Species Status Assessment for the Callippe Silverspot Butterfly (*Speyeria callippe callippe*) Version 1.0

July 2020
U.S. Fish and Wildlife Service
Region 10
Sacramento, California

EXECUTIVE SUMMARY

This report summarizes a Species Status Assessment (SSA) completed for the callippe silverspot butterfly (*Speyeria callippe callippe*). The callippe silverspot butterfly is a medium-sized butterfly subspecies that occurs in grasslands and associated habitats in the San Francisco Bay Area. To assess the species' viability, we used the three conservation biology principles of resiliency, redundancy, and representation (together, the 3 Rs). We analyzed the current and future condition at the population level to assess population resiliency, and discussed the representation and redundancy of species as a whole to assess current and future viability. We identified 4 extant metapopulations (used interchangeably with populations) that were assessed in this analysis. There are also several extirpated populations discussed in the report.

Our analysis of the past, current, and future factors influencing viability in the callippe silverspot butterfly revealed that there are several factors that contribute to the current condition and pose a risk to future viability of the species. The primary threat at the time of listing was loss and degradation of habitat from human activities, which continues to threaten the species. Habitat development and fragmentation was a historical threat to habitat which continues to threaten the species on private land. Additional threats to habitat include competition with non-native species and encroachment with native shrubs that influences grassland habitat for the species, limiting host and nectar plants used by the species as well as limiting larval movement. Other current threats include fire, pesticide use, and factors associated with small population sizes. Ongoing conservation and management actions or factors positively influencing resiliency include land protection, grazing, and removal of non-native species and scrub habitat.

Resiliency of populations was measured by assessing habitat factors (contiguous grassland size, residual dry matter, California golden violet (*Viola pedunculata*), and nectar plants) and one demographic factor (adult abundance). We analyzed the current condition of callippe silverspot populations relative to these factors, then translating this into an overall condition score for each population. We assessed these scores across the range of the species to evaluate species representation and redundancy. Under current conditions, there is one population in moderate condition and three populations in low condition.

The rates at which future threats may act throughout the species' range, and the long-term efficacy of current management actions, are unknown. Although it is likely that climate change will change temperature, coastal fog, and precipitation levels in areas occupied by callippe silverspot butterflies, it is unclear at on what time scale these affects will begin to have noticeable impacts for the species. Instead, the most likely influence to viability associated with climate change may be an increased change of wildfire. However, the likelihood of a significant fire affecting any given population is difficult to predict, and we did not carry that risk forward in our future condition analysis. We used the best available science to predict how future conditions could influence the resiliency, redundancy, representation, and overall condition of the callippe silverspot butterfly under two future plausible scenarios, which are evaluated on a time frame of

approximately 30 years (through 2050). The following is a description of the two future scenarios and the status of the species when analyzed under each scenario:

The first scenario assumes "business as usual." We assume that management practices (including grazing, habitat management, etc.) are maintained at current levels and that threats to the species also continue at current levels. In the second scenario, we assume that management continues or increases from current levels. This has the potential to counteract some of the current threats to the species. For example, in Scenario 1 we acknowledge that deteriorating conditions for the Sears Point population could lead the species to become extirpated at that site, but in Scenario 2 we assume that prioritizing management to increase nectar sources and reduce thatch could increase conditions at that site. In Scenario 1, one population drops down to becoming possibly extirpated. In Scenario 2, three populations rise in condition and one populations maintain their current condition level.

County	Population	Current Condition	Scenario 1 Condition	Scenario 2 Condition
San Mateo	**San Bruno Mountain**	Moderate	Moderate	High
Solano	**Ferrari Ranch**	Low	Low	Low
	Cordelia Hills	Low	Low	Moderate
Sonoma	**Sears Point**	Low	Low/Extirpated	Moderate

Even under the "business as usual" scenario, the continuation of management activities on protected lands is important in maintaining the current condition for three of the populations. The main difference between outcomes of the scenarios depends on a successful increase in habitat restoration techniques or implementation. We think that Scenario 2, or a combination of the two scenarios, is most likely to occur.

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Chapter 1. Introduction

This report summarizes the analytical phase of a Species Status Assessment (SSA) for the callippe silverspot butterfly (*Speyeria callippe callippe*). The callippe silverspot butterfly is a medium-sized subspecies of butterfly found in central California grasslands. From here on within this document, when referring to the callippe silverspot butterfly we use the terms "species" and "subspecies" interchangeably depending on the context, based on the definition of species in the Endangered Species Act, as amended (Act).

The SSA framework uses the three biological principles of resiliency, representation, and redundancy to assess the species viability, or its ability to persist over time. To do so, we present a synthesis of our current understanding of the species' ecology and the factors that influence it, to evaluate the current status, and to predict the future status of its resources and condition. This report is intended to provide biological support for a status review and the Recovery Plan for the callippe silverspot butterfly, and as such does not represent an opinion or decision by the U.S. Fish and Wildlife Service (Service). Instead, the document provides a review of the best available information related to the biological status of the callippe silverspot butterfly.

Federal History

The callippe silverspot butterfly was listed as endangered in 1997 (Service 1997) after several previously proposed rules to list the species and critical habitat in 1978 and 1980. There has been one status review of the species since its listing (Service 2009a).

The Species Status Assessment Framework

This report is a summary of the Species Status Assessment analysis, which entails three iterative assessment stages (Figure 1):

Species Ecology. An SSA begins with a compilation of the best available biological information on the species (taxonomy, life history, and habitat) and its ecological needs at the individual, population, and species levels based on how environmental factors are understood to act on the species and its habitat.

Current Species Condition. Next, an SSA describes the current condition of the species habitat and demographics and the probable explanations for past and ongoing changes in abundance and distribution within the species ecological settings (i.e. areas representative of the geographic, genetic, or life history variation across the species range).

Future Species Condition. Lastly, an SSA forecasts the species response to probable future scenarios of environmental conditions and conservation efforts. As a result, the SSA characterizes species ability to sustain populations in the wild over time (viability) based on the best scientific understanding of current and future abundance and distribution within the species ecological settings.

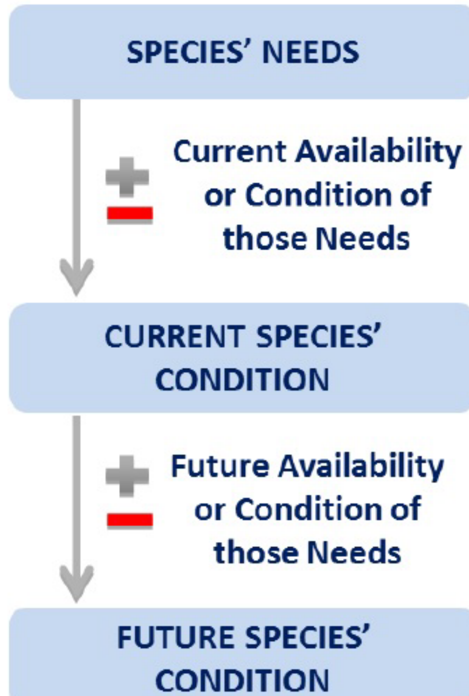

Figure 1. Species status assessment framework (Source: USFWS 2016, p. 6)

Throughout the assessment, the SSA uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs") as a lens to evaluate the current and future condition of the species. Representation describes the ability of a species to adapt to changing environmental conditions, which is related to the breadth of genetic and ecological diversity within and among populations. Resiliency describes the ability of the species to withstand stochastic disturbance events, an ability that is associated with population size, growth rate, and habitat quality. Redundancy describes the ability of a species to withstand catastrophic events, an ability that is related to the number, distribution, and resilience of populations. Together, the 3Rs—and their core autecological parameters of abundance, distribution, and diversity—comprise the key characteristics that contribute to a species ability to sustain populations in the wild over time. When combined across populations, they measure the health of the species as a whole.

Summary of New Information

In addition to the information in our files and in conjunction with prior federal actions for this species (e.g., the Recovery Plan and Status Review), we collected information for this analysis from a variety of sources. Our main sources of new information were reports from partner agencies monitoring populations of callippe silverspot butterflies and a recent report on population genetics and the development of a genetics management plan (Hill 2018, entire). These data are presented in the *Genetics, Range and Distribution*, and *Life History* sections of the report.

Uncertainties and Assumptions

This report incorporates the best available information through reports, peer-reviewed literature, and communication with species experts. Use of the name "callippe silverspot butterfly" refers to *Speyeria callippe callippe*. When information is not available at the species level, we sometimes use surrogate species, but are always careful to make this clear throughout the report. Information on other *Speyeria* butterflies are frequently presented. We use *Speyeria callippe* when information refers to the overarching species rather than the specific subspecies *S. c. callippe*.

Chapter 2. Background

Taxonomy

Butterflies in the genus *Speyeria* are commonly known as silverspots or fritillaries. The genus *Speyeria* has at least 16 species and over 100 subspecies (Sims 2017, p. 1; Thompson *et al.* 2019, pp. 7-10), and many of these species exhibit a high level of intraspecific phenotypic variation (members of a species may appear different from other members of the same species). For this reason, the taxonomy of some *Speyeria* species has been subject to revision, with the genus at one point having over 100 species (dos Passos and Grey 1947, p. 1). However, the taxonomic status of the callippe silverspot butterfly (*Speyeria callippe callippe*) has not changed since listing (Table 1). The callippe silverspot butterfly was described by Jean Boisduval as *Argynnis callippe* (Boisduval 1852), referring to specimens collected by Pierre Lorquin in an unknown year in San Francisco, California (dos Passos and Grey 1947, p. 14). Because the genus *Argynnis* is restricted to the Old World, and the genus *Speyeria,* is found only in North America (dos Passos and Grey 1945), the butterfly described as *Argynnis callippe* is now considered *Speyeria callippe*.

Table 1. Callippe silverspot butterfly taxonomy

Class	Order	Family	Subfamily	Genus	Species	Subspecies
Insecta	Lepidoptera	Nymphalidae	Argynninae	Speyeria	callippe	callippe

Although the taxonomic status of the callippe silverspot butterfly has not changed, the taxonomic identity of *Speyeria callippe* and its subspecies has been the subject of debate. Arnold (1983, entire; 1985, entire) presented a revision of the subspecies of *Speyeria callippe* based on quantitative analysis of quantitative and qualitative wing characteristics. Because he failed to detect concordant geographic variation in these characteristics, he limited his taxonomic description to the color of the ventral disc only (Arnold 1985, p. 5). His revised taxonomy lumped 10 of the previously recognized subspecies of *Speyeria callippe* (including the callippe silverspot butterfly) under the subspecies name *Speyeria callippe callippe*, and reduced the number of *Speyeria callippe* subspecies to 3 from the 16 accepted at the time (Arnold 1983; Arnold 1985). However, numerous amateur and professional lepidopterists have rejected the revision (Hammond 1985, entire; Murphy 1990, pp. 17-18). Hammond (1985) presented a detailed critique of the revision and its methodology, questioning the choice of characteristics and the philosophic approach to taxonomy that Arnold (1985) had relied on. In a report on rare California butterflies, Murphy (1990, p. 18) stated that he did not know of any lepidopterists (experts on butterfly biology) who accepted Arnold's (1985) taxonomy of *Speyeria callippe* (but see Grey 1989, p. 7).

GENETICS

Speyeria butterflies have traditionally been classified based on phenotypic characters including wing morphology or genitalia, but recent molecular analyses have provided more insight into genetic relationships and uniqueness within the genus. Recent phylogenetic and population genomic analyses confirmed the monophyletic (descended from a common ancestor) nature for the genus *Speyeria* (de Moya *et al.* 2017, p. 640) and the 16 canonical species (Thompson *et al*. 2019, pp. 4-11). Although five of the ten species with multiple taxa sampled were monophyletic in this analysis, *Speyeria callippe* was either paraphyletic (descended from a common ancestor, but not including all of the descendant groups) or polyphyletic (derived from more than one common ancestor) depending on the analytical method (de Moya *et al.* 2017, p. 641). Previous phylogenetic studies on the genus *Speyeria* have had less support for *Speyeria* species and subspecies, which suggests that the evolutionary history of *Speyeria* butterflies may be recent (Brittnacher *et al.* 1978, entire; McHugh *et al.* 2013, p. 1239-1246). Possible explanations for lack of clarity in earlier genetic studies or discordance between mitochondrial and nuclear DNA include improper species definitions, incomplete lineage sorting, or hybridization between and within species (McHugh *et al*. 2013, pp. 1246-1247). Hammond *et al.* (2013, p. 267) conducted hybridization studies on the genomic compatibility and phenotypic expression for many of the species within the genus and found that most of the species within the *callippe* species group (i.e., *S. callippe*, *S. egleis*, *S. atlantis*, *S. hydapse*, *S. zerene*, *S. mormonia*, *S. hollandi*, *S. sorocko*, *S. edwardsii*, and *S. coronis*) can be hybridized using hand-pairing. Hammond *et al.* (2013, p. 265) speculate that reproductive isolation among the various species in the genus results from species-specific pheromones in both males and females that are used during courtship, and that hybrid mating is rare despite observations of interspecific courtship.

Hill (2018, entire) used multiple genetic markers to investigate the population genetics of *Speyeria callippe* in the California Coast Ranges across 28 locations, including genome wide restriction associated DNA (RADseq) data and mitochondrial DNA (mtDNA). A separate paper (Hill *et al.* 2018a, entire) presenting only mtDNA data used DNA barcoding of the mitochondrial gene *cytochrome oxidase subunit I (CoI)* to separate Bay Area *Speyeria* species, recovered each species, including *S. callippe*, but found that *S. callippe* subspecies did not cluster separately using this analysis method. In this analysis, comparisons between *S. c. callippe* and *S. c. comstocki* or *S. c. liliana* sometimes showed no differences (P-distance 0.000) between individuals (as identified by morphology). Because single loci had limited resolution for resolving differences between Bay Area *Speyeria* subspecies, Hill (2018) took a population genetics approach using RADseq data. Admixture analysis among the populations showed strong evidence that callippe silverspot butterfly is a genetically distinct subspecies (Hill 2018, pp. 9-14). Using the method of Evanno *et al.* (2005, entire), the optimal number of clusters supported three genetic groups within Bay Area *Speyeria callippe* (North Coast Ranges, Solano populations, and South Coast Ranges). The Solano populations comprised *Speyeria callippe callippe* with well-defined population structure (Hill 2018, pp. 18, 31). There was also good support for additional clusters using the Evanno method, with both San Bruno Mountain and Sears Point populations recognized as having distinct populations (Hill 2018, p. 14). Populations at these locations had less diversity in mitochondrial DNA than other populations, which is consistent with their isolated locations (Hill 2018, p. 31). Together, these analyses demonstrate that callippe silverspot butterfly populations in Solano County, Sears Point (Sonoma County), and San Bruno Mountain (San Mateo County) were distinct from other neighboring populations including Green Valley Ranch (Napa County) and the Diablo Range populations (Contra Costa County) (Hill 2018, p. 14). Notably, these data found that butterflies from some populations that have been previously phenotypically identified as callippe silverspot butterflies instead show more mixing with Comstock's silverspot butterfly (*Speyeria callippe comstocki*). Populations in Contra Costa, Alameda, and Santa Clara Counties were more closely associated with Comstock's silverspot butterfly in the genetic analyses despite phenotypic similarities with callippe silverspot butterflies (Hill 2018, pp. 13-14, 31-3).

