The Species Status Assessment (SSA) is intended to be an in-depth review of the species’ biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability.

Methods and Background

This document draws scientific information from resources such as primary peer-reviewed literature, reports submitted to the Service and other public agencies, species occurrence information in GIS databases, and expert experience and observations. It is preceded by, and draws upon analyses presented in, other Service documents, including the 12-month finding (Service 2011) and the Species Assessment and Listing Priority Assignment Form associated with the most recent Candidate Notice of Review (Service 2015). Finally, we coordinate closely with our partners engaged in ongoing research and conservation efforts. This assures consideration of the most current scientific and conservation status information.

Analytical Framework

The SSA analytical framework is designed for assessing a species’ biological condition and level of viability. The document is temporally structured, generally walking the reader through what is known from past data, how data inform current species’ status, and what potential changes to this status may occur in the future based on data and models. The future condition analysis includes the potential conditions that the species or its habitat may face and discusses the most probable scenario if those conditions come to fruition. This most probable scenario includes

Comment [MD1]: I would mention the IUCN threat status of the species (Vulnerable) in the introduction to underpin the importance of the conservation of this endemic species (http://www.iucnredlist.org/details/12435/0).
consideration of the sources most likely to impact the species at the population or rangewide scales in the future, including potential cumulative impacts.

For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in the natural ecosystem beyond a biologically meaningful timeframe, in this case, 30 years. We chose 30 years because it is within the range of the available hydrological and climate change model forecasts. Additionally, 30 years encompasses approximately 30 generations of Hermes copper butterflies, the length of time we are confident estimating the likelihood of future scenarios for this species, given its short life span and our ability to predict environmental changes (e.g. downscaled climate-change models).

Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Wolf et al. 2015, entire).

We begin an SSA with an understanding of the species’ unique life history, and from that evaluate a species’ resource needs or biological requirements at the scales of individuals, populations (in this document we discuss “occurrences,” because population dynamics and distributions for the Hermes copper butterfly are not well understood), and species using the principles of redundancy, representation, and resilience. These three concepts (or analogous ones) apply at the population and species levels, and are explained that way below for simplicity and clarity as we introduce them.

1. **Redundancy** at the population level can be quantified by the range within which population size naturally fluctuates. Species-level redundancy is quantified by the range within which the number of populations in a species’ range fluctuates (see Climate Change and Drought sections below for Hermes copper butterfly discussion population fluctuation discussion). Redundancy spreads risk among multiple individuals or
populations to minimize the potential loss of the population or species from catastrophic events.

2. **Representation** has two components, genetic and environmental. It is defined by the amount of genetic and habitat diversity within a population distribution (population-level representation) and among populations within the species’ range (species-level representation).

3. **Resiliency** is the capacity of a population or species to withstand stochastic disturbance events, that is, to rebound from relatively extreme numerical lows (individuals at the population-level and populations at the species-level) during a given time period. Resilience depends primarily, or entirely, on representation and redundancy. The population-level resilience depends on the minimum size of a population within its natural range of fluctuation and on how diverse the existing gene pool and occupied habitat are. Species-level resilience depends on the minimum number of populations within a species’ natural range of fluctuation. All else being equal, resilience over a given time period does not change, regardless of a species' current size and distribution. The only time resilience does shift is when all else is not equal, and the minimum population size or number within its range of fluctuations over that period is reduced by longer-term changes in environmental circumstances. The quantitative concept of population viability (calculated in population viability analyses) is the probability that a population will be extirpated within a given number of years. In this context it is qualitatively equivalent to population-level resiliency, and analogous to species-level resiliency. Because species status assessments we analyze what the species needs to maintain viability, species-level resiliency will be hereafter referred to as “species viability”).

Using the SSA framework, we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation.

**Modeling**
We have included a conceptual model created as a product of a workshop convened by the Institute for Ecological Monitoring and Management (Strahm et al. 2012, pp. 8–16; Figure 2; Appendix II). This workshop brought together species and ecology experts from around southern California, to create conceptual ecology models for species of concern. This model illustrates interactions among species’ biological attributes, resources, and stressors. We also constructed a relatively simple “theoretical probability” viability model (see Species Viability Model below). This type of model assumes likelihood of event occurrence, or in this case level of influence, based on the proportion of times an independent event can occur given the number of possible outcomes. In this model, population existence is treated as an independent event (each historical population is assumed to have had equal influence on species’ redundancy) and species’ redundancy and representation are assumed to equally influence species’ viability. Our measure of viability is inversely proportional to, but not necessarily the inverse of, extinction likelihood; therefore it is useful for measuring change but not a measure of extinction risk.

**Chapter 2. Ecology**

**Background**

**Description**

The Hermes copper butterfly (*Lycaena hermes*) is a small, brightly-colored butterfly in the family Lycaenidae. It is approximately 1 to 1.25 inches (in) (2.5 to 3.2 centimeters (cm)) in length, with one tail on the hindwing. The forewing upperside is brown with a yellow or orange area enclosing several black spots, and the hindwing upperside has orange spots that may be merged into a band along the margin. On the underside, the forewing is yellow with four to six black spots, and the hindwing is bright yellow with three to six black spots (USGS 2006). Mean last instar (caterpillar life stage between molts) larval body length is 0.6 in (15 millimeters (mm)) (Ballmer and Pratt 1988, p. 4). Emmel and Emmel (1973, pp. 62, 63) provide a full description of the early stages of the species (eggs, larvae, and pupae).
Figure 1. Hermes copper butterfly life cycle. (Peer reviewers - please note, this is a draft image, and will be updated for the final SSA with an actual picture of a Hermes copper pupa, and brand new information that pupae are not, in fact, found in leaf litter).
**Taxonomy**

Hermes copper butterfly was first described as *Chrysophanus hermes* by Edwards (1870, p. 21). Scudder (1876, p. 125) then placed this species in the genus *Tharsalea* based on the presence of hindwing tails. Freeman (1936, p. 279) placed Hermes copper butterfly in the genus *Lycaena* as based on the assessment of the male genitalia, finding it was distinctly a lycaenid and not typical of the other taxa of the genus *Tharsalea*. Miller and Brown (1979, p. 22) erected a monotypic genus to accommodate Hermes copper butterfly as *Hermelycaena hermes*. Its unique use of a host plant in the family Rhamnaceae, the broadly-based morphological assessment of Miller and Brown (1979, p. 97), the allozyme work of Pratt and Wright (2002, p. 225), and the larval morphology analysis of Ballmer and Pratt (1988, pp. 4), all support recognition of Hermes copper butterfly as belonging to the distinct genus *Hermelycaena* (Shepard and Guppy 2001, p. 188; D. Marschalek 2015a, pers. comm.). Furthermore, recent mitochondrial DNA work indicates the Hermes copper butterfly ancestor evolved first in North America, then spread to Asia and evolved to *Phoenicurusia* and other genera (Yago in Faulkner and Klein 2012, p. 28). This means Hermes copper butterfly is an isolated “relict species,” with its closest modern, more derived, relatives found in Asia (not in the genus *Lycaena*). Nevertheless, *Lycaena hermes* is the name last published in a peer-reviewed taxonomic treatment (Pelham 2008, p. 191), which places Hermes copper butterfly in the genus *Lycaena*, subgenus *Hermelycaena*. The name “*Lycaena hermes*” is also predominantly used in other recent literature (Scott 1986, p. 392; Faulkner and Brown 1993, p. 120; Emmel 1998, p. 832; Opler and Warren 2005, p. 22; Marschalek and Deutschman 2008, p. 97; Marschalek and Deutschman 2009, p. 400; Marschalek and Klein 2011, p. 1), therefore we recognize it as such for the purposes of this assessment. In this document we have corrected the nomenclature used in past assessments, and note that the extended taxonomic nomenclature should be written as “*Lycaena hermes* [formerly in *Hermelycaena*],” or *Lycaena [Hermelycaena] hermes*,” the latter denoting *Hermelycaena* as a subgenus (International Commission on Zoological Nomenclature 2015).

**Habitat and Life History**


Hermes copper butterflies are active in late spring and early summer. Females deposit single eggs exclusively on *Rhamnus crocea* (spiny redberry; Thorne 1963, p. 143; Emmel and Emmel 1973, p. 62) in the early summer, often where a branch splits or on a leaf (Marschalek and Deutschman 2009, p. 401; Figure 2). In 2014, researchers typically only found one egg per shrub and on one occasion two were observed (D. Marschalek, 2015b, pers. comm.). Eggs overwinter, with larvae reported from mid-April to mid-May (Marschalek and Deutschman 2009, p. 400) followed by pupation on the host plant (Emmel and Emmel 1973, p. 63). Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401). Hermes copper butterflies have one flight period (termed univoltine) typically occurring in mid-May to early July, depending on weather conditions and elevation (Marschalek and Deutschman 2008, p. 100; Marschalek and Klein 2010, p. 5). Emergence appears to be influenced by weather; however this relationship is not well understood. For example, weather conditions in the spring of 2010 were cool and moist and resulted in a late emergence; however, the spring of 2006 was hot and dry and also resulted in a late emergence period (Deutschman *et al.* 2010, p. 4). We know that Hermes copper butterfly individuals diapause (undergo a low metabolic rate resting stage) during the late summer, fall, and winter as eggs (Deutschman *et al.* 2010, p. 4). Multiple year diapause typically occurs in butterfly species that diapause in stages more advanced than the egg, such as pupae or larvae, after larvae have fed on an ephemeral herbaceous annual host plant and accumulated energy reserves (U.S. Fish and Wildlife Service (Service) 2003, p. 8; Gullan and Cranston 2010, p. 169). It is less likely to occur with Hermes copper butterflies because they diapause as eggs, and their host plant is a relatively dependable perennial shrub. However, 2 year diapause was documented by SDSU researchers in 2015, who reported one egg located in the field in January 2014 (deposited in 2013) did not eclose (hatch) until 2015 (D. Marschalek, 2015b, pers. comm.).

Hermes copper butterflies inhabit areas of coastal sage scrub and southern mixed chaparral in San Diego County, California (Marschalek and Deutschman 2008, p. 98). Spiny redberry occurs in “well-drained soil of better than average depth, yet not deep enough to support trees …along canyon bottoms and on hillsides with a northern exposure” (Thorne 1963, p. 143). The range of spiny redberry extends throughout coastal northern California, as far north as San Francisco.
(Consortium of California Herbaria 2010); however, Hermes copper butterfly has never been documented north of San Diego County (Carlsbad Fish and Wildlife Office (CFWO) GIS database). Therefore, some factor other than host plant species availability apparently has historically limited or currently limits the range of the species. Researchers report adults are rarely found far from spiny redberry (Thorne 1963, p. 143) and take nectar almost exclusively from *Eriogonum fasciculatum* (California buckwheat) (Marschalek and Deutschman 2008, p. 5), but will opportunistically take nectar from other flowering plants in the vicinity of spiny redberry. The densities of host plants and nectar sources required to support a Hermes copper occurrence are not known. Hermes copper butterflies can be found in San Diego within stands of spiny redberry associated with stands of California buckwheat, typically inhabiting intermediate-depth soils on north facing slopes.