In summary, we consider the current range of the callippe silverspot butterfly to follow results from the recent genetic study (Hill 2018, entire), with populations in San Bruno Mountain (San Mateo County), Sears Point (Sonoma County), and multiple populations in Solano County. Because of similarity between *Speyeria callippe* subspecies, phenotypic variation within populations, and potential for genetic intercrossing, subspecific status is best determined at the population level rather than the individual level. For example, butterflies in the San Bruno and Solano populations that were genetically identified as callippe silverspot butterflies had varying phenotypes that resembled callippe, as well as *comstocki* and *callippe* X *comstocki* intercross butterflies (Hill pers. comm. 2018).

SPECIES DESCRIPTION

The callippe silverspot butterfly is a medium sized butterfly in the brush-footed family (Nymphalidae). It has a wingspan of approximately 5.5 centimeters (2.2 inches) (Coast Range Ecology 2009, p. 24; Hammond 1985, p. 204; Howe 1975, p. 233). In the type specimen, and other specimens collected from the San Francisco Peninsula, the upper wings are brown with extensive black spots and lines, and the basal areas are extremely melanic (dark-colored). Wing undersides are brown, orange-brown, and tan with black lines and distinctive black and bright silver spots. Basal areas of the wings and body are densely pubescent (hairy) (Service 2009a, p. 1). Comstock's silverspot butterfly larvae and pupae are described and photographed from specimens grown in captivity in Zaman *et al.* 2014 (pp. 35-37), and we assume that callippe silverspot butterflies have the same phenotype.

There is not a published key for the *Speyeria* genus, and only experts are able to reliably identify individuals (Pyle 2002, p. 262); even experts often require knowledge of the geographic region from which a specimen was collected in order to identify the species and/or subspecies (McHugh *et al.* 2013, p. 1237-8). Indeed, in the Bay Area, a field guide notes that "even many experienced observers are unable to determine whether some individuals are Callippe or Coronis Fritillaries" at the species level (Glassberg 2001 in Thompson *et al*. 2019, p. 2), let alone make subspecific determinations. Two subspecies within the *Speyeria callippe* complex occur in proximity to the callippe silverspot butterfly: Comstock's silverspot butterfly (*S. c. comstockii*) occurs to the south and east of the historical range of the callippe silverspot butterfly, and the Lilian's silverspot butterfly (*S. c. liliana*) occurs to the north of the callippe silverspot butterfly in and around the Napa Valley (Pelham 2008, pp. 314-315). There is extensive variation and overlap in phenotypic characteristics among these subspecies (see Coast Range Ecology 2009, p. A-1, for representative pictures of *S. c. callippe*, *S. c. liliana*, and *S. c. comstocki*, as well as photos showing the degree of similarity across some specimens). The type specimen of another subspecies of silverspot butterfly, *Speyeria zerene sonomensis,* was collected from Sears Point in Sonoma County and occurs in sympatry with callippe silverspot butterflies in this area (Emmel *et al.* 1998, pp. 455-456; Hill *et al*. 2018a, pp. 3-5).

RANGE AND DISTRIBUTION

There are no definitive geographic boundaries separating the callippe silverspot butterfly from Comstock's or Lilian's silverspot butterflies, and there is extensive variation in phenotype within populations. Currently, the Service considers the range of the callippe silverspot butterfly to follow results from the most recent genetic study (Hill 2018, entire), with populations in San Bruno Mountain (San Mateo County), Sears Point (Sonoma County), and at least four populations in Solano County (Figure 2; see *Genetics* above). The historical range also included populations in San Francisco County (e.g., Twin Peaks) and Joaquin Miller Park in Alameda County, which are now extirpated and were not included in the genetic study (62 FR 64306; Service 2009a, p. 5). As described in Hill 2018 (p. 14), the distribution is similar to a backwards "C" surrounding the Bay Area; this area coincides with areas in the Bay Area fog belt (Figure 2).

Historically, specimens that were phenotypically identified as callippe silverspot butterflies come from 8 counties (Alameda, Monterey, San Francisco, San Mateo, Santa Clara, Solano, Sonoma, and Stanislaus) and as intermediates between callippe and adjacent silverspot butterflies from 4 more (Contra Costa, Marin, Napa, and San Benito) (Brittnacher *et al.* 1978, p. 200; GBIF.org; Hammond 1985, p. 206; Hill *in litt.* 2018; Howe 1975, pp. 232-233; Mattoon 1992, pp. 4-10; Savage 2013, p. 16). Here, we briefly summarize historical observations in the context of our current understanding of the callippe silverspot range throughout four geographic areas: North Bay, San Francisco Peninsula, East Bay, and southern Bay Area, including all locations south of San Mateo County.

North Bay

Populations of callippe silverspot butterflies are known from Sears Point and from a complex of populations in Solano County. A population at Green Valley Ranch in Napa County, north of the Solano County populations, has too much genetic admixture with more northern populations (i.e., Lilian's silverspot butterflies) to be included within callippe silverspot butterflies (Hill 2018, p. 14).

San Francisco Peninsula

At the time of listing, callippe silverspot butterflies had already been extirpated from the type locality (Twin Peaks in San Francisco County) (62 FR 64306). Re-establishing a population at Twin Peaks would add redundancy for the species, but would not increase representation because the population would need to be sourced from another site. Although there is still protected open space at the Twin Peaks Natural Area, the area is surrounded by housing and it is unclear if there is sufficient available habitat to support a resilient population of callippe silverspot butterflies.

A population at San Bruno Mountain in San Mateo County is genetically distinct from other callippe subspecies, and is recognized as callippe silverspot butterfly in the most recent genetic study (Hill 2018, p. 14).

The range of callippe silverspot butterflies at the time of listing extended south to La Honda (Mattoon 1992). However, this locality was not included in Mattoon's collection sheets and we are not aware of specific historical or current observations between San Bruno Mountain and La Honda.

East Bay

The population at Joaquin Miller Park in northwestern Alameda County, recognized at the time of listing as belonging to callippe silverspot butterflies, has been subsequently extirpated (Service 2009a). This locality falls within the fog belt of the San Francisco Bay Area (Torregrosa *et al.* 2016, pp. 53-54)) (Figure 2), which is correlated with the melanic phenotype characteristic of the callippe silverspot butterfly.

Current populations of *Speyeria callippe* butterflies in Contra Costa County at Mount Diablo, in Alameda County at Mines Road County Park, the Pleasanton Golf Course, Ohlone West Conservation Bank, Wauhab Ridge, Camp Ohlone, and Oak Ridge Road, and in Santa Clara County at Joseph Grant Park, all genetically group with Comstock's silverspot butterflies (Hill 2018, pp. 12-14). These populations each have some individuals that have phenotypic characteristics similar to callippe silverspot butterflies (Hill *in litt*. 2018), but there are only trace levels of admixture with the San Bruno Mountain population of callippe silverspot butterflies (Hill 2018, p. 13). Although these populations are in the same level IV ecoregion (East Bay Hills/Western Diablo Range; Griffith *et al.* 2016, p. 17) as Joaquin Miller Park and the Solano County populations of callippe silverspot butterflies, they are in areas that have much less fog influence than those populations genetically identified as callippe silverspot butterflies (Figure

2). We therefore consider these populations to be most consistent with Comstock's silverspot butterflies.

Although there are some open spaces in the fog belt of northwestern Alameda County (e.g., Joaquin Miller Park, Redwood Regional Park, and potentially Leona Canyon Regional Open Space Preserve), it is unclear if these areas have sufficient amounts of suitable grassland habitat to support callippe silverspot butterfly populations. Although re-establishing populations in these locations would add to redundancy of the species, it would not increase genetic representation because butterflies would need to be sourced from existing populations in other areas.

Southern Bay Area Coast (South of San Mateo County)

Butterflies included in the genetic study from Monterey, San Benito, and Monterey Counties were all consistent with Comstock's silverspot butterflies (Hill 2018, p. 13). Substructure within the South Bay butterfly samples in the study showed one genetic cluster in the Diablo Range samples (the East Bay populations discussed above) geographically separated from a second genetic cluster south of the Hamilton Range (Hill 2018, pp. 18-19).

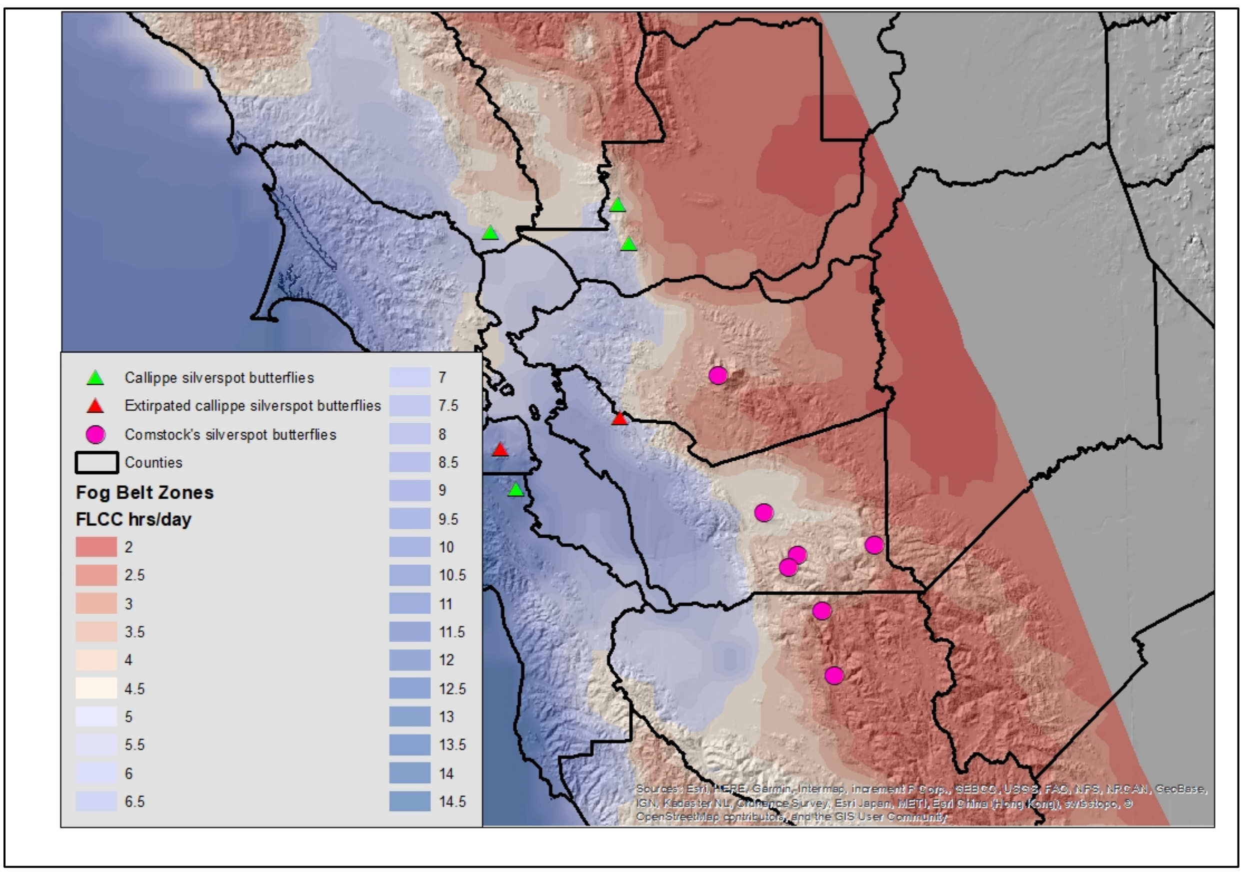

Figure 2. Callippe silverspot butterfly extant and extirpated populations. Nearby populations genetically similar to Comstock's silverspot butterflies are also shown. Although some individual butterflies in the Diablo Range can strongly resemble callippe silverspot butterflies, butterflies sampled from this region showed more mixing with Comstock's silverspot butterflies. Callippe silverspot butterfly populations generally occur in a "C" shaped pattern around the Bay Area that corresponds to areas with more hours of fog per day.

Chapter 3. Species Ecology and Needs

In this chapter, we provide biological information about the callippe silverspot butterfly, including its taxonomic history and genetic relationships, morphological description, life history traits, and individual and population habitat needs. For the purposes of this SSA, we define a population of callippe silverspot butterflies as a group of male and female butterflies in a large area of suitable habitat containing all essential features (listed in *Individual and Population Habitat Needs* below) within 2 km (1.2 miles) of each other. This distance was chosen based on observations of individuals traveling at least 1.6 km (0.99 mi) to visit preferred nectar sources (Arnold 2007, p. 11), with the assumption that individuals may travel slightly further than the observed distance.

LIFE HISTORY

Callippe silverspot butterflies are sedentary (non-migratory), and one or more of the life stages are present within suitable habitat patches year-round. They are univoltine (having one generation per year), and undergo complete metamorphosis (a structural transformation during the development of an organism) from egg to larva, pupa, and adult stages. Adults emerge in early summer and lay eggs, eggs hatch into larva and remain in this state until the following spring, and then pupate in late spring or early summer (Figure 3, Table 2).

On average, adults are seen from mid-May to mid-July (Service 2009a, p. 1), with an average lifespan of 4.9 days for adult males and 7.3 days for adult females (Arnold 1981, p. 23). The longest time between captures indicates that adults can live at least 14 days (Arnold 1981, p. 24). The period of the adult flight (*i.e.*, the time between first and last observation of adults) ranged from 44 to 95 days in 20 years of monitoring at San Bruno Mountain (summarized in Thomas Reid Associates 2001, p. 5; Figure 4). After 2006 annual monitoring reports for San Bruno Mountain do not consistently report the dates that butterflies were first and last seen, instead focusing on monitoring surveys. Surveys at San Bruno Mountain also include sightings of several individuals in April, as well as late flight periods starting in early June and extending into early August (e.g., Thomas Reid Associates 1992, p. 21). Male callippe silverspot butterflies are more commonly observed than females, likely due to behavioral differences (Thomas Reid Associates 1982, p. IV-4; Hill 2018, p. 29). Females tend to be more secretive than males (Arnold 1981, p. 19; Hill 2018, p. 29). Notwithstanding differences in observation and capture, the sex ratio for the subspecies is presumed to be 1:1 (Arnold 1981, p. 23).