Where Hermes copper butterflies occupy stands of spiny redberry, additional details of habitat use have been characterized in a number of ways. Marschalek and Deutschman (2008, p. 3) recorded densities of Hermes copper butterfly adults on paired transects along edges and within the interior of host plant stands in rural areas. Their study indicates that Hermes copper butterfly densities are significantly higher near host plant stand edges than in the interior (Marschalek and Deutschman 2008, p. 102). Adult males have a strong preference for openings in the vegetation, including roads and trails, specifically for the north and west sides of canopy openings (Marschalek and Deutschman 2008, p. 102). These areas capture the first morning light and reach the temperature threshold for activity, around 72 degrees Fahrenheit (°F) (22 degrees Celsius (°C)) (Marschalek and Deutschman 2008, p. 5), more quickly than other areas (Deutschman et al. 2010, p. 4). Hermes copper butterflies tend to remain inactive under conditions of heavy cloud cover and cooler weather (Marschalek and Deutschman 2008, p. 5). Across all four sites sampled by Marschalek and Deutschman, Hermes copper butterfly presence was positively associated with California buckwheat, but negatively associated with *Adenostema fasciculatum* (chamise) (Marschalek and Deutschman 2008, p. 102; Figure 2). Therefore, woody canopy openings within stands of spiny redberry and adjacent stands of California buckwheat appear to be characteristic of micro-habitat used by Hermes copper butterfly.

Hermes copper butterflies are typically sedentary, but movement propensity is difficult to
measure (Marschalek and Klein 2010, p. 1). They appear to have limited directed movement ability (Marschalek and Klein 2010, p. 1) although lyceanids can be dispersed relatively far by the wind resulting in occasional, but significant, long distance dispersal events (Robbins and Small 1981 p. 312). Marschalek and Klein (2010) studied intra-habitat movement of Hermes copper butterflies using mark-release-recapture techniques. The highest median dispersal distance was 146 ft (44.5 m), and maximum recapture distance was 0.7 mile (mi) (1.1 kilometers (km)) (Marschalek and Klein 2010, p. 1). They found no adult movement across non-habitat areas, such as type-converted grassland or riparian woodland (Marschalek and Klein 2010, p. 6). Studies infer that most individuals typically move less than 656 ft. (200 m) (Marschalek and Deutschman 2008, p. 102, Marschalek and Klein 2010, pp. 725–726). Genetic research indicates females may disperse longer distances than males (Deutschman et al. 2010, p. 16) contradicting previous methods used such as mark-release-recapture (Marschalek and Deutschman 2008, p. 102) that may not detect the movement of females and over-sample territorial males. More information is needed to fully understand movement patterns of Hermes copper butterfly; however, dispersal is likely aided by winds, and inhibited by lack of available dispersal/connectivity habitat in many areas (Deutschman et al. 2010, p. 17).

Landscape genetic studies have allowed researchers to develop a description of Hermes copper butterfly population structure, providing some dispersal inference (Strahm et al. 2012, p. 23). Individuals from Van Dam Peak, Mission Trails, and Boulder Creek Road (Figure 3; Table 1; Appendix III) showed the greatest genetic differentiation (Strahm et al. 2012, p. 24). Although these results provide evidence that individuals can disperse across much of the landscape, Strahm et al. (2012, p. 32) suggest these patterns likely reflect historical processes, as detectable genetic differences reflecting contemporary influences, such as habitat fragmentation, would probably require more time. Additionally, recolonization events following large fires are typically slow to occur, suggesting dispersal is limited (Klein and Faulkner 2003, pp. 96 and 97; Strahm et al. 2012, p. 32; Figure 2). Information from the genetic study (Strahm et al. 2012, p. 23) was used to help define some occurrences, where they would have otherwise been merged, for example, North and South McGinty Mountain (occurrence numbers 23 and 24; Figure 2).
Figure 2. Hermes copper butterfly range in San Diego County, California, and Baja California, Mexico.
Conceptual Model

Conceptual population ecology models are useful for conservation planning. In February 2012 the Institute for Ecological Monitoring and Management convened a workshop to help local managers and experts develop conceptual models for five topics of regional importance, including the Hermes copper butterfly. The conceptual model presented here is the result of collaboration among a working group of local experts (Strahm et al. 2012, pp. 8–16; Figure 2; Appendix II). The working group set management and monitoring goals to guide model construction; the management goal was to ensure persistence throughout the range, the monitoring goal was to address critical biological uncertainties. The group identified six biological uncertainties (A–F) and four management actions (G–J) important to Hermes copper butterfly persistence (not prioritized):

Biological Uncertainties

A. **Sex Dependent Habitat Use and Dispersal.** Male and female Hermes copper adults seem to use habitat differently and contribute differently to dispersal, which has implications for reproduction and connectivity. It is unclear what triggers dispersal and if dispersal is wind-aided or directed flight. Genetic work suggests landscape features impede movement, but occasional long distance dispersal occurs within the central portion of their range.

B. **Larval Biology and Secondary Diapause.** Very little is known about larval biology, physiology, habitat requirements, and behavior. We have little information on the potential for multiple-year diapause, but given large annual fluctuations in adult population size it may be a factor. If rearing is conducted, a better understanding of larval requirements is needed.

C. **Predators, Parasitoids, and Other Sources of Mortality.** We have little information on predators and parasitoids of Hermes copper, in part because larvae and eggs are difficult to locate in the field. Two observations of adult mortality have been made in the field: one due to a jumping spider and one by road kill, but relative importance of these threats is unknown.

D. **Vegetation Community Structure.** In spiny redberry patches it is not clear what determines when and where Hermes copper will occur. Many seemingly suitable sites are not occupied. These sites may simply be unoccupied as an accident of history, but the possibility that other
factors are at work cannot be eliminated. It is also not clear if the distribution of California buckwheat and other nectar sources impact behavior.

E. Climatic Conditions. Spring rainfall, temperature regimes, and other factors seem to influence annual population sizes and emergence. They may also represent important factors when considering the potential influence of climate change on the species.

F. Undiscovered Populations and Corridors. Undiscovered populations of Hermes copper butterfly likely exist, especially on private property. In addition, what constitutes a movement corridor is not yet understood. Defining potential corridors can be based on genetics work and the study of dispersal behavior.

Management Actions

Some are contingent on biological uncertainties being resolved prior to implementation.

G. Fire Management. Possible actions include Fuel breaks, fire suppression, fuel manipulation, weed abatement, and other measures to protect occupied spiny redberry stands (such as reducing the risk of ignitions due to recreation) from fire in the short term. [The Service believes the most effective way to mitigate fire as a stressor is to maintain maximum species redundancy (as many resilient populations as possible).]

H. Habitat and Corridor Enhancement. Selection of strategic areas and corridors for enhancement in order to facilitate dispersal throughout its range. This could also include prioritizing areas for conservation to ensure that suitable habitat is within dispersal distance.

I. Assisted Dispersal/Translocation. Perform controlled reintroduction to previously occupied sites extirpated by wildfire.

J. In-Vitro Rearing. Rearing of Hermes copper for release and preservation of genetic diversity, similar to the Quino checkerspot (*Euphydryas editha quino*) butterfly program. This may become necessary if the species declines further or if assisted dispersal becomes necessary.

**Figure 2.** Hermes copper butterfly conceptual model from Strahm *et al.* (2012 p. 16). Colors correspond with narrative labels (Appendix II). Green = species variables, blue = natural drivers (including resources), red = stressors. Thickness of arrows indicates strength of effect.
Distribution

Historical data indicate Hermes copper butterflies ranged from the vicinity of the community of Pala, California, in northern San Diego County (CFWO GIS database) to approximately 18 mi (29 km) south of Santo Tomas in Baja California, Mexico, and from Pine Valley in eastern San Diego County to coastal mesas in southwestern San Diego County (Thorne 1963, pp. 143, 147; Figure 3). The Hermes copper butterfly is endemic to the southern California and Baja California, Mexico region, primarily occurring in southern San Diego County, California (Thorne 1963, p. 143; Marschalek and Klein 2010, p. 4). Notable exceptions to the southern distribution pattern are two historical museum specimens collected in north San Diego County, one from the vicinity of the community of Bonsall in 1934, and another from the vicinity of the community of Pala in 1932. Hermes copper butterfly occurrences have never been recorded immediately adjacent to the coast, and have not been found east of the western slopes of the Cuyamaca Mountains above approximately 1,300 m (4,264 ft) (Marschalek and Klein 2010, p. 4; Marschalek et al. 2016, p. 7).
The primary gap in our knowledge of Hermes copper butterfly distribution is the extent of the species occurrence in Mexico. The distribution of Hermes copper butterfly in Mexico is not well-known, as researchers have not generally explored this area, and locations are primarily known from museum specimen records (Marschalek and Klein 2010, p. 4). Of the two museum specimens from Mexico, one collected in 1936 was labeled “12 miles north of Ensenada,” and another collected in 1983 was labeled “Salsipuedes” (Marschalek and Klein 2010, p. 4). Assuming older specimens were usually collected relatively close to roads that existed at the time (Thorne 1963, p. 145), these Mexican locations probably were collected from approximately the same location, which is a popular surf destination known as “Salsipuedes,” located approximately 12 mi (19 km) north of Ensenada off the Esconica Tijuana-Ensenada (coastal highway to Ensenada). The distribution in Mexico of spiny redberry is relatively contiguous with that in the U.S., extending to approximately 190 mi (312 km) south of the border into Mexico along the western Baja California Peninsula (Little 1976, p. 150). Hermes copper butterflies have been recorded as far south into Mexico as 18 mi (29 km) south of Santo Tomas, which is approximately half the distance of the extent of spiny redberry’s Mexican range (Thorne 1963, p. 143). More exploration of redberry stands in Mexico, starting with areas closest to the U.S. border and where specimens have been historically collected, should be undertaken.

We conducted an analysis to best determine the historical range of Hermes copper butterfly within the United States. We entered all Hermes copper butterfly observation records that had information about collection location in our GIS database as of 2016, and mapped all observed and museum specimen records with an appropriate level of detail and location description. To better determine the geographic locations of historical Hermes copper butterfly records mapped by Thorne (1963, p. 147), we overlaid a transparent image of his map on Google Earth imagery, and scaled it appropriately to ensure that geographic features and community locations corresponded with those of the imagery. Examination of Thorne’s (1963 p. 147) map expanded the known historical range as described by Deutschman et al. (2010, p. 3) to the southeast in the vicinity of the community of Pine Valley and Corte Madera Valley. The resulting known historical range of Hermes copper butterfly within the United States can be described as comprised of a narrow northern portion north of Los Peñasquitos Canyon and Scripps Poway.
Parkway (latitude midway between the northernmost record location and the international border), and a wider southern portion (see Figure 3 and Table 1 below; San Diego County Plant Atlas 2010).

Although the distribution of Hermes copper butterfly occurrences in Mexico is not well understood, the U.S. occurrences minimally encompass half the species’ known historical latitudinal range. The results of our occurrence distribution analysis indicate areas in the United States most likely to harbor possible extant undiscovered Hermes copper butterfly occurrences are primarily limited to a relatively narrow area within the southern portion of the range bordered on the north and south by the 2003 Cedar Fire and 2007 Harris Fire perimeters, and on the west and east roughly by Sycuan Peak and Long Valley (see Figure 3 and Table 1 below).
Table 1. Historical Hermes copper butterfly occurrences in the United States and Mexico.