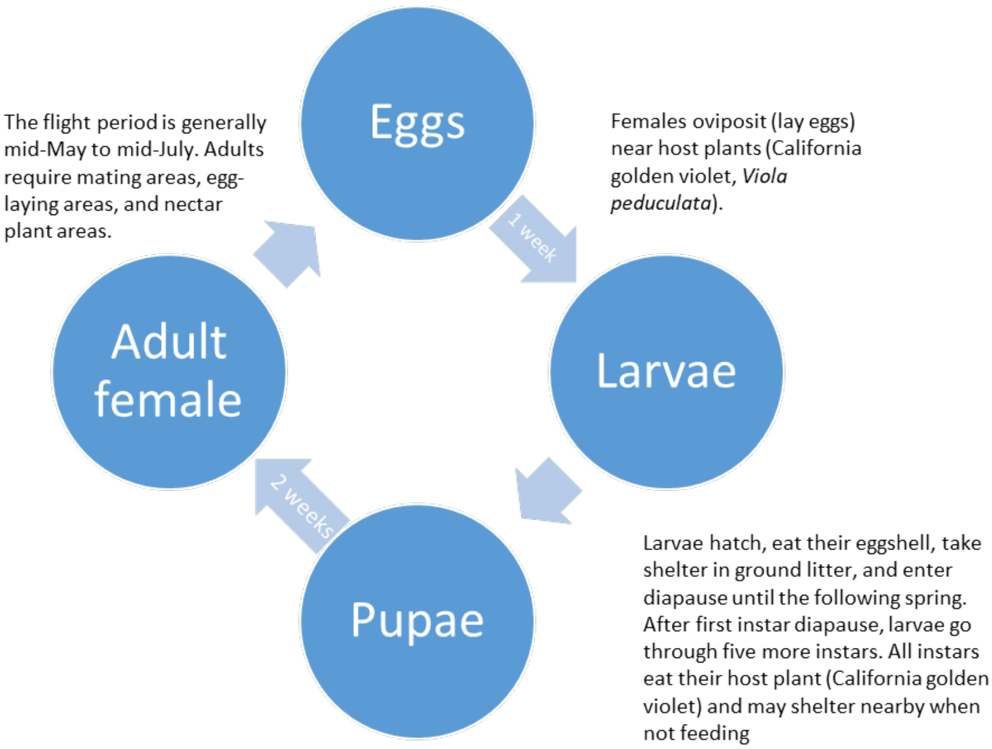

Figure 3. Callippe silverspot butterflies are univoltine, with a life cycle consisting of eggs, larvae, pupae, and adults.

Table 2. Gant timeline chart for one year in the life cycle of the callippe silverspot butterfly egg, larva, pupa, and adult life stages. Lighter shading indicates that individuals in that life stage may engage in that activity during those months, although more individuals will be present in darker shaded boxes.

Life stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Egg												
Larva							Diapause					
					Feeding							
Pupa												
Adult					Flight period							
						Egg deposition						

Figure 4. Flight period of callippe silverspot butterfly at San Bruno Mountain from 1982 to 2006, excluding 2001 because the first day butterflies was seen was not included in the annual report for that year. After 2006 annual monitoring reports for San Bruno Mountain do not consistently report the dates that butterflies were first and last seen, instead focusing on monitoring surveys. Data from 1982 to 2000 taken from Thomas Reid Associates 2000, p. 5; 2002 to 2006 from annual monitoring reports after that.

Butterflies are poikilothermic (have a variable body temperature), and regulate their body temperature through a variety of physiological and behavioral mechanisms (Clench 1966, entire; Kingsolver 1985, pp. 1-9). A combination of physical and behavior elements may influence thermoregulation in butterflies, such as wing coloration and basking position. Morphologically, the dense hair on the thorax of the callippe silverspot butterfly may decrease heat loss

(Kingsolver and Moffat 1982, pp. 27-33). Butterflies use a variety of behavioral actions to raise their body temperature including changing the wing and body orientation to the sun, elevating or depressing their abdomen, perching at different heights or locations, changing the height of their flight, and moving in or out of the shade (Kingsolver 1985, pp. 4-9). In other butterfly species, wing color, specifically melanization, has been demonstrated to play an important role in thermoregulation (Kingsolver 1985, p. 8). *Speyeria* butterflies use a dorsal basking position, extending their wings horizontally from their body to expose dark basal suffusion on the dorsal surface of the wings to solar radiation (McCorkle and Hammond 1988, p. 190). Hammond (1990, pp. 62-3, 76) notes the plasticity of darkness of color (i.e., melanic basal suffusion), which has been subject to repeated convergence and reversal in *Speyeria* evolution. Atlantis fritillary (*Speyeria atlantis*) populations that live in cool, moist conditions exhibit heavy melanic basal suffusion on the dorsal wing surfaces and a dark disc on the ventral hindwing, while populations in warm, dry conditions display pale wing colors (Hammond 1990, pp. 61-62). In the callippe silverspot butterfly, very heavy basal suffusion on the dorsal wings (Hammond 1990, p. 76) may be a thermal adaptation to the cool climate surrounding the San Francisco Bay.

Male callippe silverspot butterflies emerge from their pupa before females, a characteristic known as protandry. Males usually eclose (emerge from the pupal case) about a week before females (Mattoon *et al.* 1971, p. 247; Arnold 1981, p. 22), likely because of faster development (Arnold 1981, p. 20; McCorkle and Hammond 1988, p. 190). Specifically, males eat less than females (Hill *et al*. 2018b, p. 7) and pupate faster and at a smaller size (Hill *in litt*. 2020). Zaman *et al*. (2015, p. 760) suggest that increased time that *Speyeria* butterflies spend in immature life phases may mean that females have increased mortality of larvae or pupae. Females are mated almost immediately upon emergence from pupae, sometimes before their maiden flight (Mattoon *et al.* 1971, p. 247). Mating occurs with both butterflies in the air, or perched on grasses, shrubs, or soil (Thomas Reid Associates 1982).

Callippe silverspot butterflies begin ovipositing soon after mating, as in some *Speyeria* butterflies (*S. callippe*, Brittnacher *et al.* 1978, p. 207; *S. adiaste*, Zaman *et al.* 2014, p. 38). Some *Speyeria* species go through a reproductive diapause following mating, becoming inactive for a period before ovipositing. This phenomenon is observed in California species including the coronis silverspot (*S. coronis*) and the zerene silverspot (*S. zerene*) butterflies (Sims 1984, p. 211), and in *Speyeria* in the eastern United States including the great spangled silverspot (*S. cybele*), Diana fritillary (*S. diana*), and Aphrodite silverspot (*S. aphrodite*) butterflies (Edwards 1874, p. 125). Callippe silverspot butterflies show no indication of undergoing reproductive diapause (Hill *in litt*. 2020).

After mating, female callippe silverspot butterflies oviposit singly on dirt, dry grass, mixed plant debris, and rodent trails and holes near their host plant, the California golden violet (also known as the Johnny jump-up or yellow pansy; *Viola pedunculata*) (Thomas Reid Associates 1982, p. IV-42). It is presumed that female silverspot butterflies are stimulated to oviposit by a volatile signal from their host plant (McCorkle and Hammond 1988, p. 185; Arnold 1981, p. 19). Hill

(2018, pp. 29-20) observed females ovipositing along the drip line of oaks (*Quercus* sp.) where green violet leaves were still present. Although an early report on ecology of callippe silverspot butterflies reported that they lay their eggs on the undersides of leaves and stems of their host plant (Arnold 1981, p. 19), it was subsequently reported that callippe silverspot butterflies lay their eggs in the vicinity of California golden violet, but not on it (Thomas Reid Associates 1982, p. IV-42). Females at San Bruno Mountain did not touch any specimens of the California golden violet, but laid all of their eggs within a few centimeters of these plants, and no more than 0.9 meters (3 feet) away (Thomas Reid Associates 1982, p. IV-42). This is supported by observations that other silverspot butterfly species laid eggs near, but not on, their host plant (McCorkle and Hammond 1988, p. 185; Kopper *et al*. 2000, p. 657; Zaman *et al*. 2014, p. 41). A single female *Speyeria* butterfly may lay as many as 1000 eggs (100-1000 eggs, *Speyeria zerene*, James and Nunnallee 2011, p. 236; as many as 600 eggs, Mattoon *et al.* 1971, p. 248; 100-150 eggs, *Speyeria callippe*, James and Nunnallee 2011, p. 238; up to 70 eggs in the laboratory, although it is expected they would lay more in the field, Zaman *et al*. 2014, p. 31). Female silverspot butterflies captured from San Bruno Mountain laid up to 412 eggs, with high viability (Arnold 1981, p. 21). The high number of eggs produced per female butterfly allows for a ‘sweepstakes strategy’ in oviposition (Kopper *et al.* 2000). This means that many eggs are laid in the vicinity of good habitat, but not much care is taken where each egg is laid. By laying many eggs, each female makes up for the lack of fine-scale oviposition choice.

Other fritillary butterfly species typically oviposit at microsites that are shaded by grasses or forbs (broad-leaved herbaceous plants) (Kopper *et al.* 2000, p. 657). Callippe silverspot butterflies at San Bruno Mountain do the same, at least during the hottest part of the day (Thomas Reid Associates 1982, p. IV-41). However, McCorkle and Hammond (1988, p. 185) report that Oregon silverspot butterfly (*Speyeria zerene hippolyta*) females choose sunny sites for oviposition. Callippe silverspot butterflies oviposit between 10 A.M. and 2 P.M., with the maximum rate of oviposition occurring between 11 A.M. and noon (Thomas Reid Associates 1982, p. IV-41).

Larvae hatch from eggs following a 1-week developmental period (Arnold 1981, p. 20). After hatching, larvae eat the eggshell, take shelter in ground litter, and then enter diapause (a period of reduced activity and development) (Arnold 1981, p. 20). Diapause lasts for at least 8 months in *Speyeria* larvae (Mattoon *et al.* 1971, p. 248), generally beginning in early summer and extending into the following spring. Some individuals briefly interrupt diapause by seeking shelter from adverse conditions during this period, followed by a return to diapause (Mattoon *et al.* 1971, p. 251). Callippe silverspot butterfly larvae experience a high rate of mortality during the first instar diapause stage (the overwintering stage) (Mattoon *et al.* 1971, p. 248; Arnold 1981, p. 20); in other subspecies this is thought to be related to winter humidity (James and Nunnallee 2011, p. 238). For callippe silverspot butterflies mortality during diapause may also be related to dry hot summer conditions (Hill *in litt*. 2020).

After diapause, larvae eat the foliage of their host plant, California golden violet, but not the sympatric (occurring in the same geographic area) early blue violet (*Viola adunca*) (Arnold 1981, p. 22). Although reports of early field and laboratory studies of callippe silverspot butterfly larvae suggest that they develop through five instars (larval development stages) (Arnold 1981, p. 20), the species most likely goes through six instars as in other *Speyeria callippe*. For example, captive rearing of other *Speyeria callippe* subspecies including Comstock's silverspot butterfly indicate that they go through six instars (Zaman *et al.* 2015, p. 36; Hill 2018, p. 28; James and Nunnallee 2011, p. 238). Early references may have been referring to five instars subsequent to the first instar. Arnold (1981, p. 20) documented callippe silverspot butterfly larvae feeding in late afternoon and twilight, and crawl off of the violets when not feeding. We suspect that callippe silverspot butterfly larvae, as observed for other *Speyeria* species, feed quickly and then crawl to hiding places (Kopper *et al.* 2001, p. 97).

The specific time for development of callippe silverspot butterfly larvae is not known, although development of other *Speyeria* ranges from 6-14 weeks (Mattoon *et al.* 1971, p. 248; McCorkle and Hammond 1988, p. 192; Zaman *et al*. 2014, pp. 31-35). Longer larval development is thought to be an adaptation to variable and unpredictable environments (McCorkle and Hammond 1988, p. 192); in the same study the authors say that *Speyeria callippe* (subspecies not indicated) had the fastest rate of larval and pupal development compared to other *Speyeria* species (p. 193). Larval development in the lab depends on temperature during rearing (James and Nunnallee 2011, p. 236). The pupal chamber of most *Speyeria* consists of several leaves drawn together with silk, with the pupa attached to the top in a hanging position (McCorkle and Hammond 1988, p. 188). In Washington, *Speyeria callippe* pupate close to the ground in lightly silked leaf tents (James and Nunnallee 2011, p. 238). The pupal stage of the callippe silverspot butterfly lasts about 2 weeks (Arnold 1981), which is average for the genus *Speyeria* (Macy and Shepard 1941).

HABITAT

The habitat for the callippe silverspot butterfly was described in the listing as native grasslands and associated habitats in the San Francisco Bay area (62 FR 64306-64320). Essential features of callippe silverspot habitat include: grasslands and associated habitats with proper topography; hilltops for mating congregations; larval host plants; and, nectar sources (Service 2009a, pp. 7-8). Fog is also included in the Service (2009, p. 8) description of essential habitat features; we have included a discussion of fog in *Grasslands* below, but do not consider it to be an ecological need for the species.

Grasslands

The callippe silverspot butterfly is generally considered to be a grassland animal (Murphy and Weiss 1990, p. 1). However, individuals do not necessarily stay within grasslands alone; they may fly over, around, and through dense brush, between and over trees along the grassland border and in riparian areas, and have been observed congregating in bushes (Thomas Reid

Associates 1982, p. IV-37). Adjacent habitats may also be important for nectaring (see below) or providing habitat suitable for oviposition.

Callippe silverspot butterfly distribution across grasslands may vary based on individual factors, such as sex, or physical features of the grassland. Although both males and females likely fly uphill upon emerging from pupae, females spend more time searching for oviposition sites once mated, while males spend most of their time patrolling for females at hilltops. Hill (2018, pp. 29-30) frequently observed females using oak (*Quercus* spp.) habitat, often walking along the ground or ovipositing at the drip line of trees. Grassland topography can also be an important determinant of distribution. Topography influences the amount of seasonal sun exposure, temperature variations, and site-specific moisture, which in turn will affect host plant abundance and health, as well as larval thermoregulation and water balance. Topography influences larval host plant growth and survival (Weiss *et al.* 1993, entire) and adult emergence (Weiss and Weiss 1998, entire) of another Bay Area butterfly, the bay checkerspot butterfly (*Euphydryas editha bayensis*). However, bay checkerspot larvae often bask in direct sun (Weiss *et al.* 1993, p. 262), in contrast to callippe silverspot butterfly larvae which are more cryptic. North- and east-facing slope exposures have been identified as the location of (or at least included within) the most important grassland habitat areas, possibly because they are relatively cooler (Murphy and Weiss 1990, p. 1).

Weiss and Murphy (1990, p. 56) describe the range of callippe silverspot butterfly at San Bruno Mountain as restricted to areas outside the fog line, a topographic barrier that affects wind and air temperatures and thus limits regular fogs. At San Bruno Mountain, this results in a distribution on north- and east-facing slopes that are east of the fog line (Weiss and Murphy 1990, p. 56) (the same slope exposures noted above as being important habitat, in that case referencing the relatively cooler conditions). Thus, while callippe silverspot butterflies are generally found within the fog influenced zone surrounding San Francisco Bay on a regional scale, at the local scale its distribution may be limited by avoidance of fog during the flight season. Fog is likely related to the melanic phenotype associated with callippe silverspot butterflies (see discussion above about melanic basal suffusion in *Life History*). However, evidence of multiple phenotypes at several known populations, including individuals without extensive melanic coloration, suggests that the coloration is an adaptation to climate, rather than fog being a need for the species.

Hilltops

Callippe silverspot butterflies engage in hilltopping behavior, the practice of congregating on hilltops for the purpose of locating mates (Shields 1967, entire; Thomas Reid Associates 1982, p. IV-35; 62 FR 64306). Hilltopping allows the congregation of males and females for mating (Shields 1967, entire). Evidence from studies of multiple butterfly species that occupy gently rolling topography indicates that hilltopping behavior can be triggered by even small variations in topography (Murphy 1988, p. 441). Males are more likely than females to spend time on hilltops, and to utilize hilltops throughout their lifetimes (Thomas Reid Associates 1982, p. IV-

35). Callippe silverspot butterfly females spend less time on hills and more time searching for oviposition sites and nectar sources (Hill 2018, pp. 29-30).

Importance of hilltops for adult mating likely varies with population density. At high population levels, male Edith's checkerspot butterflies *(Euphydryas editha*) may patrol below hilltops, and congregate on them during periods of low population levels (Baughman *et al.* 1988, p. 596). Female Edith's checkerspot butterflies only hilltop as virgins (Baughman *et al.* 1988, p. 597), which is likely also true for female callippe silverspot butterflies.

Host plants

Callippe silverspot butterfly larvae feed on California golden violet (Service 1978, p. 28941; Arnold 1981, p. 19; Figures 5 and 6). California golden violet is a low-growing, yellow-flowered perennial herb that blooms from early January through April (Calflora 2019). In the San Francisco Bay area, California golden violet tends to be associated with deep soils that have established grass cover (County of San Mateo 2002, p. 14), although the species can also be found on disturbed roadsides (Ormshaw 2018, p. 22). However, studies have found no significant relationship between California golden violet abundance and soil depth, moisture storage, pH, clay content, or microclimate (Thomas Reid Associates 1982, p. IV-17), therefore it is not known what affects the abundance of this food plant. Lab studies had high success in seed germination of California golden violets, which was correlated with stratification (breaking up seed dormancy) but not removal of the seed elaiosomes (fleshy structures attached to the seed) (Franklin *et al.* 2017, pp. 46-48). Arnold (1981, p. 19) noted that California golden violets are sometimes found in association with bracken ferns (*Pteridium aquilinum*). However, field investigations suggested that although both species are often found in mesic (moist) conditions, the association between them was coincidental rather than causal (Thomas Reid Associates 1982, p. IV-20).

Figure 5. California golden violet (Viola pedunculata) at San Bruno Mountain.

Figure 6. California golden violet growing along a trail at San Bruno Mountain.

California golden violet is a perennial herb that flowers from February-April (Calflora 2019). It is summer deciduous, meaning that the plant dries up and goes dormant during the hotter months and leafs out again the following year. This means that the host plant leaves may be dried up when female callippe silverspot butterflies lay eggs and larvae hatch (Arnold 1981, p. 19; Thomas Reid Associates 2000, p. S-6), as is the case for other *Speyeria* butterflies and their host plants (e.g., Kopper *et al*. 2000, p. 653).

Larval host plants are a resource requirement for adult females and for larvae. Females rely on dense patches of the larval host plant, the California golden violet, as a cue for egg deposition. In the congeneric (belonging to the same genus) Oregon silverspot butterfly, females selected areas with higher host plant density for egg laying (Singleton and Courtney 1991, p. 11; Damiani 2011, pp. 7-12). Oviposition was greatest in sites with greater than 16 violets per m^2 (Damiani 2011 p. 10).

Upon emergence from diapause, larvae feed exclusively on the host plant, and rely on dense patches so that they can initially locate plants and move between them. Each Oregon silverspot butterfly larva requires 200 to 300 leaves of early blue violet in order to pupate (Service 2018, p. 1). Quantifying leaf consumption by area rather than number of leaves, unsilvered fritillary (*Speyeria adiaste*) larvae in the laboratory consumed between 163.3 cm^2 to 310.3 cm^2 of leaves, with females consuming more than males (Hill *et al*. 2018b, p. 7). It is likely that requirements of callippe silverspot butterfly larva are similar to those of other Speyeria butterflies. Although foraging Oregon silverspot butterfly larvae orient towards vegetation, they are unable to differentiate between host vs. non-host plants at close distances and it is likely that they must physically contact their host plant to distinguish it from a non-host plant (Bierzychudek *et al.* 2009, pp. 634-6). A fifth instar regal silverspot larva moved 25 linear meters (79 linear feet) in 24 hours, but missed many violets that were centimeters away from its path but not directly on it (Kopper *et al.* 2001, p. 97), underscoring the importance of dense host plants for the larva. We assume that fifth instar larvae of the callippe silverspot butterfly are capable of similar movements in their search for host plants and pupation sites (sites where larvae metamorphose from the larval stage to the pupal stage).

Adult population estimates of regal fritillary tend to correlate with host plant density (Kelly and Debinski 1998, p. 267), although some isolated patches containing up to 13,000 violets were not occupied by regal fritillary (Kelly and Debinski 1998, p. 273). Female Oregon silverspot butterflies, which are similar to the callippe silverspot butterfly in that they oviposit near their host plant, chose sites with vegetation heights of 22 to 25 centimeters (8.6 to 10 inches) and avoided areas with taller vegetation (Singleton and Courtney 1991, p. 27). However, the authors caution that areas with low violet densities but other vegetation of the appropriate height could serve as ecological sinks (Singleton and Courtney 1991, p. 18). Although the historical density of California golden violets in native grasslands is not known, density of violets in consistently occupied habitat on the Northeast Ridge of San Bruno Mountain was approximately 500-1500 plants per acre on 25% of the habitat in that area (Thomas Reid Associates 2001, p. 12). A simulation model of Oregon silverspot butterfly caterpillar movement found that 4th instar larvae require a host plant density of four host violets per square meter (depending on predation intensity) in order to have a 10% chance of survival to pupation, with survival rates increasing linearly with host plant density (Bierzychudek and Warner 2015, p. 51). In the same study, host-finding success was highest when plants were clustered rather than uniformly distributed (Bierzychudek and Warner 2015, p. 51).

Nectar plants

Adult butterflies feed on flower nectar to acquire nutrients. Nectar flowers provide a source of energy for adult butterflies, and may be found in grasslands or nearby oak woodlands, riparian areas, rock outcrops, or disturbed areas (Arnold 2007, p. 3). A variety of flowering plants provide nectar sources used by the adult callippe silverspot butterfly. See Bernhardt and Swiecki (2007, entire) for a comprehensive list of native and non-native plants used as nectar sources. Additional nectar sources not included in the list are cobweb thistle (*Cirsium occidentale*) and mule's ears (*Wyethia* spp.) (Hill *in litt*. 2020).

Adults rely on habitat with a diversity of nectar sources. Preferred nectar sources for adult callippe silverspot butterflies at San Bruno Mountain include both native (Alameda coyote thistle, *Cirsium quercetorum*; coyote wildmint, *Monardella villosa*) and non-native plants (non-native thistles, *Carduus* spp.; blessed milk thistle, *Silybum marianum*) (Thomas Reid and Associates 1982, p. IV-20). At the King/Swett Ranch in the Cordelia Hills, callippe silverspot butterflies were found to travel up to 1 mile in order to nectar from the native California buckeye (*Aesculus californica*) (Arnold 2007, p. 11). Having diverse nectar sources available ensures that nectar is available throughout the flight season, which may be particularly important during years with early or late emergence. Mule's ears are common at Sears Point but dry up early in the flight period, thus might be important for early emerging callippe silverspot butterflies at that site (Hill *in litt*. 2020). Shifts in the frequency of nectar source use by unsilvered fritillary across two years highlight the importance of having nectar sources that persist throughout the flight period, particularly during drought years (Zaman *et al*. 2014, pp. 37, 42).

Topographic diversity is important because it can extend the blooming period of some nectar sources (Arnold 2007, p. 4). We are not aware of evidence showing that nectar from native plants is superior to nectar from exotic species. For example, non-native thistles (*Carduus* and *Silybus* spp.) are some of the preferred nectar sources at San Bruno Mountain (Ormshaw 2018, p. 22) and in Solano County (Arnold 2007, p. 11-2).

Movements and Dispersal

Callippe silverspot butterflies are strong fliers, as is the genus *Speyeria* as a whole (Howe 1975, p. 212). At San Bruno Mountain, mark-release-recapture data revealed that numerous callippe silverspot butterflies fly 1.2 kilometers (0.8 miles) from one breeding colony to the other, and approximately 5 percent of individuals traveled even farther (Thomas Reid Associates 1982, p.

IV.9-IV.10). These data seem consistent with data for the unsilvered fritillary and regal fritillary (*Speyeria idalia*), which both had maximum distances moved of 1.6 km (1.0 mi) (Nagel *et al*. 1991, p. 148; Zaman *et al*. 2015, pp. 758-759). Based on models of dispersal, Zaman *et al*. (2015, pp. 759-761) presented the probability of a males unsilvered frillilary moving 1 km (0.6 miles) as 0.04, while the same probability for a female was 0.005. Probabilities of moving greater distances (e.g., 5 km or 10 km) were very rare.

Individual callippe silverspot butterflies can have a home range covering many hectares of grassland habitat (Weiss and Murphy 1990, p. 56), thus populations need extensive, continuous habitat with connectivity between hilltops or ridges for mating, areas with host plants for oviposition, and nectar plants for food. Connectivity between populations is necessary to maintain gene flow, and female callippe silverspot butterflies are likely to have reduced long dispersal compared to males (Hill 2018, p. 25), as in other *Speyeria* (Zaman *et al.* 2015, pp. 758759). In a mark-release-recapture study at San Bruno Mountain, most callippe silverspot butterflies flew within an area that is 1.2 km across, with about 5% of individuals captured at a greater distance from their first capture point (Thomas Reid Associates 1982, p. IV-9). Arnold (2007, p. 11) reported that individuals traveled about 1.6 km (0.99 mile) to nectar at buckeye trees in offsite areas. Movements were similar to those of other *Speyeria* butterflies. Regal silverspot adults moved 68 meters (223 feet) per day on average, with some individuals traveling up to 1.6 kilometers (1.0 mile) (Nagel *et al.* 1991, p. 148). Male unsilvered fritillaries moved 145 m (476 feet) between captures and 254 m (833) overall on average, with a maximum distance of 1.6 km (1.0 mi) (Zaman *et al*. 2015, pp. 758-759). Based on studies at San Bruno Mountain, urbanization presents a total barrier to movement (Thomas Reid Associates 1982, p. IV-33). Dense clusters of tall trees, and paved roads and residential lots, present partial barriers, while scattered trees and dense brush present minimal barriers, and cyclone fences, dirt roads, and scattered brush formed no barrier (Thomas Reid Associates 1982, p. IV-33).

Callippe Silverspot Butterfly Needs

As a species, the callippe silverspot butterfly needs multiple, resilient populations to maintain ecological and genetic diversity throughout its range (Table 4). Populations need individuals that emerge throughout the flight season to maintain adaptive ability to survive with changing environmental conditions (e.g., variation in flowering period of the host plant). Results from a genetic study (Hill 2018, entire) suggest that focusing on maintaining the viability of populations within spatially and genetically distinct areas in the species range may be preferable to trying to homogenize the populations by reestablishing gene flow. Well-connected populations are necessary in each of the genetically distinct areas in suitable habitat containing all of the components discussed above. Maintaining genetic and ecological diversity (representation) and multiple populations distributed across the range (redundancy) is necessary for the species to be able to adapt to changing physical and biological conditions.

Individual Needs

Individual needs for callippe silverspot butterfly vary somewhat by life stage (Table 3). Adult callippe silverspot butterflies need expansive contiguous grasslands with hilltops for males and females to gather for breeding. These grasslands also need to have sufficient numbers of nectar sources available throughout the flight period of the butterflies. Females need host plants because they oviposit in the areas immediately surrounding them; these host plants are the sole food source for larvae. Larvae also need protected areas around the host plants for when they enter diapause in the ground litter. Although the range of the species is associated with the fog-influenced zone in the San Francisco Bay Area (Service 2009a, p. 8), we do not consider fog to be a "need" for the species but rather a habitat correlate that is linked to the species' evolutionary history and phenotype.

Table 3. Callippe silverspot butterfly individual resource needs for each life stage. Individuals need these resources to breed (B), feed (F), shelter (S), and disperse (D).

Resource	Life Stage	Resource Function
California golden violet	Larva; adult females	F; B
Nectar plants	Adults	F
Grasslands	All	B, F, S, D
Hilltops or ridges	Adults	B

Population Needs

For the purposes of this SSA, we define a population of callippe silverspot butterflies as a group of many male and female butterflies. Populations generally function as metapopulations made up of multiple subpopulations that interact with each other. Previous publications use both the terms "population" and "colony" (e.g., Arnold 1981, p. 28), but we chose to use population throughout for consistency, and out of simplicity we frequently use the term "population" throughout this document when referring to a metapopulation. For example, San Bruno Mountain has multiple discrete habitat areas with callippe silverspot butterflies, but was considered to function as one genetically homogenous population based on long distance movements in one of the original population studies on the mountain (Thomas Reid Associates 1982, p. IV-2) and in Hill (2018, p. 13). During genetic sampling, Hill (2018, p. 9) distinguished populations based on an approximately 5 mile radius, and we maintain this definition to separate populations because of varying land ownership that could influence threats and/or management.

Population Resiliency

Resiliency describes the ability of the species to withstand stochastic disturbance events, an ability that is associated with habitat quality and demographic characteristics (Figure 7). Resilient populations rely on the same habitat resources as individuals. Because the flight period is variable between years (and potentially sites), habitat must have nectar sources with staggered blooming phenology so that adults in a population can find nectar throughout the flight period (Arnold 2007, p. 4). Because callippe silverspot butterflies are strong fliers, grasslands size is important in maintaining resilient populations. Topography within these grasslands is important, as described above in *Habitat*, although specific microtopographic characteristics are unclear.