<table>
<thead>
<tr>
<th>Map #</th>
<th>Occurrence name (other names)</th>
<th>Last Observed</th>
<th>Presumed Status</th>
<th>Extant in 2000</th>
<th>Fire</th>
<th>Extirpated Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lopez Canyon</td>
<td>2011</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mira Mesa</td>
<td>Prior to 1963</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Development</td>
</tr>
<tr>
<td>3</td>
<td>Kearny Mesa</td>
<td>1939</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Development</td>
</tr>
<tr>
<td>4</td>
<td>Mission Valley (Fairmont Canyon, Canyons near Mission Valley)</td>
<td>1908</td>
<td>Extirpated</td>
<td>Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dictionary Hill</td>
<td>1962</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Isolation (Development)</td>
</tr>
<tr>
<td>6</td>
<td>South Otay Mesa</td>
<td>Pre-1920</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Development</td>
</tr>
<tr>
<td>7</td>
<td>Bonsall</td>
<td>1934</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Unknown</td>
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<tr>
<td>8</td>
<td>San Elijo Hills (San Marcos Creek, San Elijo Road and Questhaven Road)</td>
<td>1979</td>
<td>Extirpated</td>
<td>Development</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>Elfin Forest (Onyx Ridge)</td>
<td>2011</td>
<td>Extant</td>
<td>Y</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Lake Hodges</td>
<td>1982</td>
<td>Extirpated</td>
<td></td>
<td>2007</td>
<td>Fire</td>
</tr>
<tr>
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<td>Rancho Santa Fe (Del Dios)</td>
<td>2004</td>
<td>Extirpated</td>
<td>Y</td>
<td>2007</td>
<td>Fire, Development</td>
</tr>
<tr>
<td>12</td>
<td>Black Mountain</td>
<td>2004</td>
<td>Unknown</td>
<td>Y</td>
<td></td>
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<tr>
<td>13</td>
<td>Van Dam Peak (Meadowbrook)</td>
<td>2011</td>
<td>Extant</td>
<td>Y</td>
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<td></td>
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<tr>
<td>14</td>
<td>Sabre Springs (Poway Road and 395)</td>
<td>2001</td>
<td>Extirpated</td>
<td>Development</td>
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<td>1960</td>
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<td>Fire, Development</td>
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<tr>
<td>16</td>
<td>North Santee (Fanita Ranch)</td>
<td>2005</td>
<td>Unknown</td>
<td>Y</td>
<td>2003</td>
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<tr>
<td>17</td>
<td>Miramar</td>
<td>1996</td>
<td>Extirpated</td>
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<td>Development</td>
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<tr>
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<td>Y</td>
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<td>19</td>
<td>Mission Trails (Mission Gorge, Mission Dam)</td>
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<td>Extant</td>
<td>Y, 2003</td>
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<td>20</td>
<td>South Santee</td>
<td>1967</td>
<td>Extirpated</td>
<td></td>
<td></td>
<td>Development</td>
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<tr>
<td>21</td>
<td>Cowles Mountain (Big Rock Road Park)</td>
<td>1973</td>
<td>Extirpated</td>
<td>Isolation</td>
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<tr>
<td></td>
<td>Site Description</td>
<td>Year</td>
<td>Status</td>
<td>Extant</td>
<td>Development</td>
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<tr>
<td>22</td>
<td>San Diego State University (San Diego State College)</td>
<td>1957</td>
<td>Extirpated</td>
<td>Y</td>
<td>Development</td>
<td></td>
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<tr>
<td>23</td>
<td>North McGinty Mountain</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>South McGinty Mountain</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Rancho San Diego</td>
<td>2009</td>
<td>Unknown</td>
<td>Y</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Los Montanas</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>North Jamul</td>
<td>2004</td>
<td>Unknown</td>
<td>Y</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>San Miguel Mountain</td>
<td>2006</td>
<td>Extirpated</td>
<td>Y</td>
<td>2007, Fire</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Pala</td>
<td>1932</td>
<td>Extirpated</td>
<td>Y</td>
<td>Unknown</td>
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</tr>
<tr>
<td>31</td>
<td>Sycamore Canyon</td>
<td>2003</td>
<td>Extirpated</td>
<td>Y</td>
<td>2003, Fire</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>BLM Truck Trail</td>
<td>2003</td>
<td>Extirpated</td>
<td>Y</td>
<td>2003, Fire</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Willows (Viejas Grade Road)</td>
<td>2003</td>
<td>Extirpated</td>
<td>Y</td>
<td>2003, Fire</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Crestridge</td>
<td>2007</td>
<td>Extirpated</td>
<td>Y</td>
<td>2003, Fire</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Alpine (Wright's Field)</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Japutal (Japutal Valley)</td>
<td>2012</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Loveland Reservoir</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Hidden Glen (Japutal Valley, Lyons Valley Road)</td>
<td>2008</td>
<td>Unknown</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Sycuan Peak</td>
<td>2016</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>East McGinty Mountain</td>
<td>2001</td>
<td>Unknown</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Lawson Valley (Lawson Peak)</td>
<td>2016</td>
<td>Extant</td>
<td>Y</td>
<td>2006, 2007</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Skyline Truck Trail (Lawson Valley)</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Lyons Peak</td>
<td>2003</td>
<td>Unknown</td>
<td>Y</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Hollenbeck Canyon</td>
<td>2016</td>
<td>Unknown²</td>
<td>Y</td>
<td>2003, 2007</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Hartley Peak, Potrero Peak (Portrero)</td>
<td>2012</td>
<td>Extant</td>
<td>Y</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Deerhorn Valley</td>
<td>1970</td>
<td>Extirpated</td>
<td>Y</td>
<td>2007, Fire</td>
<td></td>
</tr>
</tbody>
</table>

² Unknown extension year.
<table>
<thead>
<tr>
<th></th>
<th>Location</th>
<th>Year</th>
<th>Status</th>
<th>Year</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>Otay Mountain (Little Cedar Canyon, Otay foothill)</td>
<td>1979</td>
<td>Extirpated</td>
<td>2003, 2007</td>
<td>Fire</td>
</tr>
<tr>
<td>49</td>
<td>Tecate Peak</td>
<td>1980</td>
<td>Extirpated</td>
<td>2007</td>
<td>Fire</td>
</tr>
<tr>
<td>50</td>
<td>Boulder Creek Road</td>
<td>2016</td>
<td>Extant</td>
<td>Y</td>
<td>2003</td>
</tr>
<tr>
<td>51</td>
<td>North Guatay Mountain</td>
<td>2004</td>
<td>Unknown</td>
<td>Y</td>
<td>2003</td>
</tr>
<tr>
<td>52</td>
<td>Pine Valley</td>
<td>Pre-1963</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>North Descanso (Wildwood Glen, Descanso)</td>
<td>2010</td>
<td>Extant</td>
<td>Y</td>
<td>2003</td>
</tr>
<tr>
<td>54</td>
<td>South Guatay Mountain</td>
<td>2008</td>
<td>Extant</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>South Descanso (Roberts Ranch)</td>
<td>2016</td>
<td>Extant</td>
<td>Y</td>
<td>2003</td>
</tr>
<tr>
<td>56</td>
<td>Corte Madera</td>
<td>Pre-1963</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Salsipuedes (12 miles North of Ensenada)</td>
<td>1983</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Santo Tomas (18 miles south of Santo Tomas)</td>
<td>Pre-1920</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>North Ensenada (Bajamar)</td>
<td>1936</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Occurrences with last observation prior to 2000 have lower geographic accuracy.

2 One adult observed after 2015 translocation.
Ecological Needs

In this section, we describe Hermes copper butterfly ecological needs at the hierarchical levels of individual, population, and species. There are also spatial and temporal components to hierarchical resource needs, reflected in the average area occupied by and “life expectancy” of each ecological entity. Individual needs are met and resource availability should be assessed at the adult male territory scale on an annual basis, reflecting the life span of an individual. Population-level resilience needs are met and resource availability should be assessed on the habitat patch or metapopulation (interconnected habitat patches) scale over a period of decades. Populations or sub-populations persist until they are extirpated by wildfire or other stochastic events, to eventually be replaced as habitat is recolonized (estimated recolonization time is 4-20 years). Species-level viability needs must always be met and assessed on a range-wide scale for perpetual maintenance, if the species is to avoid extinction.

1. Individual Resource Needs:
   a. Larvae: suitable Spiny redberry leaf tissue for development.
   b. Pupae: shelter for pupation in litter below host plant.
   c. Adults: suitable Spiny redberry leaf tissue for oviposition; nectar sources (primarily California buckwheat); mates.

2. Population Needs
   2.1. Resource Needs and/or Circumstances: Habitat elements required by populations include north-facing slopes with spiny redberry bushes (quantity unknown, but it must be a stand, not isolated individuals) and associated stands of California buckwheat.
   2.2. Population-level redundancy: Populations must have enough individuals (population growth) in “good years,” that after reproduction is limited by poor environmental conditions such as drought in intervening “bad” years that they can still find mates. That is, populations are always large enough to persist through periods of “worst-case” negative population growth.
   2.3. Population-level representation: It is unclear how susceptible Hermes copper butterfly is to inbreeding depression. Varying degrees of northern slope exposure should be present within habitat patches, as well as a mix of open, sunny areas, and stands of California buckwheat for nectar in the vicinity of spiny redberry host plants.
Additionally, individuals must be distributed over a large enough area (population footprint/distribution) that not all are likely to be killed by stochastic events such as wildfire.

3. Species Needs

3.1. Resource Needs and/or Circumstances: Connectivity among populations or subpopulations to maintain metapopulation dynamics. For Hermes copper butterfly, this means suitable corridor habitat with suitable intervening vegetation structure and topography between habitat patches, close enough to other habitat patches that individual movement among habitat patches is likely. Apparent impediments to dispersal include forested and riparian areas, mountains, and development.

3.2. Species-level redundancy: Loss and weakness of remaining isolated north San Diego County populations indicates a threshold number of extant connected populations to maintain this portion of the range, 3–6 based on the proximity, juxtaposition, and number of “large” populations in southern areas (Figures 2 and 6; Appendix III).

3.3. Species-level representation: Populations must be distributed in a variety of habitats so that there are always some populations experiencing conditions that support some level of population growth. In especially warm dry years, populations in wetter habitats should experience the highest population growth rates within the species’ range, and in colder, wetter years populations in drier habitats would. Absent range-wide genetic analysis of populations, we can assume some local adaptation and use habitat variability as a proxy for genetic variability. Populations should be represented across a continuum of elevation levels, from the coast to the mountain foothills. Populations in higher elevation, cooler habitats, and coastal habitats with more marine influence that are less susceptible to a warming climate are important to maintain. Available genetic and population fluctuation information for Hermes copper butterfly supports these assumptions (Strahm et al. 2012, p. 23; also see Climate Change and Drought, and Species Viability Model discussions below).

Chapter 3. Status
Stressors

Stressors negatively affect Hermes copper butterfly populations and habitats, which may then prevent needs from being met. Stressors reduce population-level resilience, which in turn reduces species-level redundancy and representation, lowering overall species viability (see species viability model discussion below).

Current Species Condition

3.1 Wildfire

3.1.1 Habitat modification

The vegetation types that support Hermes copper butterfly, chaparral and coastal sage scrub, are prone to relatively frequent wildfire ignitions, and many plant species are fire-adapted. The historical fire regime in southern California likely was characterized by many small lightning-ignited fires in the summer and a few, infrequent large fires in the fall (Keeley and Fotheringham 2003, pp. 242–243). These infrequent, large, high-intensity wildfires, so-called “megafires” (greater than 50,000 ha (123,553 ac) in size), burned the landscape long before Europeans settled the Pacific coast (Keeley and Zedler 2009, p. 90). As such, modern fire regimes in southern California “have much in common with historical regimes” (Keeley and Zedler 2009, p. 69). While some researchers claim that the fire regime of chaparral growing in adjacent Baja California is not affected by megafires due to a lack of fire suppression activities (for example, Minnich and Chou 1997; Minnich 2001); Keeley and Zedler (2009, p. 86) believe that the fire regime in Baja California similarly consists of “small fires punctuated at periodic intervals by large fire events.” Frequent smaller fires (those prevented by fire suppression activities) prevent the buildup of large, contiguous areas of fuel thought to increase the likelihood of megafires.

The current fire regime in southern California consists of numerous small fires and periodic megafires generally driven by extreme “Santa Ana” weather conditions of high temperatures, low humidity, and strong erratic winds (Keeley and Zedler 2009, p. 90). The primary difference
between the current fire regime and historical fire regimes in southern California is that human-induced or anthropogenic ignitions have increased the frequency of fires, megafires in particular, above historical levels. Frequent fires open up the landscape, particularly coastal sage scrub, making the habitat more vulnerable to invasive, nonnative plants and vegetation type-conversion (Keeley et al. 2005, p. 2117). However the primary concern with frequent megafires is the mortality associated with these extensive and intense events (see Direct Mortality Stressor discussion below) that can isolate habitat from potential source populations, and reduce the recolonization likelihood of burned areas by Hermes copper butterfly.