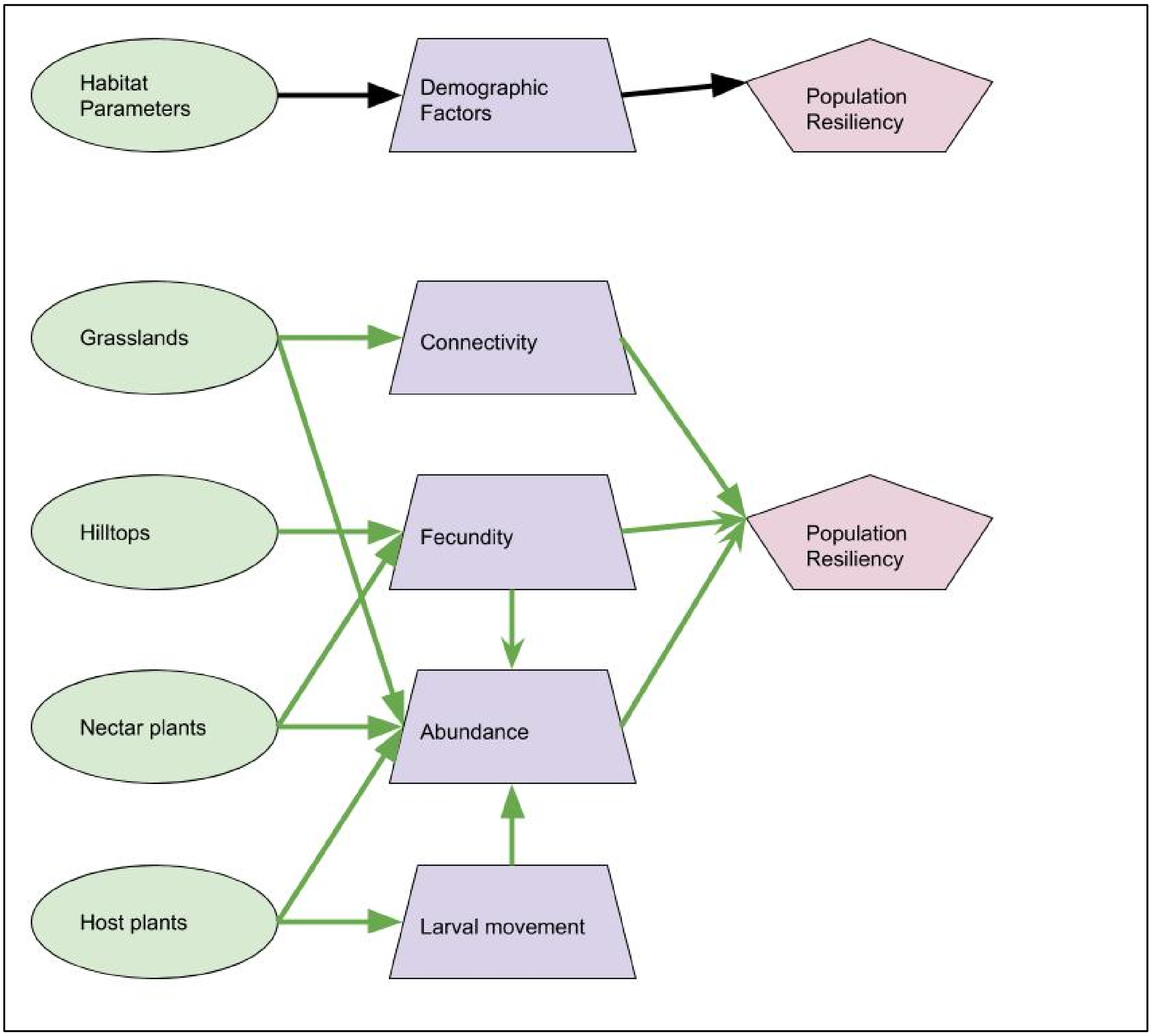

Figure 7. Habitat and demographic factors influencing callippe silverspot butterfly population resiliency. Green arrows represent positive associations. Shapes and colors of polygons are for visual effect and do not have meaning other than to symbolize the type of factor.

Demographic indicators that might suggest population resiliency are related to abundance, fecundity (the ability to produce offspring), movement, and connectivity. Because the entire population of butterflies is replenished each year, abundance is important because the number of adults determines the potential for eggs, larvae, and pupae in the subsequent generation. The number of eggs produced by individual females varies, and could be related to nectar sources. In an experimental study, food availability to females of the congeneric (same genus as the callippe silverspot) Mormon silverspot butterfly (*Speyeria mormonia*) correlated with fecundity (Boggs and Ross 1993, p. 436). We include larval movement as a need because thatch build-up threatens the ability of larvae to move between host plants for feeding (see *Habitat Loss and Degradation* below). Connectivity between habitat features is important for population resiliency, and when possible it is important to maintain connectivity between populations for gene flow.

Species Needs

In order to adapt to changing environmental conditions, the species needs to maintain its ecological and genetic diversity (representation) in resilient populations distributed throughout the species range (representation and redundancy). Within the Solano complex of populations, contiguous habitat or corridors are important to maintain or reestablish gene flow.

Representation

Representation describes the ability of a species to adapt to changing environmental conditions, which is related to the breadth of genetic and ecological diversity within and among populations. For the callippe silverspot butterfly, we assessed species representation based on genetic diversity based on a recent genetic study. This study found that callippe silverspot butterfly populations are genetically represented in the Bay Area across three counties: San Bruno Mountain in San Mateo County, Sears Point in Sonoma County, and a complex of populations in Solano County. The study supports the idea that the San Bruno Mountain, Sears Point, and Solano County complex of populations, are genetically distinct, thus maintaining resilient populations across all three areas is recommended rather than trying to homogenize the species across the remaining localities (Hill 2018, pp. 31-32). Because of urbanization, it is unlikely that historical gene flow and population structure will ever be restored across the range of the species. Mixing with other *Speyeria callippe* subspecies, in addition to fragmentation, may have contributed to genetic differences between the callippe silverspot butterfly populations.

Redundancy

Redundancy describes the ability of a species to withstand catastrophic events, an ability that is related to the number, distribution, and resilience of populations. Extirpation of historical callippe silverspot butterfly populations has reduced redundancy for the species. An example of a potentially catastrophic event that might affect the callippe silverspot butterfly is a high intensity wildfire. Populations with large sizes and across diverse topography are necessary at both San Bruno Mountain and Sears Point to safeguard against catastrophic events. In the complex of Solano County populations, resilient populations should be maintained at multiple locations to ensure redundancy. Connectivity between these Solano County populations can help repopulate any areas affected by wildfires.

Table 4. Summary of individual, population, and species' needs for the callippe silverspot butterfly in terms of the 3Rs

Level	Need	Function of Need	Association with 3 Rs
Individual	Host plants	Stimulus for oviposition of females; food for larva	Resiliency
	Nectar plants	Provides caloric needs for adults	Resiliency
	Grasslands with proper topography	Habitat for all life stages	Resiliency
	Hilltops	Provides area for mating congregations	Resiliency
Population	High fecundity	Females lay hundreds of eggs in a sweepstakes fashion, which is necessary because of high larval mortality	Resiliency
	Connectivity	Provides for dispersal of adults; increases genetic diversity and allows for immigration following catastrophic events	Resiliency, Redundancy
Species	Multiple, connected, resilient populations in genetically distinct areas	Improves species viability by spreading risk associated with catastrophic events	Redundancy
	Full breadth of ecological and genetic diversity within the species' range	Maintains diversity and allows for adaptability to changing environmental conditions	Representation

Chapter 4. Historical and Current Condition

In this chapter, we discuss historical and current condition of the callippe silverspot butterfly at the population and species levels. In addition to presenting the historical and current range and distribution of the species, we also consider past and current factors influencing viability throughout some or all of its range. Note that the term “factors” can refer to both threats and conservation measures, thus can be either detrimental or beneficial to the species. We then discuss the current condition of the species in the context of resiliency, redundancy, and representation in order to assess the current viability of the species.

Factors influencing viability of the species

Here we consider the historical and current anthropogenic and environmental factors influencing callippe silverspot butterfly population resiliency, which in turn contribute to the overall viability of the species. We acknowledge that there are other factors that have an influence on the callippe silverspot butterfly, but for the purposes of this SSA we focus on those factors that are generally thought to have population or species-level effects. Additional threats to the callippe silverspot butterfly, including predation, illegal collection, human interface activities (e.g., recreation), and dust from the San Bruno Mountain quarry, are summarized in the five-factor analysis of the 2009 status review (Service 2009a, pp. 9-19) but are excluded from the analysis in this report because we deemed them more likely to affect individual butterflies (Table 5). Climate change is included in this tabular summary but is discussed in more detail in Chapter 5 (Future Condition).

Table 5. Threats identified in five-factor analysis in the 2009 Status Review for the species, and our current understanding of the level at which these threats currently influence callippe silverspot butterfly viability. Threats with population-level effects are discussed in more detail in this Chapter. Air pollution is discussed in the context of Competition with non-native plants because it increases growth of non-native grasses.

Threat	Individual	Population	Species
Off-road vehicle use	x		
Overgrazing or trampling by cattle	x		
Trampling by hikers and horses	x		
Fragmentation	x	x	x
Competition from non-native plants (and associated thatch build-up)	x	x	x
Grassland Conversion	x	x	
Illegal collection	x		
Predation	x		
Pesticides	x	?	
Fire suppression	x	x	
Small population size		x	x
Dust from quarries	x	x	
Road mortalities	x		
Air pollution (increases non-native grasses)	x	x	
Climate change	x	x	x

In this section, we first discuss factors that are limiting callippe silverspot populations, including a description of the factor, the path through which it is thought to influence population resiliency, and the magnitude of its impact (if known). We then discuss management actions that are currently underway or in consideration and how these actions may alleviate some limiting factors. Figure 8 is an influence diagram summarizing the pathways through which management actions and anthropogenic or environmental factors can influence callippe silverspot butterfly resiliency through their effects on habitat needs or demographic parameters.

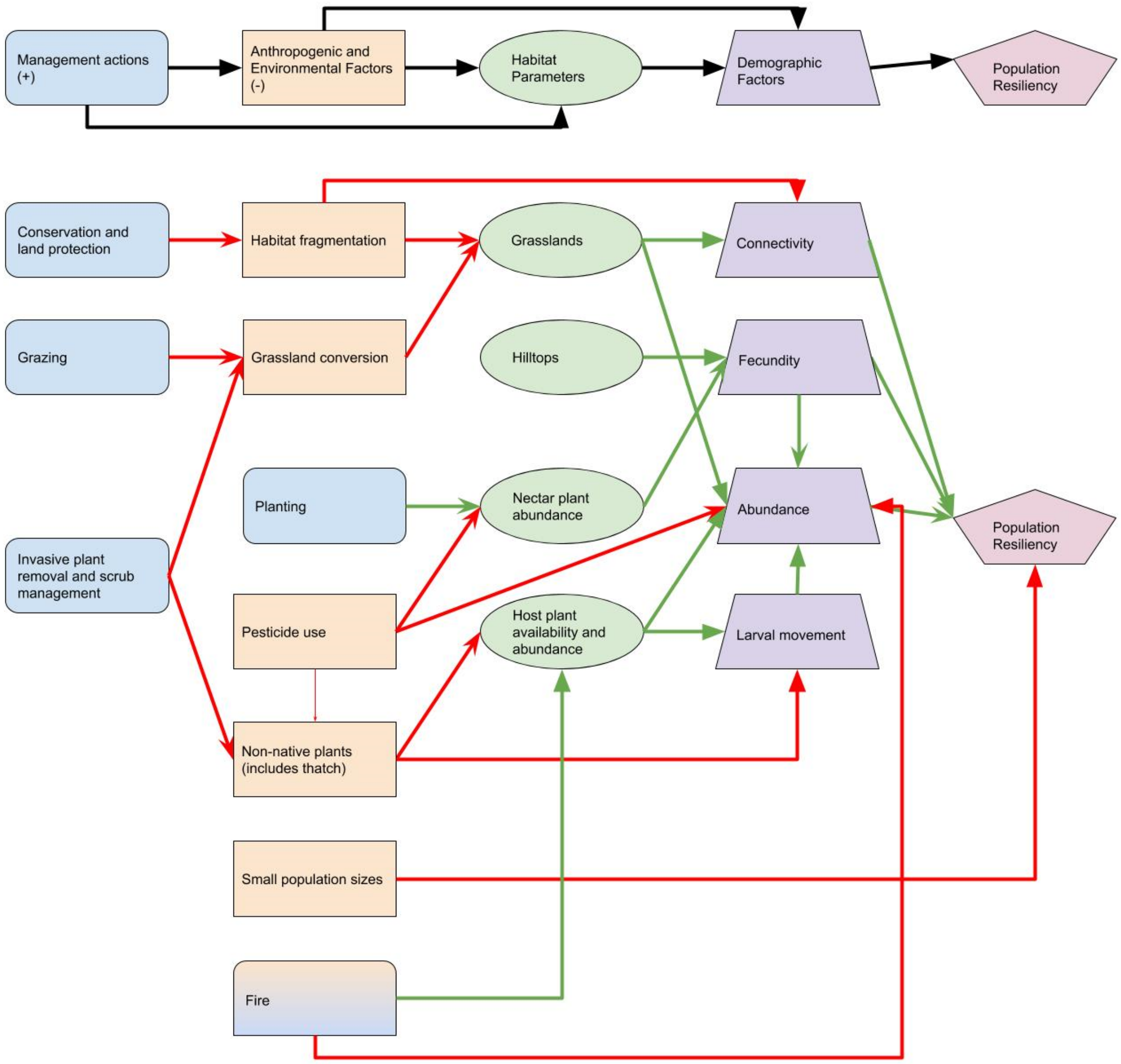

Figure 8. Influence diagram showing pathways through which management and anthropogenic or environmental factors can affect callippe silverspot butterfly habitat needs and demographic parameters. Red arrows represent negative associations and green arrows represent positive associations (e.g., planting may increase nectar plant abundance, while pesticide use may decrease nectar plant abundance). Blue arrows represent associations that can be positive or negative. Shapes and colors of polygons are for visual effect and do not have meaning other than to symbolize the type of factor.

Habitat Loss and Degradation

The primary factor limiting callippe silverspot butterfly populations is habitat loss and degradation, including fragmentation, competition with invasive non-native vegetation (including thatch build-up from non-native grasses), and grassland conversion to coastal scrub or chaparral, which are discussed in more detail below. The listing documents and status review also include discussion of degradation to habitat by human activities including off-road vehicle use and trampling by hikers and horses, which we consider to be more likely to affect individuals than populations and do not discuss in detail in this status assessment.

Fragmentation

Historically, habitat fragmentation and urbanization limiting dispersal have played a large role in shaping the current population distribution. Habitat fragmentation, the division of habitat into smaller and more isolated patches, has led to the disjointed callippe silverspot population distribution found in the species currently. Indeed, the wide separation between known callippe silverspot butterfly populations has led to distinct genetic signatures in some cases, and it is likely that the limited dispersal capabilities of the species are not sufficient to maintain or reestablish connectivity (Hill 2018, pp. 31-32). As habitat patches become more isolated due to habitat fragmentation, the likelihood of adult butterflies dispersing from one patch to another decreases, which limits opportunities for genetic exchange among populations.

Additionally, butterfly species may be sensitive to changes in habitat structure such as edges of grasslands (Schultz and Crone 2001, p. 1887; Ries and Debinski 2001, pp. 844-847) or forests (DeVries and Walla 1999, pp. 340-342; Haddad *et al.* 2008, p. 219). Fragmentation increases habitat edges, which are avoided by some butterfly species (Ries and Debinski 2001, pp. 844-848). Fragmentation also increases the potential for barriers between resource needs including hilltops for mating, nectar plants, and host plants. Continued fragmentation is still a threat for populations on private land (including at least one population in Solano County), while populations in protected areas are threatened by other forms of habitat loss.