The Hermes copper host plant, spiny redberry, resprouts after fires and is relatively resilient to frequent burns (Keeley 1998, p. 258). Although Keeley and Fotheringham (2003, p. 244) indicated that continued habitat disturbance, such as fire, will result in conversion of native shrublands to nonnative grasslands, Keeley (2004, p. 7) also noted that invasive, nonnative plants will not typically displace obligate resprouting plant species in mesic shrublands that burn once every 10 years. Therefore, because spiny redberry is a resprouter, it will likely recover in those areas that retain this burn frequency.

The effect of wildfire on Hermes copper butterfly’s primary nectar source (California buckwheat) is more complicated than impacts to host plants. California buckwheat is a facultative seeder and high proportions of this nectar source are likely killed by fire, and densities are reduced the following year within burned areas (Zedler et al. 1983, p. 814); however, California buckwheat does show minimal resprouting capability (approximately 10 percent) if individuals are young (Keeley 2006, p. 375). The extent of invasion of nonnative plants and type conversion in areas specifically inhabited by Hermes copper butterfly are unknown. However, information clearly indicates that wildfire results in at least temporary reductions in suitable habitat for Hermes copper butterfly and may result in lower densities of California buckwheat (Zedler et al. 1983, p. 814; Keeley 2006, p. 375; Marschalek and Klein 2010, p. 728). Where spiny redberry resprouts, the quantity of California buckwheat as a nectar source necessary to support a Hermes copper butterfly occurrence may be temporarily unavailable due to recent fire impacts, and nonnative grasses commonly compete with native flowering plants that would otherwise provide abundant nectar after fire. Marschalek and
Deutschman (2016b, p. 12) found that while habitats burned 8 to 12 years earlier had similar abundance of redberry and buckwheat to unburned habitats, they were characterized by reduced percentage of bare ground.

### 3.1.2 Direct Mortality

Extensive and intense wildfire events are the primary cause of direct mortality and extirpation of Hermes copper butterfly occurrences. The magnitude of this stressor appears to have increased over the past 15 years due to a number of megafires created by extreme “Santa Ana” weather conditions of high temperatures, low humidity, and strong erratic winds (see habitat wildfire discussion above; Keeley and Zedler 2009, p. 90).

The 2003 Otay and Cedar fires and the 2007 Harris and Witch Creek fires (Appendix IV) in particular have negatively impacted the species, resulting in or contributing to the extirpation of 9 of the 37 known occurrences in 2000 (see Table 1 above). It is well-documented that wildfires that occur in occupied Hermes copper butterfly habitat result in loss of Hermes copper butterflies (Klein and Faulkner 2003, pp. 96, 97; Marschalek and Klein 2010, pp. 4, 5). The butterflies rarely survive wildfire because life stages of the butterfly inhabit host plant foliage, and spiny redberry typically burns to the ground and resprouts from stumps (Deutschman et al. 2010, p. 8; Marschalek and Klein 2010, p. 8). This results in at least the temporal loss of both the habitat (until the spiny redberry and nectar source regrowth occurs) and the presence of butterflies (occupancy) in the area. Wildfires can also leave patches of unburned occupied habitat that are functionally isolated (e.g., further than the typical dispersal distance of the butterfly) from other occupied habitat. Furthermore, large fires can eliminate source populations before previously burned habitat can be recolonized, and can result in long-term or permanent loss of butterfly populations. For example, in Mission Trails Park the 7,303 ac (2596 ha) “Assist #59” Fire in 1981 and the smaller 126 ac (51 ha) “Assist #14” Fire in 1983 (no significant overlap between acreages burned by the fires), resulted in an approximate 18-year extirpation of the Mission Trails Park Hermes copper butterfly occurrence (Klein and Faulkner 2003, pp. 96, 97). More recent examples include extirpations of the monitored Crestridge, Rancho Jamul, Anderson Road, Hollenbeck Canyon, and San Miguel Mountain occurrences, as well as other less-
monitored occurrences (Marschalek and Klein 2010, pp. 4, 5; Deutschman et al. 2010, p. 36; Marschalek and Deutschman 2016b, p. 10; Figure 4).

Seven post-fire occurrence sites monitored in south San Diego County have yet to be recolonized since the 2003 and 2007 fires (Table 1; Marschalek and Deutschman 2016b p. 10 and 13). After the 2003 Cedar Fire, Hermes copper butterfly records at the regularly monitored Crestridge occurrence, once considered the largest and most robust population within the species’ range (Klein and Faulkner 2003, p. 86), were limited to presumably the same male for a 6-day period in 2005, and another single male observed in 2007 (Marschalek and Klein 2010, p. 4; Deutschman et al. 2010, p. 33). When Marschalek’s (2010, p. 2) study “colonies” in the Rancho Jamul occurrence were extirpated by fire in 2003, he discovered additional occupied habitat on the other side of a nearby firebreak in 2004; however the remaining occurrence distribution was extirpated in the 2007 Harris Fire (Marschalek 2010, pers. comm.). Data indicate all historical occurrences that burned in both the 2003 and 2007 fires were extirpated except North Descanso, where record locations were within a narrow extension of the fire perimeter surrounded on three sides by unburned habitat (see Table 1 and Figure 3 above). We know this habitat was recolonized because genetic research determined the colonizing individuals were not related to those collected before the fire (Deutschman et al. 2010, p. 16). These facts underscore the importance of having available Hermes copper butterfly source populations to recolonize habitat after fire. Of the 37 extant Hermes copper butterfly occurrences in 2000, 1 northern Hermes copper butterfly occurrence and 9 southern occurrences are believed to have been extirpated by fire or a combination of fire and development (see Table 1 above).
Figure 4. Hermes copper butterfly occurrences with wildfire footprints.
It is difficult to predict where and when the next megafire will occur. We examined maps of recent high fire hazard areas in San Diego County (SANDAG 2010; Appendix IV). Areas identified as most vulnerable include most occupied and potentially occupied Hermes copper butterfly habitats in San Diego County within the southern portion of the range bordered on the north and south by the 2003 Cedar Fire and 2007 Harris Fire perimeters. Nineteen potential source occurrences for recolonization of habitats burned in the past 10 years (extant or of unknown status) fall within a contiguous area that has not recently burned (southeastern occurrences in Figure 4), and where the fire hazard is considered high (SANDAG (Sand Diego Association of Governments) 2010; Appendix IV). All except three of these potential source occurrences (North Descanso, Hartley Peak, and North Guatay Mountain) also fall within the 174,026 ac (70,426 ha) 1970 Laguna Fire megafire perimeter (similar in size to the 2003 and 2007 fires; Figure 1), and the three that do not fall within the Laguna Fire perimeter fall partially within the 2003 and 2007 megafire perimeters (Figure 4). There were numerous wildfires in 2014, and although none of them reached megafire proportion, some may have impacted habitat associated with extant occurrences. The Cocos and Bernardo fires (Appendix IV) burned approximately 2,000 ac (809 ha) and 1,500 ac (607 ha) of potential Hermes copper butterfly habitat near the Elfin Forest and the Black Mountain occurrences (Figure 4). A smaller unnamed fire burned approximately 95 ac (38 ha) of potential habitat near the extant Mission Trails occurrence in Mission Trails Regional Park (Burns et al., 2014; City News Source 2014).

Annual mean area under extreme fire risk has increased steadily in California since 1979, and 2014 ranked highest in the history of the state (Yoon et al. 2015, p. S5). Although precipitation in the winter of 2016-2017 has been relatively high and the three-year drought appears to have been at least temporarily interrupted, these conditions typically increase the fuel load for wildfires that start later in the year.

The fire regime in Mexico is not as well understood. Some researchers claim chaparral habitat in Mexico within Hermes copper butterfly’s range is not as affected by megafires, because there has been less fire suppression activities than in the U.S. (Minnich and Chou 1997, pp. 244–245; Minnich 2001, pp. 1549–1552). Nevertheless, Keeley and Zedler (2009, p. 86) believe that the fire regime in Baja California mirrors that of Southern California, similarly consisting of “small fires punctuated at periodic intervals by large fire events.” Climate change and drought effects
on wildfire in Mexico should also be similar to the U.S. Therefore we expect impacts from wildfire in Mexico will be similar to those in San Diego County where Hermes copper butterfly occurs.

This analysis of current fire danger and fire history illustrates the potential for permanent loss of the majority of remaining butterfly occurrences should another large fire occur prior to recolonization of burned habitats (per discussion above, recolonization may not occur for up to 18 years). As discussed by Marschalek and Klein (2010, p. 9) and Deutschman et al. (2010, p. 42), there is a risk that one or more wildfires could extirpate the majority of extant Hermes copper butterfly occurrences. Marschalek and Deutschman (2016c) initiated a translocation study in 2015 to try and assist recolonization of habitat formerly occupied by the large Sycamore Canyon occurrence. While it is not clear this attempt will be successful, and it was doubtless greatly hindered by drought, one adult was observed in 2016, indicating some level of success (Marschalek and Deutschman (2016c, p. 10). Regulatory protections, such as ignition reduction measures, do exist to reduce fire danger in general. Large megafires that are the stressor of concern for Hermes copper butterflies are considered resistant to control (Durland, P., pers. comm., in Scauzillo 2015). Therefore, no regulatory protections exist to adequately reduce the risk posed to the species by wildfire.

3.1.3 Summary

Only two habitat areas occupied by the 16 occurrences extirpated by fire have been naturally recolonized since 2003. Based on our analysis above, we believe wildfire has been the most significant source of Hermes copper butterfly population decline and loss. This stressor affects Hermes copper butterfly population and habitat across the species' international range.

3.2 Land use change

Current Hermes copper butterfly habitat distribution relative to historical conditions in San Diego County has been reduced by urban development within coastal and interior San Diego County; this development has resulted in the loss and fragmentation of Hermes copper butterfly
habitat (CalFlora 2010; Consortium of California Herbaria 2010; San Diego County Plant Atlas 2010). Of the 27 known extirpated Hermes copper butterfly occurrences, loss and fragmentation of habitat as a result of development has contributed to extirpation of 13 occurrences (48 percent; Table 1, not including Sycamore Canyon translocation site). There is still uncertainty regarding the Hermes copper butterfly’s condition within its southernmost known historical range, because we have very little information on the status of the species in Mexico. Since the year 2000, occupied habitats containing Hermes copper butterfly’s host plant, spiny redberry, were lost due to urban development in the community of Rancho Santa Fe and the community of Sabre Springs. In the City of San Marcos, one spiny redberry stand near Jack’s Pond was lost to development (Anderson 2010a, pp. 1, 2) and another spiny redberry stand was significantly reduced in the vicinity of Palomar College (Anderson 2010b, pp. 1, 2). The spiny redberry stand in Lopez Canyon is currently found within a relatively small preserve (roughly rectangular area 0.4 mi (0.6 km) by 0.5 mi (0.8 km)) that is contiguous with suitable Hermes copper butterfly habitat in Del Mar Mesa where development is ongoing. This stand of spiny redberry is likely all that remains of what was once a wider distribution, encompassing the community of Mira Mesa and the western portion of Miramar Naval Air Station (per Thorne’s 1963 map, p. 147). Of particular concern is ongoing rural development in the vicinity of Lyon’s Valley, north of the community of Jamul (E. Porter 2017, pers. comm.).

3.2.1 Conservation Status

Although a significant amount of habitat has been lost due to development throughout the range of Hermes copper butterfly within the United States, approximately 48 percent of the remaining occupied areas are currently protected from destruction by development due to their presence on federally owned lands or on lands conserved under regional habitat conservation plans (see Appendix III for maps from Marschalek and Deutschman 2016b that generally illustrate this). Land ownership analysis in 2011 indicated of the approximately 48 percent conserved habitat, 19 percent (encompassing portions of 13 occurrences) is located within established regional habitat conservation plan preserve lands, approximately 20 percent (encompassing portions of 12 occurrences) falls within U.S. Forest Service lands, approximately 6 percent (encompassing portions of 4 occurrences) falls within U.S. Fish and Wildlife Service lands, and approximately 2
percent (encompassing portions of 4 occurrences) falls within Bureau of Land Management (BLM) land.

3.2.2 Regulatory Protection

The County of San Diego has two ordinances in place that restrict new development or other proposed projects within sensitive habitats. The Biological Mitigation Ordinance of the County of San Diego Subarea Plan (County of San Diego 1998, Ord. Nos. 8845, 9246) regulates development within coastal sage scrub and mixed chaparral habitats that currently support portions of 10 extant Hermes copper butterfly populations on non-federal land within the boundaries of the County’s MSCP subarea plan. The County of San Diego Resource Protection Ordinance (County of San Diego 2007) regulates development within coastal sage scrub and mixed chaparral habitats that currently support all extant Hermes copper butterfly populations on non-federal lands throughout the county. County regulations mandate surveys and mitigation for Hermes copper butterfly occupancy and habitat. These local resource protection ordinances provide some regulatory measures of protection for the remaining 52 percent of extant Hermes copper butterfly habitat throughout the species occupied range. Although past development in occupied Hermes copper butterfly habitat resulted in a substantial number of extirpations of Hermes copper butterfly occurrences, restrictions are now in place to limit future development and the corresponding destruction and modification of Hermes copper butterfly habitat. Therefore, we do not conclude development alone is significantly contributing to reduction or fragmentation of remaining Hermes copper butterfly habitat on non-federal lands at this time.

3.2.3 Summary

Land use change, while considered a current stressor that is resulting in relatively small, but ongoing amounts of habitat loss, is not a primary cause of population loss. A significant amount of remaining Hermes copper butterfly habitat has been conserved within the United States; approximately 48 percent of the remaining occupied areas are currently protected from destruction by development. Some regulatory protections are in place, and development alone
does not appear to be a significantly contributor to reduction or fragmentation of remaining Hermes copper butterfly habitat.

3.3 Habitat Fragmentation

Habitat fragmentation can result in smaller, more vulnerable Hermes copper butterfly populations, and is caused by land use change as described above. The presence of suitable habitat on which Hermes copper butterflies depend will determine the size and range of a local population. Wildfires and past development have caused habitat fragmentation that separates extant occurrences and inhibits movement by creating a gap that Hermes copper butterflies are not likely to traverse. The connectivity of habitat occupied by a butterfly population is not defined by host plant distribution at the scale of stands or patches, but rather by adult butterfly movement that results in interbreeding (see Service 2003, pp. 22, 162–165). Any loss of resource contiguity on the ground that does not affect butterfly movement, such as burned vegetation, may degrade but not fragment habitat. Therefore, in order for habitat to be fragmented, movement must either be inhibited by a barrier, or the distance between remaining host plants where larvae develop must be greater than adult butterflies will typically move to mate or deposit eggs. Genetic analysis (Deutschman et al. 2010; p. 16) indicates that Hermes copper butterflies can show differentiation even when close in proximity, presumably due to physical barriers that may be a result of development or a landscape feature (i.e., the three McGinty Mountain sites that are on opposite sides of the mountain may be separated by topography). Alternately, sampling locations that are not close have shown little genetic differentiation (Deutschman et al. 2010; p. 16), indicating that the butterflies can also occasionally disperse long distances under the right conditions, such as high winds. Sampling at one location before and after a fire found genetically differentiated groups. Deutschman et al. (2010, p. 16) concluded findings supported the idea that Hermes copper butterfly individuals can move long-distance movement (at least if aided by the wind; e.g. Robbins and Small 1981 p. 312), but developed areas and natural landscape features may restrict or enhance dispersal, respectively. It is important to note that although movement may be possible, the newly occupied habitat must be suitable at the time Hermes copper butterflies arrive to ensure successful recolonization.
Hermes copper butterfly habitat has become fragmented both permanently (past urban development) and more temporarily (wildfires). Comparison of Hermes copper butterfly occurrences and host plant distribution with mapped wildfire perimeters indicates that wildfires cause short-term fragmentation of habitat, and historically, Hermes copper butterfly habitat in San Diego County has been fragmented and lost due to the progression of development over the last 50 years. Analysis of the Hermes copper butterfly occurrences indicates that in the northern portion of the U.S. range, the habitat has been fragmented (and lost) permanently by development and further fragmented temporally by wildfires, resulting in extirpation of at least four Hermes copper butterfly occurrences (see Table 1 above). A historical Hermes copper butterfly occurrence (Rancho Santa Fe) in the northern portion of the range has been lost since the year 2000. This area is not expected to be recolonized because it is mostly surrounded by development and the nearest potential “source” occurrence is Elfin Forest 2.7 mi (4.3 km) away, where a single individual was last detected during by monitoring in 2011, and none in 2016 (Marschalek and Deutschman 2016a, p. 8). Further to the south, Black Mountain, Lopez Canyon, Van Dam Peak, and the complex of occurrences comprised of Mission Trails Park, North Santee, and Lakeside Downs are isolated from other occurrences by development. Habitat fragmentation directly affects the likelihood of Hermes copper butterfly population persistence in portions of its range, and exacerbates other effects from fire and development.

3.4 Climate Change and Drought

3.4.1 Climate Change

The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements (IPCC 2013a, p. 1450). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a, p. 1450).
Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon et al. 2007, pp. 35–54, 82–85; IPCC 2013b, pp. 3-29; IPCC 2014, pp. 1–32). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon et al. 2007, pp. 21–35; IPCC 2013b, pp. 11–12 and figures SPM.4 and SPM.5). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl et al. 2007, entire; Ganguly et al. 2009, pp. 11555, 15558; Prinn et al. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl et al. 2007, pp. 760–764, 797–811; Ganguly et al. 2009, pp. 15555–15558; Prinn et al. 2011, pp. 527, 529; IPCC 2013b, pp. 19–23). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.
Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as threats in combination and interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2014, pp. 4–11). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (Glick et al. 2011, pp. 19–22; IPCC 2014, p. 5). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of the best scientific information available regarding various aspects of climate change.

Global climate projections are informative, and, in some cases, the only or the best scientific information available. However, projected changes in climate and related impacts can vary across and within different regions of the world (IPCC 2013b, pp. 15–16). Therefore, we use “downscaled” projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick et al. 2011, pp. 58–61, for a discussion of downscaling).

Southern California has a typical Mediterranean climate. Summers are typically dry and hot while winters are cool, with minimal rainfall averaging about 10 inches per year. The maritime influence of the Pacific Ocean combined with the coastal and inland mountain ranges creates an inversion layer typical of Mediterranean-like climates, particularly in southern California. These conditions also create microclimates, where the weather can be highly variable within small geographic areas at the same time. Therefore, Hermes copper butterfly’s ability to adapt to a changing climate may depend on species’ representation in a variety of habitats throughout the species’ range.
We evaluated the available historical weather data and the species biology to determine the likelihood of effects assuming the climate has been and will continue to change. The typical effect of a warmer climate, as observed with Hermes copper butterfly in lower, warmer elevation habitats compared to higher, cooler elevations, is an earlier flight season by several days (Thorne 1963, p. 146; Marschalek and Deutschman 2008, p. 98). Marschalek and Klein (2010, p. 2) noted that past records suggest a slightly earlier flight season in recent years compared to the 1960s. The earliest published day of flight prior to 1963, after “30 years of extensive collecting,” was May 20 (Thorne 1963, pp. 143, 146), but adults began flying on May 1 and May 3 in 2015 and 2016, respectively (Marschalek and Deutschman 20016b, p. 7 and 9), and were reported as early as April 29 in 2003 (CFWO GIS database). The record early observation on April 29, was from Fortuna Mountain in Mission Trails Park, a well-collected occurrence with records dating back to 1958, including collections by Thorne (called “Mission Gorge” or “Mission Dam” on museum specimen labels) where May 21 was the earliest documented record from the 1960s and early 1970s (before climate change trends were reasonably detectable as described by the IPCC (2013b, p. 4)).

The historical temperature trend in Hermes copper butterfly habitats for the month of April (when larvae are typically developing and pupating) from 1951-2006 can be calculated with relatively high confidence (p values from 0.001 to 0.05). The mean temperature change in occupied areas ranged from 0.04 to 0.07 °F (0.07 to 0.13 °C) per year (Climate Wizard 2016), which could explain the earlier than average flight seasons. The latest published observation date (presumed end of flight season) of an adult prior to 1970 was on July 30, 1967 (museum specimen collected by Thorne at “Suncrest”); however, the latest observation date from monitoring data and other records in the past 16 years was almost a month earlier on July 2 in 2016, despite an uncharacteristically late start to the flight season (May 29). Shorter flight seasons are also consistent with higher average temperatures, as a higher metabolism in these exothermic short-lived invertebrates typically results in faster growth and earlier death. Nevertheless, given the temporal and geographical availability of their widespread perennial host plant, and exposure to extremes of climate throughout their known historical range (Thorne 1963, p. 144), Hermes copper butterfly and its host and nectar plants are not likely to be
negatively affected throughout the majority of the species’ range by phenological shifts in
development of a few days (unlike species such as Edith’s checkerspot (Euphydryas editha) that
depend on annual host plants; Service 2003, pp. 63, 64). While it is possible the species’
climatic tolerance, such as temperature thresholds for activity, could result in a change in the
species niche and distribution of suitable habitat as the climate changes, predicting any such
changes would be speculative because we do not understand what currently limits the species’
range to a much smaller geographic area than its host plant.

3.4.2 Drought

Drought has been a major factor affecting southern California ecosystems, starting with the driest
Monitoring of adult abundance at occurrences since 2010 indicates that the past 4 years of warm,
dry drought conditions negatively affected habitat suitability and suppressed adult population
sizes, most noticeably the Sycuan Peak monitored occurrence that has remained at record low
numbers for two years in a row (Figure 5; Marschalek and Deutschman 2016b, p. 10). The
highest elevation, wettest occurrence (Boulder Creek Road) was the largest in 2016 following 3
years of drought and high temperatures (Figure 5). This higher elevation site got more rain than
lower sites, indicating representation in higher elevation inland habitats is important to species’
viability. No coastal sites were monitored (Appendix III).

Based on this information, we believe drought is a significant stressor on its own, but is of most
concern with regard to its synergistic relationship with climate and increasing fire hazard
(See Combined Stressor Effects below).
Figure 5. Hermes copper butterfly counts vs. annual precipitation from 2009 to 2016. The primary y-axis shows adult counts from unburned sentinel sites. The secondary y-axis shows mean precipitation from two weather stations within the range of the species.
3.4.3 Summary

The information indicates that climate change significantly exacerbates other stressors (see Combined Stressor Effects below), especially wildfire and drought. Therefore, it continues to be a significant source of Hermes copper butterfly population decline and loss.

3.5 Other Stressors

Potential stressors, including disease, predation, roadkill, and overutilization have been identified (Service 2015, pp. 7 and 8). When we investigated internet listings offering to sell specimens of Hermes copper butterfly (Service 2015, p. 7, Anderson 2017, personal observation), we found no evidence that Hermes copper butterflies, whole or in parts, were being used in commercial business activities. Through literature research we evaluated the potential of disease to threaten Hermes copper butterfly rangewide and found no information indicating disease to be a current stressor for Hermes copper butterfly. Predation (including parasitism) is a factor known to cause mortality in butterflies, and therefore could potentially threaten any butterfly species. Faulkner and Klein (2005, p. 26) stated that “no papers have reported any parasites or predators for the Hermes copper butterfly, though they obviously exist.” Birds may consume Hermes copper butterfly larvae, although we are not aware of any data that indicate bird predation is a significant threat to Hermes copper butterfly. To our knowledge, disease, predation, roadkill, and overutilization have not impacted the species to such an extent that they would have a negative impact on species’ viability, so are not discussed further.