Competition with Non-native Species

Non-native annual grasses and forbs that have displaced native forbs in California native grasslands are a serious threat to the larval food plant and nectar plants on which the butterfly depends. Some of the non-native grasses and forbs that have invaded grasslands of the San Francisco Bay area are *Lolium multiflorum* (Italian ryegrass), *Avena barbata* (slender oats), *Bromus diandrus* (ripgut), *B. madritensis rubens* (red brome), *B. hordaceus* and *B. mollis* (softchess), *Carduus pycnocephalus* (Italian thistle), *Centaurea solstitialis* (yellow star thistle), *Cirsium vulgare* (bull thistle), *Ehrharta erecta* (ehrharta), *Erodium* species (filaree), *Hypochaeris radicata* (cat's ears), *Medicago polymorpha* (burclover), *Oxalis pes-caprae* (yellow oxalis, *Rumex acetosella* (sheep sorrel), *Silybum marianum* (blessed milk thistle), and *Brassica* species and *Sisymbrium* species (mustards) (Amme 2002, p. 2). Non-native *Plantago lanceolata* (English plantain) has been identified as a potential alternate host plant for Bay checkerspot butterfly (*Euphydryas editha bayensis*), thus will not be treated like an invasive species at San Bruno Mountain (Terry *in litt*. 2020). We note that some of these non-native species, including thistles and mustards, can be used as nectar sources by callippe silverspot butterflies (Bernhardt and Swiecki 2007, pp. 9-10).

Non-native grasses can affect butterfly host plants, behavior, or fitness. Non-native grasses and forbs have been demonstrated to out-compete native plants including the host plant of the callippe silverspot butterfly (Allen *et al.* 2000 in Service 2009a, p. 17; Figure 9). Vegetation height was negatively correlated with violet density in habitat selection studies for the Oregon silverspot butterfly (*Speyeria zerene hippolyta*) (Singleton and Courtney 1991, p. 12). In Fender's blue butterfly (*Icaricia icarioides fenderi*), oviposition was significantly lower in areas with tall grasses, suggesting that females were less able to detect host plants or less likely to oviposit for other reasons related to vegetation differences (Severns 2008, p. 655). Population declines of bay checkerspot butterflies were linked to rapid invasion by non-native grasses and subsequent losses of the butterfly's host plant in areas without grazing (Weiss 1999, pp. 1479-1482).

Figure 9. Tall grass can compete with and make it difficult to detect host plants for the callippe silverspot butterfly. Tall grass can make it difficult to detect even flowering (left) host plants, or non-flowering individuals prior to senescence (right).

The threat of non-native annual grasses is exacerbated by human alteration of the global nitrogen cycle (reviewed in Galloway *et al.* 1995, entire; Vitousek *et al.* 1997, entire). Because nitrogen is often a limiting factor in soil, nitrogen deposition can alter structure and function of communities by providing nutrients that facilitate competition by non-native plants with native plants. Atmospheric nitrogen deposition into soils in California varies widely based on location (Blanchard *et al.* 1996, pp. III.5-III.8; Weiss 2006, pp. 25-27). Weiss (2006) chose a benchmark for nitrogen deposition of 5 kg per hectare per year, which is not necessarily a critical threshold for negative impacts to ecosystems, but is useful for comparative purposes. About a third of annual grasslands and half of coastal sage scrub in California are above this threshold (Weiss 2006, pp. 25-29). Habitat near heavily used roads, highways and freeways are particularly at risk from nitrogen deposition because air pollution from transportation can lead to increased atmospheric nitrogen deposition (Weiss 1999, p. 1477). All callippe silverspot butterfly populations are situated in areas near major highways.

An additional threat posed by non-native invasive grasses is thatch build-up. Thatch produced as a result of the build-up of dead invasive grasses and forbs may inhibit the natural reproductive cycle of native plants and may also adversely alter soil chemistry and composition. Thatch build-up is linked to extirpation of a population of Oregon silverspot butterfly at one site because of overcrowding host plants and other plants (Hammond and McCorkle 1983, p. 222). Thatch, or residual dry matter (RDM), can affect the ability of adults to find suitable sites for oviposition near host plants. Thatch can also affect the ability of larvae to travel to or between host plants. The small size of larvae and the exponential increase in distance that they need to travel with increasing grassland complexity underscores the threat imposed by thatch build-up. Due to the complex texture of grassland vegetation and soil, a first instar larva (approximately 1-2 millimeters (0.04-0.08 inches) in length) would need to travel 2 meters (6.6 feet) up and down the surfaces of plants and soil clumps to cover a linear distance of 1 meter (3.3 feet) in an area with only slight surface roughness, with this amount increasing exponentially based on habitat complexity. In a more complex environment, a 1 mm (0.04 inch) larvae would need to travel 15.8 m (51.8 feet) to cover 1 linear meter (3.3 feet). The range of grassland complexity in relation to the calculations in this study are not known (Weiss and Murphy 1988, p. 117). However, based on the number of host plant leaves that larvae consume, traveling to a host plant upon emergence and between host plants while foraging is necessary for larvae foraging.

Grassland Conversion and Scrub Encroachment

Some coastal California grasslands may succeed to coastal scrub or chaparral in the absence of natural disturbance mechanisms such as fire or management actions such as grazing. Scrub encroachment includes both native and exotic species. Although coastal scrub and chaparral may include plant species that could be used for nectaring, it is not appropriate for all callippe silverspot butterfly life stages. At San Bruno Mountain, historically home to the largest population of callippe silverspot butterflies, San Bruno Mountain Watch estimated that grassland habitat was being converted to coastal scrub at a rate of 5 acres per year from 1982 to 2007 (TRA Environmental Sciences 2008, p. III-3). A 2015 assessment indicated that grassland loss through 2002 occurred at a rate of 9.5 acres per year. Using this rate, they estimated that grassland acreage had decreased from 1419 acres to an estimated 1180 acres because of encroachment or succession since the Habitat Conservation Plan (HCP) was approved in 1983 (Weiss *et al.* 2015, p. 3). This estimate was conservatively high based on the mapping technique; a corrected estimate assuming an overestimation in a 2002 mapping process yielded 944 acres (Weiss *et al.* 2015, p. 57). This acreage was designated as Priority Grasslands, which was further subdivided into Essential (431 acres), Valuable (308 acres), and Potential habitat for the callippe silverspot and mission blue butterflies (*Icaricia icarioides missionensis*) (see Weiss *et al.* 2015, pp. 58-66 for discussion of grassland area classification).

Fire

Fire is the primary natural disturbance mechanism that would have historically maintained California grasslands. The effects of fire to the callippe silverspot butterfly and its host plant, would depend on fire size and intensity, and time of year. Effects of fire would also vary based on life stage: eggs, larvae, and pupae may suffer direct mortality from fires, while adults would likely be able to disperse during a fire event. Regal fritillaries were largely absent in the weeks following fire, but returned to the area shortly thereafter (Huebschman and Bragg 2000, p. 387; see also Moranz *et al*. 2014, pp. 34-38), and it is likely that based on the expected vagility (dispersal capability) of callippe silverspot butterflies that they might have a similar response. On a longer time scale, a mosaic of fire in a large habitat area could be beneficial if it retards shrub invasion, reduces thatch, or otherwise promotes host plant growth. Prescribed burns by The Nature Conservancy in Oregon silverspot butterfly habitat improved host plant densities by up to 550 percent in the following year. However, in other habitat for the same species with high non-native grass cover, there can be mixed results following prescribed burns (Service 2001, pp. 31, 36). Further, the response of silverspot butterflies to burns is unclear (Walker in litt. 2019).

Although controlled burns are generally considered a management tool rather than a threat for butterfly species, it is unlikely that fires will be prescribed in the near future in areas of human population density like San Bruno Mountain. Uncontrolled wildfires during the larval or pupal stages of the callippe silverspot butterfly have the potential to catastrophically affect populations, because larva and pupae would likely be destroyed by fire.

Pesticide Use

Pesticides, including both insecticides and herbicides, pose a potential threat to the callippe silverspot butterfly. At the time of listing, the use of insecticides was considered a threat to the butterfly if used in proximity to occupied habitat. This threat was based on the finding that concentrations of insecticides found in agricultural runoff and the concentration deposited in soil after spraying was lethal to larvae of various species in the genus *Speyeria,* which is of particular concern when rearing them by hand (Mattoon *et al.* 1971, p. 254). Insecticides are not commonly used in the areas which are known to support the callippe silverspot butterflies. However, drifting spray from insecticides, could threaten all of the butterfly species on San Bruno Mountain (Service 2009b, p. 52) and other locations. The latest status review also mentions the potential threat of insecticides or other control measures for the exotic light brown apple moth (Varela *et al*. 2008, pp. 60-61), although we are unaware of control efforts for this pest near callippe silverspot butterfly populations. Herbicides have been used to control the spread of invasive plants around the San Francisco Bay Area. An experimental study that applied herbicides directly to Behr's metalmark butterfly (*Apodemia virgulti*) larvae at recommended field rates found that the treatment resulted in a reduction in the number of pupae produced, demonstrating a negative effect of herbicides on butterfly early life stages (Stark *et al.* 2012, pp. 25-26). The results of this study can be applied to the larvae of other butterfly species, including the callippe silverspot butterfly.

More recently, use of neonicotinoid insecticides has been correlated with declines in population indices for widespread butterfly species (Gilburn *et al*. 2015, pp. 5-6), and in butterfly diversity (Forister *et al*. 2016, entire). In Northern California, including one site in Solano County, analyses compared the number of butterfly species to neonicotinoid use while accounting for other factors including land use and summer temperature. The effects of neonicotinoids and land conversion were roughly equal. Butterfly species that had only one brood per year had the strongest negative response to neonicotinoid use (Forister *et al*. 2016, pp. 2-5).

Small population size

At the time of listing we stated that the callippe silverspot butterfly existed only as very small isolated populations. Sizes of the callippe silverspot populations were unknown at that time, and the listing proposed that isolated, small populations were vulnerable to extinction from random fluctuations in population size or variations in population characteristics that may be caused by annual weather patterns, food availability, and other factors. Further reduction in population numbers along with decreased genetic interchange among the populations through genetic drift, isolation, and inbreeding depression were also discussed as part of the threat of low population numbers since this would result in even less vigorous populations of the butterfly (62 FR 64306). The threat posed by population sizes is discussed further in the status review (Service 2009a, pp. 15-16).

This effect is potentially exacerbated by the distance between the known populations of the callippe silverspot butterfly and distinct genetics between populations across the three different counties. Genetic studies of the isolated populations at Sears Point and San Bruno Mountain show characteristics of mitochondrial DNA that are consistent with genetic drift (Hill 2018, p. 25). Further, observations of low abundance at Sears Point prior to the large fire that occurred in 2017 make it likely that this population in particular could be threatened by small population size. The Service is not aware of any research that has been completed to estimate the minimum effective population size for the callippe silverspot butterfly.

Management Actions

Conservation through the Endangered Species Act (ESA)

The Endangered Species Act, as amended (Act), is the primary Federal law providing protection for the callippe silverspot butterfly. The Service has responsibility for administering the Act, including Sections 7, 9, and 10 that address take. Section 9 prohibits the taking of any federally listed endangered or threatened species. Take is defined in Section 3 as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by Service regulations at 50 CFR 17.3 as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is defined by the same regulations as an act which actually kills or injures wildlife. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species.

Since listing, the Service has analyzed the potential effects of Federal projects under Section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to Section 10(a)(1)(B). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 CFR 402.02). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan that details measures to minimize and mitigate the project's adverse impacts to listed species. Many of these Habitat Conservation Plans are coordinated with the State of California's related Natural Community Conservation Planning program.

The status of the callippe silverspot butterfly as a species listed under the ESA can reduce the severity of the effects of habitat loss due to fragmentation association with urban development, which continues to be a threat to the callippe silverspot butterfly in unprotected habitat in Solano County (see *Fragmentation* above). Development projects that are subject to Section 7 consultation or result in the issuance of an incidental take permit under Section 10 typically include habitat compensation, which can reduce the severity of overall habitat loss typically associated with these projects. Habitat compensation can occur via a variety of mechanisms, including the purchase of credits at approved conservation banks, through permittee responsible mitigation, and through the development of Habitat Conservation Plans (HCPs). In addition to reducing the amount of overall habitat loss for the species, Section 10(a)(1)(A) of the Act allows for permits to be issued for recovery activities that result in take. Recovery activities are those activities that are specifically implemented for scientific purposes or to enhance the propagation or survival of the affected species, including interstate commerce activities.

Conservation Banks

A mitigation bank or conservation bank (bank) is a property or suite of properties (i.e., umbrella bank, phased bank, etc.), providing habitat or other conservation values that are conserved and managed in perpetuity, and provides ecological functions and services for specified listed species or resources. Mitigation and conservation banks function to offset adverse impacts that occurred elsewhere; therefore, the Service approves a specified number of credits that the bank owner may sell to developers or other project proponents for use as compensation to offset adverse impacts their projects will likely have on listed species. The money from the initial investment and bank credit sales is then used to permanently protect and manage the land for those species and resources. More information about conservation banks within the Sacramento Fish and Wildlife Office's Service area can be found at: https://www.fws.gov/sacramento/es/Conservation-Banking/Banks/In-Area/.

There are two active conservation banks for the callippe silverspot butterfly. Ridge Top Ranch Wildlife Conservation Bank is a 745-acre (301 ha) grazed grassland property in unincorporated Solano County, and Ohlone West Conservation Bank is a 640-bank in Alameda County.

Permittee Responsible Mitigation

Permittee-responsible mitigation, also sometimes referred to as turn-key mitigation, includes activities or projects undertaken by a permittee (or authorized agent) to provide compensatory mitigation to offset impacts from a single project. The permittee retains full responsibility for this mitigation. Ideally, permittee-responsible mitigation projects are established in advance of the project-related impacts they are offsetting; however, this typically does not occur due to multiple factors.

Permittee-responsible mitigation for the callippe silverspot butterfly has occurred throughout the species range for several projects. More information, including biological opinions rendered by the Service, are available at https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I019.

Habitat Conservation Plans

Habitat Conservation Plans (HCPs) are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded. HCPs can apply to both listed and non-listed species, including those that are candidates or have been proposed for listing. Regional HCPs develop large-scale conservation strategies within a specific region that are designed to conserve functional ecological systems and the covered species that depend on them. Such HCPs aim to avoid a fragmented conservation landscape by working with local land use authorities and a designated implementing entity to conserve, enhance, and manage a preserve system. Project-level HCPs are designed to fully offset the impacts associated with the permitted activity by contributing to a larger conservation design.

Being included as a covered species under an HCP can result in habitat being set aside and managed for the species as mitigation for impacts associated with covered activities, such as planned urban development, within the HCP permit area. In addition to mitigation, avoidance, minimization, and other conservation measures (e.g. monitoring, seasonal work windows, habitat management, etc.) are implemented. HCPs can also utilize banks, in-lieu fee programs, or other mechanisms to preserve habitat in perpetuity and contribute to a regional conservation strategy.

There are two current HCPs and one expired HCP that include the callippe silverspot butterfly as a covered species (Table 6); specifics for each HCP are included within each agreement. The Solano Multispecies HCP is an additional HCP in preparation within the range of the callippe silverspot butterfly. More information about HCPs that include the callippe silverspot butterfly as a covered species can be found at:
https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I019.

Table 6. HCPs that include habitat for the callippe silverspot butterfly.