3.6 Combined Stressor Effects

All stressors that act above the individual level have at least an additive effect, for example habitat loss and fragmentation due to land use change combined with wildfire may together have a greater impact on the species than wildfire alone. Multiple stressors at a given hierarchical level have combined effects that emerge at the next higher level. For example, at the population level, habitat loss significantly reducing the resilience of one population, combined with wildfire...
affecting resilience of another, has a greater effect on Hermes copper butterfly species-level redundancy, and therefore species’ viability than either stressor would individually (see Species Viability Model discussion below).

Stressors that alone may not significantly reduce species viability have at least additive, if not synergistic, effects on species viability. For example, investigators have found that wildfire and habitat modification (type conversion) typically have a synergistic effect on habitat suitability in Mediterranean-type climate zones. Wildfire increases the rate of nonnative grass invasion, a component of the habitat modification stressor, which in turn increases fire frequency. Overall, these factors increase the likelihood of mega-wildfires on a landscape/species range-wide scale. The relationship between habitat fragmentation and type conversion is in part synergistic, as fragmentation increases the rate of nonnative plant species invasion and type conversion through disturbance, nitrogen deposition, and seed dispersal. Synergistic effects are a type of emergent property. Simply put, properties of the system that cannot be entirely explained by individual components and are often hard to predict (Ponge 2005, entire; Vesterby 2011, entire). At each hierarchic ecosystem level, there are properties (possibly stressors) that did not occur at or influence lower levels; however, these properties do affect the ecosystem at the level they emerge, and also at levels above. At higher hierarchical ecosystem levels, thousands of factors can be involved in the process of property emergence. In the case of interaction between wildfire and nonnative grass invasion, there are two emergent properties: increased fire frequency and accelerated invasion rate. In the case of habitat fragmentation, the emergent property is accelerated type conversion relative to more connected habitats. Although difficult to predict, we have come to understand some synergistic effects through observation and hindsight. It is important to understand the full extent and impact of emergent properties resulting from stressors may not be fully understood or appreciated. While it is also possible that emergent properties may have positive effects on a species, there is no information to indicate any exist for Hermes copper butterfly.

Combined effects, when synergistic, generally increase the likelihood of significant and irreversible loss of populations, compared to individual effects. If fewer source populations are available over time to recolonize burned habitat when host and nectar plants have sufficiently regenerated, the synergistic interaction between reduced species-level redundancy and other
stressors could result in a dramatic increase in species extinction risk (see **Possible Future Conditions** below).

### 3.7 Current Conservation Measures

As described above, the County of San Diego implements ordinances within the County that require Hermes copper butterfly surveys in potential habitat and specific measures to offset impacts to occupied Hermes copper butterfly habitat. In addition, presence of Hermes copper butterflies is a factor within San Diego County for prioritizing land acquisitions for conservation from Federal, State, and private funding sources. SANDAG has provided funding for Hermes copper butterfly surveys and research since 2010. Of particular importance is the SANDAG-funded translocation research undertaken by San Diego State University (Marschalek and Deutschman 2016c), which should provide a means to mitigate and reverse wildfire impacts to populations.

The most obvious way to capitalize on the potential for cooperative, collaborative planning and decision making in Hermes copper butterfly conservation is through scenario planning. Scenario planning (Rowland *et al.* 2014) can serve multiple purposes, including education and outreach, decision support, and research. It is particularly appropriate in complex situations where drivers are not controllable and introduce irreducible uncertainty, such as the wildfire stressor for Hermes copper butterfly. Other drivers of change external to species’ resources and beyond managers’ direct control include population growth and demographic changes, land use patterns, and financial resource availability. Such uncertainties that cannot be reduced within a decision timeframe because they are beyond managerial control and/or outside current scientific knowledge make it difficult or even impossible to develop informative predictive models.

Scenario planning offers an alternative approach to considering future conditions as uncertainties and the level of complexity of a situation increases, the longer one looks into the future. Our objective is for this SSA to be a significant first step in the scenario planning process, which we believe has the potential to increase Hermes copper butterfly viability.

**Chapter 4. Potential Changes**

40
Introduction

To analyze species’ viability, we consider the current and future availability or condition of resources. The consequences of missing resources are assessed to describe the species’ current condition and to project possible future conditions. Characterization of viability is enhanced by a straight-forward theoretical probability model and three probable scenarios to describe possible viability changes over time and characterize uncertainty.

For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in the natural ecosystem beyond a biologically meaningful timeframe, in this case, 30 years. We chose 30 years because it is within the range of the available hydrological and climate change model forecast.

As discussed above, wildfire can permanently affect habitat suitability. If areas are repeatedly burned often enough, California buckwheat may not have the time necessary to become reestablished, rendering the habitat unsuitable for Hermes copper butterfly (Marschalek and Klein 2010, p. 728). Nectar plant loss is not the only habitat effect caused by wildfire. Increased fire frequency may also stress Hermes copper butterfly populations through habitat type-conversion, and fire management plans are not expected to provide protection from megafires such as those that occurred in 2003 and 2007. Therefore, habitat modification due to wildfire is cause for both short and long-term habitat impact concerns.

Possible future development, still in the preliminary planning stage (Service and CDFW 2016), could destroy occupied or suitable habitat on private land within the North Santee (Fanita Ranch) occurrence, further fragmenting the remaining habitat and isolating the largely conserved Lakeside Downs and Mission Trails (Mission Gorge, Mission Dam) occurrences. Habitat fragmentation is discussed further below; for geographic, context see Table 1 and Figure 3). Habitat fragmentation is a continuing concern for Hermes copper butterfly, as development outside of occupied habitat can still negatively affect the species. Within U.S. Forest Service lands, we anticipate future development, if any, will be limited, and the Forest Service has
incorporated measures to address threats to Hermes copper butterfly and its habitat as it implements specific activities within forest lands. The limited number of Hermes copper butterfly occurrences within BLM lands are also unlikely to face future development pressure. Based on our analysis, we conclude land use change, while a stressor to be concerned about, will not be the most significant future source of Hermes copper butterfly population decline and loss.

The significant effect of wildfire on the Hermes copper butterfly species’ viability can be seen in the current compared to historical distributions of the species in southern California. Analysis of GIS information indicates approximately 60 percent of the extant occurrences are found within the footprint of the 1970 Laguna megafire (Figure 4). In contrast, areas north and south of the extant Hermes copper butterfly occurrences, where extirpations are concentrated, burned in the 2003 and 2007 megafires (Figure 4), indicating a similar fate could befall 60% of extant occurrences should another fire similar to the Laguna megafire occur. As discussed above, the estimate annual mean area under extreme fire risk has increased steadily in California since 1979, and 2014 ranked highest in the history of the state (Yoon et al. 2015, p. S5). In light of the recent drought-influenced wildfires in southern California, a future megafire affecting most or all of the area burned by the Laguna Fire in 1970 (40-year-old chaparral) would encompass the majority of extant occurrences and result in significantly reduced species’ viability. We analyzed the number of occurrence polygons with existing habitat that fell at least 67% within an historical fire footprints (the approximate area of the extirpated Crestridge occurrence within the 2003 Cedar Fire footprint), and found this had happened sixteen times in the past 60 years. However, eleven of those events were a result of the Laguna Fire. In our 12-month finding analysis (Service 2011, pp. 20923), we concluded that eight occurrences were extirpated by the 2003 and 2007 megafires. This number would have been significantly higher if one of those megafires had burned as many Hermes copper butterfly occurrences as the Laguna Fire in 1970.

In the case of Hermes copper butterfly, the primary limiting species-level resource is connectivity of formerly occupied to occupied habitats, on which the likelihood of post-fire recolonization depends. We further analyzed fire frequency data to determine the effect on occurrence status, and likelihood of extirpation over the next 30 years. We defined megafires as
being at least as large as the smallest of the large fires that extirpated multiple occurrences in 2003 and 2007, approximately 40,000 ac (16,187 ha). During the past 15 years (2001–2016), there were seven megafires within Hermes copper butterfly’s historical range, a significant increase compared to none during the previous 15 years (1986–2000). The two fifteen-year periods prior to that (1956–1970; 1971–1985) had only one megafire each. This means the annual probability of a megafire occurring in Hermes copper butterfly’s range during has increased from less than 7% chance to approximately 47%. Therefore, the likelihood of catastrophic extirpation events increased almost seven fold over the past 15 years. At the current megafire return rate, we expect up to 14 megafires could impact Hermes copper butterfly over the next 30 years; if the trend does not at least stabilize, the frequency of megafires could continue to increase.

We also investigated the effect of fire frequency within occurrence polygons (Figures 2 and 3) on Hermes copper butterfly occurrence status; comparing known extant polygons to extirpated ones. The mean number of fires in extant polygons for the period of 1970 (when the Laguna megafire occurred) to 2015 was significantly lower (P= 0.009 \textit{which test was used?}) at three, compared to five and a half for extirpated polygons. This indicates increased frequency of any size wildfire is a threat to the species, and isolated occurrences in more developed areas are equally vulnerable to extirpation by fire.

**Species Viability Model**

In the absence of population dynamics data required for a population viability analysis (PVA), we determined the best quantitative analysis was a relatively simple “theoretical probability” viability model. This model assumes likelihood of event occurrence based on the proportion of times an independent event can occur given the number of possible outcomes. In this model, population existence is treated as an independent event; in other words, each historical population is assumed to have had equal probability of persistence. In reality, some historical populations had a greater chance of persistence and some had a lower chance, so this is equivalent to assigning each population an average, equal probability. The model also assumes species’ redundancy and representation equally influence the probability of species persistence.
Therefore, we assign a 100% species viability index value to the baseline state of all known historical population occurrences in the U.S being extant. For this model, we do not consider Mexican occurrences because there are only 3 known out of a total of a total of 59, and all are of unknown status. This modeled baseline historical viability level may be less than the actual historical viability level (for example, there were likely more coastal populations prior to urban development), but also may be greater than the viability level required for species persistence. Thus our measure of viability is inversely proportional to, but not necessarily the inverse of, extinction likelihood (i.e. it is an index that changes proportionally with the likelihood of persistence, but is not itself a probability value). As such, our viability measure is an index useful primarily to quantify change in species’ status.

Baseline known historical 100% viability assumes 100% redundancy and 100% representation, and equal influence of each factor. Under 100% historical baseline redundancy, we assume all 59 known occurrences (Table 1) were extant and maximally resilient. That is to say, we assume that on average they were all as large and connected as the smallest, most isolated one in that category today. Although historically populations may not have ever all been extant at the same time, we can assume there were a number of undocumented, extirpated historical populations based on the large amount of fragmented and developed habitat within the Coastal Terraces California Ecological Unit (Figure 6) where a few scattered specimens were historically collected from extirpated occurrences (Table 1). Therefore, we believe attributing higher influence to some known populations than they historically had is reasonable for baseline species viability estimation.

We rated population status for redundancy weight using Marschalek and Deutschman’s (2016a and b) maps and population size ratings, and our assessment of occurrence status and general natural landscape connectivity as visible in satellite imagery (Appendix III). To estimate current redundancy, we rated each occurrence’s resilience on a scale of 0–4; 0 = extirpated (0% resilient), 1 = unknown status (25% resilient), 2 = relatively small and isolated (50% resilient), 3 = relatively small but connected, or relatively large but isolated (75% resilient), 4 = large and connected (100% resilient). We then summed the scores. Under 100% historical baseline
representation, we assume all 56 described occurrences (Table 1) were extant and distributed as mapped (Figure 3).

In order to model species representation, we used California Ecological Units (Goudey and Smith 1994 [2007]) as a measure of habitat diversity. In San Diego County, these units take the form of irregularly shaped bands aligned north to south that change as you move across the county from east to west. Baseline historical 100% representation is equal to 6 occurrences in the Coastal Terraces Ecological Unit (CT), 23 in the Coastal Hills Ecological Unit (CH), 20 in the Western Granitic Foothills Ecological Unit (WGF), and 7 in the Palomar-Cuyamaca Peak Ecological Unit (PC) (Figure 6, Appendix III). Because each unit is given equal representation weight, but has a different number of occurrences, occurrence influence is proportional to historical frequency within each unit. Loss of an occurrence in the CT unit therefore decreases representation by almost four times as much as loss of one within the WGF unit.

Using this model, we estimated current species’ viability relative to historical viability. A 100% Hermes copper butterfly viability rating relative to historical conditions would have a 100% redundancy score of 224 (all 56 U.S. occurrences with a resilience score of 4; contributing half of total viability) and 100% representation score of 56 (all 56 U.S. occurrences extant; contributing the other half of total viability). We estimate there are currently 12 unknown status (total score of 12), 4 small isolated (total score of 8), 7 small connected or large isolated (total score of 21), and 7 large connected (total score of 28) occurrences for a total current species redundancy value of 69 (Appendix III). Based on the resulting redundancy value ratio of 69/224, the species currently retains 31% of its historical population redundancy. CT ecological unit representation has been reduced to 17% (1/6 occurrences not extirpated), CH unit to 48% (11 out of 23 not extirpated), WGF unit to 55% (11 of 20 not extirpated), while the PC unit remains at 100% (7 of 7 not extirpated). Based on these proportional values, the species retains 55% (17+48+55+100/400) of its historical population representation. Therefore we estimate that overall, the species currently retains 43% (55+31/200) of its known historical viability (Appendix III).
Figure 6. Hermes copper butterfly occurrences and California Ecological Units (Goudey and Smith 1994 [2007]) used to calculate percent remaining species representation.
Possible Future Conditions

Given climate change predictions of more extreme weather, less precipitation, and warmer temperatures, and the recent trend of relatively frequent mega-wildfires, we can assume the primary stressors of drought and wildfire will continue to increase in magnitude. If land managers work to conserve and manage all occupied and temporarily unoccupied habitat, and maintain connectivity, this should prevent further habitat loss. Although fire and drought are difficult to control and manage for, natural recolonization and assisted recolonization through translocation in higher abundance years (e.g. Marschalek and Deutschman 2016c) should allow recolonization of extirpated occurrences. We believe that the most likely 30-year future scenario given current trends and projected climate conditions is no change in species viability.

Below we present three potential future scenarios and associated modeled viability measure under 3 simple sets of possible future conditions. We assume the species’ extinction risk was minimal under baseline known historical conditions, and under current conditions it is relatively high (Service 2011, p. 20918).

Conditions worsen, resulting in increased extinction risk
One potential future scenario would be a continued warming, drying trend and an inability to minimize wildfire impacts or assist recolonization. Due to a combination of increased wildfire and drought frequency there are no occurrence habitat patch recolonizations, and loss of all occurrences with a resilience score of less than 4 (without reducing the redundancy weight of based on changed size or isolation status of any remaining populations), resulting in a minimum drop to 12% species viability relative to historical conditions.

Conditions stay the same, resulting in extinction risk staying the same.
While environmental conditions never stay the same, changes that negatively affect populations may be offset by positive ones, including continued habitat conservation and management actions such as translocations to recolonize burned habitats. Habitat recolonizations and increased population resilience are balanced by occurrence extirpations and decreased resilience.
Species viability remains at approximately 43% relative to historical conditions. We believe this is the most likely potential scenario of the three discussed here.

**Conditions improve, resulting in decreased extinction risk**

One potential future scenario would be environmental stressors such as fire and drought do not continue to increase in magnitude and management actions such as continued conservation and translocation efforts are successful and conditions improve. Due to favorable climate conditions and proactive management and conservation, all fire-extirpated occurrence habitats are recolonized (assume average resilience score of 3), no further occurrences are extirpated, and at least half the “unknown status” occurrences are determined to be extant (assume average resilience score of 2), resulting in an increase to 68% species viability relative to historical conditions.

**Chapter 5. Synthesis**

It is clear Hermes copper butterfly has lost significant viability over the past 50 years, with the loss of many populations that have not been recolonized or replaced. While we know fire and drought and climate change are serious stressors that continue to affect species viability, we have much to learn about the species ecology, making the probability of unexpected ecological emergent properties and uncertainty level relatively high. We estimate that the Hermes copper butterfly has lost approximately 43% of its known historical species-level viability. This loss of historical viability is primarily due to a combination of development, and more recently, mega-wildfires. Although climate and wildfire are difficult, if not impossible, stressors to manage for, close to half known occupied or formerly occupied habitat is publicly owned and managed, making range-wide management measures such as assisted recolonization possible. Furthermore, most extant populations are on conserved lands, and more habitat is planned for conservation in the future. Therefore, there is much potential for cooperative, collaborative planning, and decision making under conditions of environmental uncertainty.

**LITERATURE CITED**


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APPENDIX I

- Glossary of Acronyms
- Glossary of Terms
APPENDIX II
Conceptual Model Narrative

In February 2012 the Institute for Ecological Monitoring and Management convened a workshop to help local managers and experts develop conceptual models for five topics of regional importance, including the Hermes copper. The following information is from Strahm et al. (2012, pp. 8–13).

Hermes Copper Butterfly Working Group

1. Alison Anderson, Entomologist, United States Fish and Wildlife Service
2. Douglas Deutschman, Professor of Biology, IEMM, San Diego State University
3. Mark Dodero, Restoration Biologist, RECON
4. David Faulkner, Entomologist, Forensic Entomology Service
5. Keith Greer, Senior Regional Planner, San Diego Association of Governments
6. Daniel Marschalek, Entomologist, California Department of Fish and Game
7. John Martin, Refuge Biologist, United States Fish and Wildlife Service
8. Dave Mayer, Senior Environmental Scientist, California Department of Fish and Game
9. Eric Porter, Biologist, United States Fish and Wildlife Service
10. Jennifer Price, Land Use/Environmental Planner, San Diego County Department of Parks and Recreation
12. Susan Wynn, Biologist, United States Fish and Wildlife Service

Anthropogenic Drivers (referred to stressors in this SSA)

Development/Fragmentation A large portion of the historical Hermes copper range is now developed, diminishing available habitat and increasing fragmentation (USFWS 2011). Hermes copper males do not disperse long distances, and generally do not cross large patches of unsuitable habitat. Although females may have the capacity for long distance dispersal, habitat fragmentation may limit dispersal (including fragmentation caused by conversion of shrub lands into grasslands) (Marschalek and Klein 2010; Marschalek and Deutschman 2008; Deutschman et al. 2010).
Fire  Wildfires cause direct mortality of Hermes copper. Frequent “megafires” (fires of unusually large extent) are especially problematic due to Hermes copper dispersal limitation and the low rate at which the species recolonizes areas (USFWS 2011; Marschalek and Klein 2010).

Road Kill  It is unclear if road kill is a substantial issue for Hermes copper. Given their short dispersal distances and relatively low-flying habit it could potentially be a problem. Marschalek (2004) has observed at least one individual that appeared to have been killed in a collision; however the relative importance of this threat is unknown and at this time seems to be far less important than that of fire (Marschalek and Klein 2010).

Invasive Plants  Invasive plants, particularly non-native grasses, add significant flash fuel to the environment and increase the probability of accidental fires. As a result, these plants may alter the fire regime which can influence Hermes copper distribution by causing local extirpations and change the population structure. 12

Recreation  Recreation involving motorized equipment increases the number of possible ignition sources in Hermes copper habitat, and as a result could impact populations by altering the fire regime.

Argentine Ants  Argentine ants (Linepithema humile) could potentially prey on immature stages of Hermes copper, and as a result could represent an artificially high predator population.

Natural Drivers

Habitat/Vegetation Community  Hermes copper occurs in coastal sage scrub and southern mixed chaparral, utilizing spiny redberry as a host plant for oviposition, larvae, and pupation. Adult Hermes copper show a strong preference for nectaring on California buckwheat, however may utilize other plants occasionally, including chamise (Adenostoma fasciculatum) and tarplants (Deinandra sp.) (Marschalek and Deutschman 2009; Marschalek and Deutschman 2008; Klein pers. com.; USFWS 2011; Thorne 1963; Marschalek pers. obs.).

Predators/Parasitoids  It is unclear if predators or parasitoids on adult butterflies play a significant role in Hermes copper population dynamics. A single observation of a jumping spider feeding on an adult was made by Marschalek in 2010. Other potential predators or parasitoids are unknown.

Climatic Conditions  Timing of emergence (beginning of the flight season) of Hermes copper appears to be influenced by temperature, precipitation, and elevation, although the specifics of this relationship are unknown. In addition, activity on a given day in the flight season is strongly influenced by temperature and cloud cover, with Hermes copper remaining inactive and generally unseen until a temperature of 22°C. Furthermore, Hermes copper tends to prefer the north and west sides of roads and trails for what seem to be purposes of thermoregulation (Marschalek and Deutschman 2008; Marschalek and Klein 2010; Deutschman et al. 2010).
Species Variables

Population Structure Genetic analysis indicates that Hermes copper dispersal is complex. Individuals at the same site do not always pose the most similar genetic composition. At this time genetic analysis suggests that populations at the center of the distribution in the southeast part of the county may be mixing at higher rates, but that there is genetic differentiation of small peripheral sites (Deutschman et al. 2010, 2011).

Adult Female Behavior Hermes copper females may be found in the same open spaces occupied by males, however, upon flushing they fly quickly away and do not generally return. Based on genetic information some long distance dispersal events do occur, however field studies suggest that Hermes copper males typically do not exhibit such movements. Other Lycaena show different behavior between the sexes with females dispersing longer distances than males (Deutschman et al. 2010; USFWS 2011).

Reproduction and Oviposition Most of the Hermes copper life cycle is achieved on spiny redberry, including oviposition, larval feeding, and pupation. Eggs are approximately one millimeter in diameter, generally positioned on the underside of relatively new growth, often near an intersection with another branch or leaf. It is unclear what degree of habitat selection is occurring by females, prior to oviposition (Thorne 1963; Marschalek and Deutschman 2009).

Dispersal and Gene Flow Hermes copper males appear to move only short distances (Marschalek and Deutschman 2008; Marschalek and Klein 2010), but females may engage in long-distance dispersal (Deutschman et al. 2010, 2011). Evidence suggests that long-distance dispersal occurs within the central region of their distribution in the southeastern portion of San Diego County, but that peripheral populations are more isolated (Deutschman et al. 2010, 2011).

Male Behavior Hermes copper males only make small movements in the process of defending territory. Even when spooked they usually return to the same area after a few minutes. Males are much more frequently encountered compared to females (Thorne 1963).

Eggs The location that females choose to oviposit could be crucial for understanding what constitutes high quality habitat. This information could be used to determine if unoccupied sites with spiny redberry are simply unoccupied, or if there is some crucial factor that makes them unsuitable. In addition reproductive success is critical for maintaining the species. It is unclear if eggs are subject to predation or other stressors.

Larvae Very little is known about the biology of Hermes copper larvae. This stage could be sensitive to a number of environmental stressors, predation and parasitism. The transition from egg to larvae is the part of the lifecycle limiting our ability to rear Hermes copper in a laboratory setting.
Pupae  Very little is known about the placement and phenology of Hermes copper pupae other than that pupation occurs on spiny redberry plants.