Plan Name	Permit Issued	Permit Term (Years)
Parkside Homes	1996	10
San Bruno Mountain Amendment #5 (North East Ridge revision)	2009	30
PG&E Bay Area Operations and Maintenance	2017	30

Recovery Permits

Recovery permits, also referred to as 10(a)1(A) permits, allow scientists to take listed species as a means to ultimately contribute to the recovery of the listed species. The data acquired from some actions covered under recovery permits (e.g., occurrence, abundance, distribution, etc.) allow the Service to make informed decisions for the species that will enhance their survival and recovery. Recovery permits can be issued for activities that directly aid the recovery of a species, such as captive breeding, reintroductions, habitat restoration, removal or reduction of threats, and educational programs. The Service's recovery permitting program aids in the conservation of listed species by ensuring permittees have adequate field experience and qualifications for conducting activities with the target listed species and, for most species, ensures that permittees are following standardized protocols while surveying. The recovery permitting application process ensures that scientific proposals are crafted using the recommended actions laid out in the Recovery Plan for the target species. There currently is no protocol survey guidance or minimum qualifications for the callippe silverspot butterfly, although other minimum qualifications and species specific protocols can be found at: https://www.fws.gov/sacramento/es/Permits/.

For callippe silverspot butterfly, research related to genetics (see *Genetics* above) was facilitated by the recovery permitting program.

Land Protection

In addition to land protection provided through various mechanisms of the ESA described above, another form of land protection includes conservation easements.

Conservation easements are voluntary legal agreements between landowners and eligible organizations (e.g., government, private land conservation organization) that place restrictions on future land uses to protect conservation value in perpetuity (Byers and Ponte 2005, p. 1). Callippe silverspot butterfly populations with habitat protected by conservation easements include Sears Point, managed by the Sonoma Land Trust, and King-Swett Ranches and the Ferrari Ranch Preserve, managed by the Solano Land Trust. These properties are all managed as grazed grasslands.

Grazing

Inappropriate levels of grazing was listed as a threat to callippe silverspot butterflies in the proposed listing, particularly if grazing occurs at harmful levels such that the vegetation is overgrazed and the food-plants and nectar sources of the butterfly are greatly reduced in abundance (62 FR 64306). However, the listing rule also acknowledged that some livestock grazing could keep other plants from outcompeting host plants for the species. The view towards grazing has shifted over time with regards to habitat conservation, and today, grazing is a common management tool for annual grasslands. There is increasing consensus that grazing is the most cost effective and flexible tool for managing California grasslands (Huntsinger *et al.* 2007, p. 233). Importantly, grazing appears to benefit butterfly species in grasslands (Weiss 1999, p. 1484; WallisDeVries and Raemakers 2001, pp. 185-186). Cattle grazing can reduce thatch and reduce competition for native plant species with non-native annual grasses (Hayes and Holl 2003, pp. 1697-1698). Reducing thatch is beneficial for callippe silverspot butterfly larvae by increasing the ability of larvae to move between host plants. Optimal grazing that increases the diversity and richness of native plants in grasslands (Beck *et al.* 2015, pp. 1262-1264) can have positive effects for butterfly populations, specifically providing nectar sources for adults that can increase reproduction. The negative effects of uncontrolled, year-long livestock grazing are well known. Livestock grazing can alter species community composition and disrupt ecosystem function, with direct or indirect effects of livestock grazing contributing to soil compaction, erosion, poor water quality, the elimination of native perennial grass, and wildlife habitat degradation (reviewed in Fleischner 1994, pp. 631-635). Thus, the impact of grazing on insects can be beneficial or detrimental, with appropriate grazing considered to be a valuable conservation tool.

Recommended levels of RDM vary based on slope; steeper hillsides need additional grass cover to reduce erosion. General guidelines for California vary based on grassland type. The East Bay Municipal Utility District uses RDM guidelines of 800, 1,120, or 1,400 pounds per acre for flat, gradual, and steep slopes, respectively (EDMUD 2001, pp. 1-9). For coastal prairies, RDM guidelines call for 1,200 to 2,100 pounds per acre depending on slope, with lower recommendations for dry annual grasslands (Bartolome *et al.* 2006, p. 3). Weiss *et al.* (2015, pp. 81-84) recommend an initial goal of managing grasslands at San Bruno Mountain at 1,200 to 2,500 pounds per acre across the mountain, in line with the recommendations for coastal prairies. These numbers are recommended as part of an adaptive management strategy that may change pending grazing studies to measure the effects on host and nectar plants of listed butterfly species at the site. In 2018, a grazing technical advisory committee was established for San Bruno Mountain to provide technical advice for a cattle grazing experiment (Ormshaw 2018, p. 53). Since the HCP was established in 1982, the only grazing has been a small goat experimental plot from 2003 to 2004 (TRA Environmental Sciences 2008, pp. V8-V9).

Cattle grazing is used to manage the landscape for populations in Solano and Sonoma Counties. The long term management plan for Ridge Top Ranch recommends target RDM of 500 to 800 pounds per acre depending on slope (WRA, Inc. 2018, pp. 7), although the most recent monitoring report estimates that RDM levels at 15 plots average 2,301 pounds per acres (WRA, Inc. 2019, p. 11). Grazed plots in 2009 and 2010 at King Ranch had less grass cover and shorter grass height, but did not see differences in cover of California golden violets, which the authors attribute in part to the short duration of the study (Bernhardt and Swiecki 2010, pp. 10-12).

Non-native Invasive Plant Removal and Scrub Management

Scrub encroachment is being actively managed at San Mateo County Parks (Ormshaw 2018, pp. 45-54). Scrub was identified as a threat in the HCP and remains one of the highest management priorities as of the most recent annual report (Weiss *et al.* 2015, p. 16; Ormshaw 2018, p. 45). The Habitat Management Plan set a goal of maintaining 1,200 to 1,800 acres of grassland habitat (TRA Environmental Sciences 2008, p. 8), with the high end of the goal being that advised by the Technical Advisory Committee and consistent with the levels of grassland in 1981 (TRA Environmental Sciences 2008, p. 8).

Removal of non-native invasive plants is a common component of habitat management that is also part of the management plan at San Bruno Mountain. However, non-native thistles can be important nectar sources for callippe silverspot butterflies, particularly early in the flight period (Arnold 2007, p. 12).

Additional information on scrub management, non-native species removal, and recommendations are provided in the Habitat Management Plan, thirty year assessment, and most recent activities report. Limited funding makes it difficult to control both native shrubs and non-native invasive plants that threaten grassland habitat (TRA Environmental Sciences 2008; Weiss *et al.* 2015; Ormshaw 2018; Terry *in litt*. 2020).

Host and Nectar Plant Planting, Monitoring, and Research

Research and monitoring of host and nectar plants for the callippe silverspot butterfly have occurred at several populations, and is a central part of habitat management plans. A lab study investigating California golden violet germination is discussed in *Habitat* above, and the authors recommend future work on growing germinated seedlings in the lab to better understand conditions for propagation (Franklin *et al.* 2017, p. 49).

At King/Swett Ranches, California golden violet densities using a point-intercept method ranged from 7 to 35 percent in plots established when the host plant was mapped on the site (Bernhardt and Swiecki 2007, p. 13). Distribution of two preferred nectar sources for the species, California buckeye trees and mints (*Monardella* spp.) is limited. Although the species also nectars on non-native species (especially thistles), enhancement of native nectar plants is recommended (Bernhardt and Swiecki 2007, entire).

Summary: Current Factors Influencing Species Viability

The primary cause for the decline of the callippe silverspot butterfly is the loss and degradation of habitat from human activities, and this continues to threaten current populations. While historically urbanization and fragmentation were the main contributing factors to habitat loss, the primary factors affecting habitat of current populations include competition from non-native species and grassland conversion. Factors influencing viability of callippe silverspot butterfly are summarized for populations (with additional information based on management within populations) in Table 7, including both threats and management actions.

Table 7. Factors influencing viability for callippe silverspot butterflies. Information is presented for six sites within the four callippe silverspot butterfly populations based on land ownership/management.

		Threats						Management Actions				
Population	**Lands within population**	**Fragmentation**	**Non-native species**	**Scrub Encroachment**	**Fire**	**Pesticide Use**	**Small population sizes**	**Land Protection**	**Management Plan**	**Grazing**	**Non-native Plant Management**	**Nectar/Host Plant Enhancement**
San Bruno Mountain		No	Yes	Yes	Yes	Maybe	Maybe	Yes	Yes	No	Yes	Yes
Sears Point Ranch		No	Yes	No	Yes	Maybe	Yes	Yes	Yes	Yes	No	No
Ferrari Ranch		Maybe	Yes	No	Yes	Maybe	Maybe	Yes	Yes	Yes	Yes	No
Cordelia Hills	**King/Swett Ranches**	No	Yes	No	Yes	Maybe	Maybe	Yes	Yes	Yes	No	No
	Ridge Top Ranch	No	Yes	No	Yes	Maybe	Maybe	Yes	Yes	Yes	Yes	No
	Lake Herman Blvd	Yes	Yes	Unknown	Yes	Maybe	Maybe	No	No	Unknown	No	No

Current Population Trends

Extant populations are known from San Mateo County (1 population), Solano County (2 populations), and Sonoma County (1 population). Populations in San Francisco County (1 population) and Alameda County (1 or more populations) are thought to be extirpated.

San Mateo County population

The largest and best-monitored metapopulation of callippe silverspot butterflies is at San Bruno Mountain, which is managed by San Mateo County Parks. Mark-release-recapture studies in 1980 and 1981 yielded population estimates of 9,000 and 11,000 on San Bruno Mountain (Thomas Reid Associates 1982, p. IV-4), with approximately 75 percent of the population on the Southeast Ridge and the remaining 25 percent in the Guadalupe hills area (Thomas Reid Associates 1982, p. IV-2).

The San Bruno Mountain population has been surveyed annually from 1982 to 2006, with surveys switching to biennial at that point. Survey methodology has varied over the years, beginning with wandering transects (Thomas Reid Associates 2000, p. 4). Twelve fixed transects were established in 2000, and additional transects were added in 2005 and 2018 (one each) so that in 2018 there were 14 transects (Ormshaw 2018, p. 23) (Figures 10, 11, and 12). Based on these survey methods, it is not feasible to accurately calculate callippe silverspot abundance at San Bruno Mountain. Wandering transects did not always cover the same geographic area or have the same sampling effort across time, and, even after the implementation of fixed surveys, butterfly detection probability along the survey routes is not known (Longcore *et al.* 2010, p. 336). An analysis of occupancy using survey data from 1982 to 2000 revealed no major changes in occupancy across San Bruno Mountain (Longcore *et al.* 2010, p. 339). Further, grid cells showed a relatively even split towards increasing or decreasing occupancy trends over time, and suggest that the callippe silverspot butterfly population in the areas surveyed was relatively stable over that period (Longcore *et al.* 2010, pp. 340-342). Data from fixed transects in 2000 to 2012, including mean, maximum, and minimum peak densities along transects, do not demonstrate a clear long-term trend, but instead demonstrate natural population fluctuations that are common in univoltine butterflies; these data are summarized in Weiss *et al.* (2015, pp. 34-36) and Ormshaw (2018, p. 30) (Figures 10 and 11).

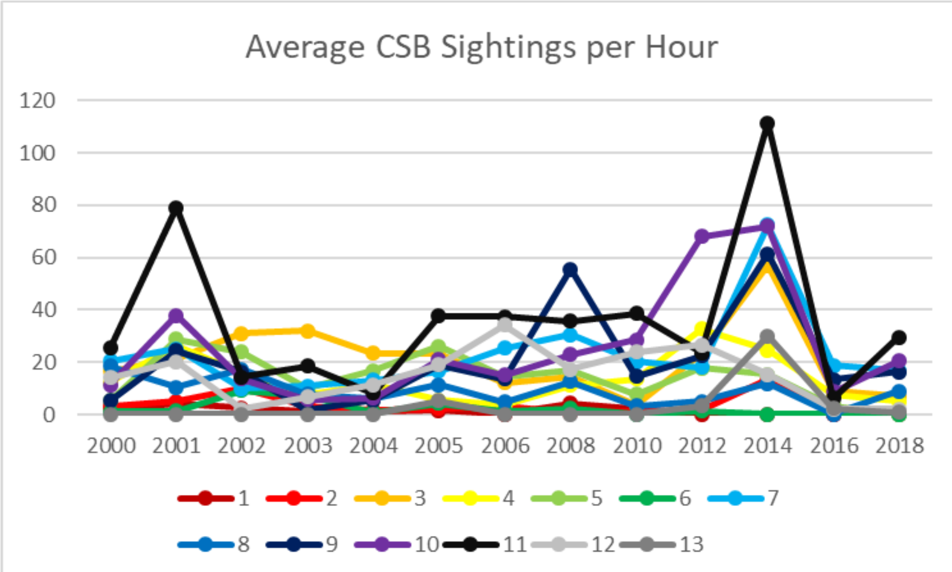

Figure 10. Average sightings per hour of callippe silverspot butterflies on fixed transects at San Bruno Mountain. Transects 1 through 12 were established in 2000, and transect 13 was established in 2005.

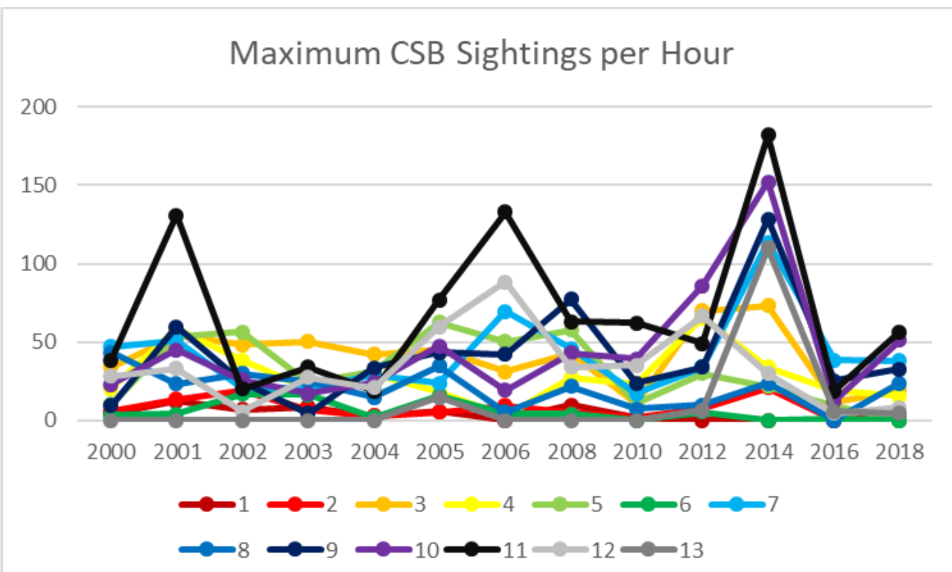

Figure 11. Maximum sightings per hour of callippe silverspot butterflies on fixed transects at San Bruno Mountain. Transects 1 through 12 were established in 2000, and transect 13 was established in 2005.