Adults  Hermes copper adults are small, but boldly colored butterflies. Although they are easy to spot much remains unknown about their biology.
APPENDIX III
Information Used in Species Viability Model

Ecological units (see Figure 6 above) were from polygons from Goudey and Smith 1994 [2007]: “Ecological types are classified and ecological units are mapped based on associations of those biotic and environmental factors that directly affect or indirectly express energy, moisture, and nutrient gradients which regulate the structure and function of ecosystems. These factors include climate, physiography, water, soils, air, hydrology, and potential natural communities.” Occurrences with polygons mapped in more than one unit were counted as occurring the the unit encompassing the majority of the polygon. Units are described moving from west-to-east as “coastal,” “inland,” “foothills,” and “mountains.” Population “size” was based on average maximum daily adult count of extant populations (not area of occupancy; see Marschalek and Deutschman 2016a and b information below). All monitored sentinel site occurrences were classified as “large,” as well as McGinty Mt. All other extant occurrences were classified as “small. To calculate percent species representation, percent populations extant within each Ecological Unit are converted to unitless values, summed, and divided by 400 (% representation = CT + CH + WGF + PC / 400). To calculate percent species viability, percent remaining representation and redundancy are converted to unitless values, summed, and divided by 200 (viability = representation + redundancy / 200).

As described in the text above, we rated population-level resilience based on a population’s size rating (as a measure of population-level redundancy and representation) and connectivity (as a measure of population-level redundancy and representation). The size is assumed to be typical relative to other populations and given current environmental conditions, and therefore representative of relative population-level redundancy. Larger populations are also more likely to be genetically diverse. Connectivity of habitat to extant populations increases the likelihood of immigration and recolonization, therefore effectively increasing population-level redundancy. Connectivity also increases the likelihood of genetic mixing among populations through immigration, therefore increasing population representation.
**Table 1.** Occurrence list with status information for species viability model.

<table>
<thead>
<tr>
<th>Map #</th>
<th>Occurrence name (other names)</th>
<th>Presumed Status</th>
<th>Resilience rating¹</th>
<th>Ecological Unit²</th>
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<tbody>
<tr>
<td>1</td>
<td>Lopez Canyon</td>
<td>Extant</td>
<td>2</td>
<td>CT</td>
</tr>
<tr>
<td>2</td>
<td>Mira Mesa</td>
<td>Extirpated</td>
<td>0</td>
<td>CT</td>
</tr>
<tr>
<td>3</td>
<td>Kearny Mesa</td>
<td>Extirpated</td>
<td>0</td>
<td>CT</td>
</tr>
<tr>
<td>4</td>
<td>Mission Valley (Fairmont Canyon, Canyons near Mission Valley)</td>
<td>Extirpated</td>
<td>0</td>
<td>CT</td>
</tr>
<tr>
<td>5</td>
<td>Dictionary Hill</td>
<td>Extirpated</td>
<td>0</td>
<td>CT</td>
</tr>
<tr>
<td>6</td>
<td>South Otay Mesa</td>
<td>Extirpated</td>
<td>0</td>
<td>CT</td>
</tr>
<tr>
<td>7</td>
<td>Bonsall</td>
<td>Extirpated</td>
<td>0</td>
<td>CH</td>
</tr>
<tr>
<td>8</td>
<td>San Elijo Hills (San Marcos Creek, San Elijo Road and Questhaven Road)</td>
<td>Extirpated</td>
<td>0</td>
<td>IL</td>
</tr>
<tr>
<td>9</td>
<td>Elfin Forest (Onyx Ridge).</td>
<td>Extant</td>
<td>2</td>
<td>CH</td>
</tr>
<tr>
<td>10</td>
<td>Lake Hodges</td>
<td>Extirpated</td>
<td>0</td>
<td>CH</td>
</tr>
<tr>
<td>11</td>
<td>Rancho Santa Fe (Del Dios)</td>
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<td>CH</td>
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<td>Van Dam Peak (Meadowbrook)</td>
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<td>16</td>
<td>North Santee (Fanita Ranch)</td>
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<td>19</td>
<td>Mission Trails (Mission Gorge, Mission Dam)</td>
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<tr>
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<td>22</td>
<td>San Diego State University (San Diego State College)</td>
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</tr>
<tr>
<td>23</td>
<td>North McGinty Mountain</td>
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</tr>
<tr>
<td>24</td>
<td>South McGinty Mountain</td>
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<td>CH</td>
</tr>
<tr>
<td>25</td>
<td>Rancho San Diego</td>
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<td>CH</td>
</tr>
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<td>Los Montanas</td>
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<td>CH</td>
</tr>
<tr>
<td>27</td>
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</tr>
<tr>
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<td>CH</td>
</tr>
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<td>29</td>
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<td>CH</td>
</tr>
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<td>---</td>
</tr>
<tr>
<td>30</td>
<td>Pala</td>
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<td>WGF</td>
</tr>
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<td>Sycamore Canyon</td>
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<td>WGF</td>
</tr>
<tr>
<td>32</td>
<td>BLM Truck Trail</td>
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<td>WGF</td>
</tr>
<tr>
<td>33</td>
<td>Willows (Viejas Grade Road)</td>
<td>Extirpated</td>
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<td>WGF</td>
</tr>
<tr>
<td>34</td>
<td>Crestridge</td>
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<td>WGF</td>
</tr>
<tr>
<td>35</td>
<td>Alpine (Wright’s Field)</td>
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</tr>
<tr>
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<td>Japutal (Japutal Valley)</td>
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<td>Loveland Reservoir</td>
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<td>Sycuan Peak</td>
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<td>4</td>
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<td>East McGinty Mountain</td>
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</tr>
<tr>
<td>41</td>
<td>Lawson Valley (Lawson Peak)</td>
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<td>WGF</td>
</tr>
<tr>
<td>42</td>
<td>Skyline Truck Trail (Lawson Valley)</td>
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<td>4</td>
<td>WGF</td>
</tr>
<tr>
<td>43</td>
<td>Lyons Peak</td>
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<td>WGF</td>
</tr>
<tr>
<td>44</td>
<td>Hollenbeck Canyon</td>
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<td>1</td>
<td>WGF</td>
</tr>
<tr>
<td>45</td>
<td>Hartley Peak, Potrero Peak (Portrero)</td>
<td>Extant</td>
<td>2</td>
<td>WGF</td>
</tr>
<tr>
<td>46</td>
<td>Deerhorn Valley</td>
<td>Extirpated</td>
<td>0</td>
<td>WGF</td>
</tr>
<tr>
<td>47</td>
<td>Dulzura (Near Marron Valley Road)</td>
<td>Extirpated</td>
<td>3</td>
<td>WGF</td>
</tr>
<tr>
<td>48</td>
<td>Otay Mountain (Little Cedar Canyon, Otay foothill)</td>
<td>Extirpated</td>
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<td>WGF</td>
</tr>
<tr>
<td>49</td>
<td>Tecate Peak</td>
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</tr>
<tr>
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<td>Boulder Creek Road</td>
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<td>3</td>
<td>PC</td>
</tr>
<tr>
<td>51</td>
<td>North Guatay Mountain</td>
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<td>1</td>
<td>PC</td>
</tr>
<tr>
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<td>Pine Valley</td>
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<td>PC</td>
</tr>
<tr>
<td>53</td>
<td>North Descanso (Wildwood Glen, Descanso)</td>
<td>Extant</td>
<td>3</td>
<td>PC</td>
</tr>
<tr>
<td>54</td>
<td>South Guatay Mountain</td>
<td>Extant</td>
<td>4</td>
<td>PC</td>
</tr>
<tr>
<td>55</td>
<td>South Descanso (Roberts Ranch)</td>
<td>Extant</td>
<td>3</td>
<td>PC</td>
</tr>
<tr>
<td>56</td>
<td>Corte Madera</td>
<td>Extant</td>
<td>1</td>
<td>PC</td>
</tr>
</tbody>
</table>

1 0 = extirpated (0% resilient), 1= unknown status (25% resilient), 2 = relatively small and isolated (50% resilient), 3 = relatively small but connected, or relatively large but isolated (75% resilient), 4 = large and connected (100% resilient).

2 CT= Coastal Terraces; CH= Coastal Hills; WGF = Western Granitic Foothills; PC = Palomar-Cuyamaca Peak. Used to rate species’ redundancy.

3 One adult observed after 2015 translocation.
Marschalek and Deutschman maps (2016a and b) and table (2016b)

This information illustrates the loss of populations/occurrences due to wildfire (especially in 2003 and 2007), and the slow rate of recolonization (4-9 years).

Table 2. Maximum counts of Hermes copper adults at four sentinel sites and an additional site that received frequent visits, 2010-2016. Sampling at sentinel sites consisted of repeated transects to obtain an accurate maximum count. Sampling at the Skyline Truck Trail site was focused on locating females and did not follow a strict protocol for determining the number of Hermes copper present.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Boulder Creek</td>
<td>---</td>
<td>---</td>
<td>18</td>
<td>29</td>
<td>17</td>
<td>6</td>
<td>11</td>
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<tr>
<td>Lawson Peak</td>
<td>2</td>
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<td>2</td>
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<tr>
<td>Roberts Ranch North</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>8</td>
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<td>3</td>
</tr>
<tr>
<td>Sycuan Peak</td>
<td>12</td>
<td>27</td>
<td>14</td>
<td>41</td>
<td>11</td>
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<td>1</td>
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<td>Other Visited Site</td>
<td></td>
<td></td>
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<tr>
<td>Skyline Truck Trail 1</td>
<td>9</td>
<td>---</td>
<td>7</td>
<td>6</td>
<td>7</td>
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<td>Skyline Truck Trail 2</td>
<td>---</td>
<td>---</td>
<td>12</td>
<td>27</td>
<td>9</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

" --- " Indicates no survey

Table 3. Hermes copper survey data from sites that experienced wildfires in 2003 and/or 2007.

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Crestline ER</td>
<td>47</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Anderson Road</td>
<td>70</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>Wildwood Glen Lane</td>
<td>13</td>
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<td>0</td>
<td>0</td>
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<tr>
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<td>---</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
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<td>42</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Rancho Jamul ER (2004)</td>
<td>---</td>
<td>10</td>
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<td>0</td>
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</tr>
</tbody>
</table>

Notes:

" --- " Indicates no survey

[4] Numbers in parentheses include those observed, but not on the historical transect.

[5] Data from John Martin (USFWS)
[6] Translocation project to reintroduce Hermes copper

Survey efforts were similar from 2003-2012 at each site if sampled (see note below)

but efforts (transect length) increased at some sites in 2012.

At Hollenbeck Canyon WA, survey efforts were similar in 2005, 2007, 2013, and 2016, but reduced in 2006.
Figure 1. Detections of Hermes copper butterflies on conserved lands, 2010-2013. Sampling locations where Hermes copper was not detected are represented by black diamonds. Small and large Hermes copper populations are indicated by different sized circles.
Figure 2. Map of 2016 northern Hermes copper population survey sites with an inset of San Diego County. Purple and black circles represent extant populations and extirpated populations, respectively. Blue circles denote sites of unknown status and black x's mark sites that have suitable habitat but have never been known to have Hermes copper populations. Green shading are conserved lands (SANDAG) and dark gray shading maps the footprints of the 2003 and 2007 wildfires.
Figure 2. Map of 2016 southern Hermiss copper population survey sites with an inset of San Diego County. Purple and black circles represent extant populations and extirpated populations, respectively. Rhodocorus denote sites of unknown status. Green shading are conserved lands (SANDAG) and dark gray shading maps the footprints of the 2003 and 2007 wildfires.
Appendix IV

2017 Fire Hazard Map for San Diego County

Screenshot from Ready San Diego website on February 2, 2017.