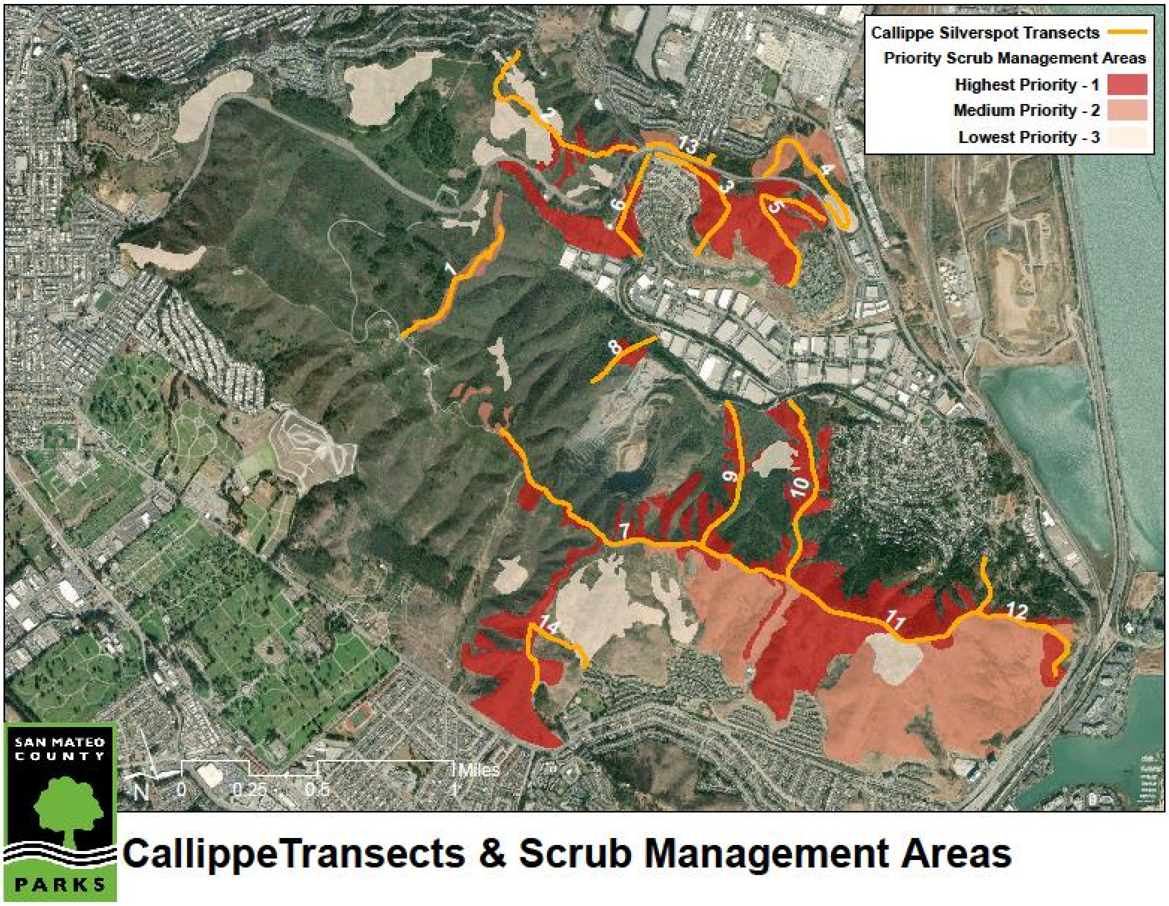

Figure 12. Callippe silverspot transects. Transects 1 through 12 were established in 2000, transect 13 was established in 2005, and transect 14 was established in 2018. Figure taken from Ormshaw 2018 (p. 26). Areas highlighted as priority for scrub management by San Mateo County Parks are also shown.

Solano County populations

We separate the callippe silverspot butterflies in Solano County into two populations based on results from a hierarchical analysis in Hill (2018, pp. 17-18). A population at Ferrari Ranch was mostly genetically distinct from the other Solano County samples. Ferrari Ranch is the farthest north of the Solano County callippe silverspot butterfly localities and is also separated from the other population by a 6-lane highway (Highway 80).

Ferrari Ranch, a 283-acre preserve, is monitored by Westervelt Ecological Services, and was established as a Preserve in 2014 as part of mitigation for Solano Transit Authority project. Monitoring for the species occurs every 5 years beginning in 2016, but results from one survey are not sufficient to establish population trends (Westervelt Ecological Services 2016, p. 9). Habitat monitoring also includes estimates of RDM and qualitative assessments of host plants. Adjacent properties include Lynch Canyon Open Space and private land, and Newell Open Space Preserve is also nearby. There are no reported observations of *Speyeria* butterflies at these nearby properties on the citizen science site iNaturalist (iNaturalist 2019).

The other population consists of individuals from localities including King Ranch, Ridge Top Ranch, and the hills above Lake Herman Boulevard, which we together refer to as the Cordelia Hills population.

King Ranch is contiguous with Swett and Eastern Swett Ranches, which are all managed by the Solano Land Trust. Studies documenting nectar and host plant occurrences at King Ranch are detailed in Arnold (2006), Bernhardt and Swieki (2007), and Bernhardt and Swieki (2010). Arnold (2006) noted that callippe silverspot butterflies are observed traveling up to 1 mile to forage at preferred host plants, indicating that sufficient nectar sources on the property might be limiting. Monitoring of callippe silverspot butterfly abundances is not conducted, thus we cannot evaluate population trends.

Ridge Top Ranch Wildlife Conservation Bank is a 745-acre conservation bank with approximately 662 acres of suitable callippe silverspot butterfly habitat (WRA, Inc. 2012. p. 5). The majority of the bank consists of non-native annual grasslands that are managed by cattle grazing. Approximately 10 acres of California golden violet stands, ranging from one to 15% cover, are scattered throughout the grasslands (WRA, Inc. 2012, p. 3). Biennial surveys in odd years since the banks establishment in 2014 serve to document callippe silverspot butterfly presence on the bank (WRA, Inc. 2018, p. 11), but are not intensive enough to estimate abundance or population trends. For example, a survey in 2017 documented 2 callippe silverspot butterflies, confirming presence but not indicative of a robust population.

The hills above Lake Herman are private property, but open spaces near the hills over Lake Herman include the Braito Open Space and Tourtelot Open Space, and Lake Herman Recreation Area (City of Benicia). We do not have information about population status or trends of callippe silverspot butterfly in this area.

Sonoma County population

Habitat at Sears Point is managed by the Sonoma Land Trust (SLT). SLT acquired 2327 acres in 2005; most of this was transferred to San Pablo Bay National Refuge in 2014 but SLT retains the 900-acre upland portion, which is managed as a working cattle ranch. Habitat at Sears Point burned in an October 2017 fire covering over 1,600 acres, overlapping with callippe silverspot butterfly locations known from genetic sampling several years earlier (Figure 13). Hill (2018, p. 2) noted that callippe silverspot butterfly numbers were low at Sears Point during the collection of genetic samples, and it is likely that the population was also hard impacted by the fire. Although fire may stimulate host plant growth, in this case it likely directly killed a large number of larvae in diapause.

Visits in 2019 confirmed presence of *Speyeria* species at the site, although it is not known if the individuals seen were callippe silverspot butterflies or a congener. Individual *Speyeria* butterflies were observed in June and July 2019 nectaring on Himalayan blackberries and on thistles (Rawlinson in litt. 2019; Lantz *et al*. personal observation 2019). Sears Point is also the type locality of *Speyeria zerene sonomensis* (Emmel *et al*. 1998, entire), and it is unknown whether the individuals observed were callippe silverspot butterflies or *S. z. sonomensis*.

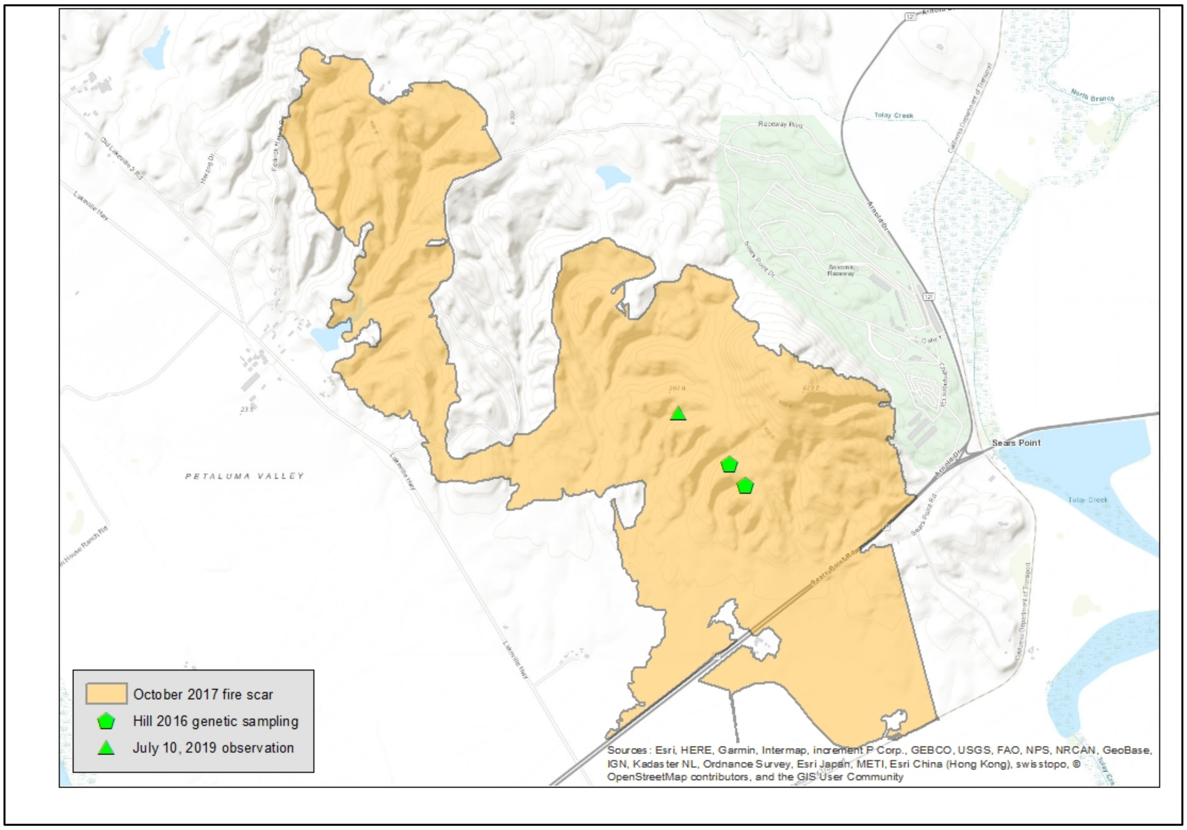

Figure 13. Fire scar from October 2017 and callippe silverspot butterfly observations in recent years. Fire scar from Sears Point staff using overlay of an aerial photo; callippe silverspot butterfly locations from Hill 2018 and a July 2019 observation of an unknown Speyeria individual.

Analysis of Current Condition

We analyzed the current condition of callippe silverspot butterflies in four analysis units according to localities sampled in Hill (2018), but separating the Solano County populations into two groups in accordance with genetics analysis (pp. 11, 17), as described above when discussing Population Trends in Solano County. These analysis units include San Bruno Mountain (San Mateo County), Ferrari Ranch (Solano County), Cordelia Hills (Solano County), and Sears Point (Sonoma County). For a callippe silverspot butterfly population to be considered in high condition, it must meet the needs listed in Chapter 3 of this SSA. At the individual and population levels, we identified habitat needs as large areas of contiguous grasslands with hilltops, nectar plants, and host plants (Table 3 in Chapter 3). Demographic factors that we identified as important in assessing population condition include connectivity, fecundity, abundance, and larval movement. We originally sought to include all of these variables in our analysis of current condition. However, after consulting with experts and taking into account data availability, we made some modifications to our analysis, incorporating an additional habitat category that helps to assess threats to the species, and assessing some demographic needs via habitat categories (Table 8).

To assess the condition of grassland habitat, we quantified the amount of contiguous grassland habitat needed to support a resilient population of callippe silverspot butterflies. These grasslands must include all necessary habitat components, including hilltops, but we do not specifically define high hilltop quality for the species. We also do not identify specific features within the grasslands (e.g., slope aspect, moisture, vegetation such as oak trees, etc.). For a population to be in high condition, we specified that the population needs to have at least 486 hectares (1200 acres) of contiguous grassland habitat, without significant barriers to habitat features within that area. We identified this target size based on long-term evidence of a stable population at San Bruno Mountain, where the persistence of at least 1200 acres is recommended in the Habitat Management Plan based on an analysis of monitoring trends (TRA Environmental Sciences 2008, p. 8). In addition to addressing the habitat need of grasslands, this habitat category also relates to the demographic need of connectivity, as contiguous areas of grassland with all habitat components are necessary for individuals within a population to move around.

Because grassland conversion is an important threat to the species, we specify the upper limits of coastal scrub or chaparral recommended within these grasslands, again using targets recommended in the San Bruno Mountain Habitat Management Plan (TRA 2008, p. II-7). However, we acknowledge and encourage other habitat elements within these grasslands as identified as important resources for callippe silverspot butterflies, including buckeyes (used for nectaring) and oak trees (whose drip lines have been observed to be oviposition sites). When assessing habitat condition, we also include a category related to RDM because non-native annual grasses can limit larval movement, compete with nectar and host plants, and make host plants less accessible to females looking for oviposition sites. We used grazing recommendations from Bartolome *et al*. (2006, p. 3) for coastal grasslands and annual dry grasslands to categorize RDM condition. Both nectar and host plants are also included as habitat factors in our condition category table, as both features are related to fecundity and survival of the species. The abundance and density of host plants also relates to larval movement, another demographic need.

To assess condition of host plants for various populations, we defined a high condition population qualitatively as having sufficient numbers of host plants in dense patches. We also provided quantitative examples of what we would consider sufficient cover or density of host plants based on suggestions in Hill (2018, p. 32) and Damiani (2011, p. 10), although we acknowledge that the conditions assigned to specific populations was made using qualitative reports and communication with species experts, not quantitative data on host plant abundance (because these data are not currently available). For nectar plants, we defined both high and moderate condition categories as having sufficient numbers of host plants. We specified that high condition was obtained when there was a sufficient number of native nectar plants, whereas moderate condition populations could also rely on non-native species used by the callippe silverspot butterfly (e.g., thistles). The presence of native nectar sources is associated with habitat quality in other butterfly species (e.g. Schultz and Dlugosch 1999, pp. 234-235) and is a better assessment of what historical high quality habitat would look like, thus indicating habitat that could support long-term populations of callippe silverspot butterflies.

To assess the demographic condition of the populations we focus on maximum sightings per hour, which we assume correlates with adult abundance. Because the species is univoltine, the number of adults in any given year directly influences the population in the next year. Although we specify the maximum sightings per hour in our table, we acknowledge that this measure relies on sampling throughout the flight period and it is impossible to know whether a stand-alone count is accurately assessing the peak of abundance. Because of the variation in the length of the flight period between years and potentially populations, we determined that maximum sightings per hour was easier to compare across years and locations. For populations that only have monitoring at one time period, we rely on this measure even though it is unlikely to be the true peak. For populations with monitoring across locations, we average maximum sightings per hour across monitoring transects when assessing this variable. The other demographic needs are all considered in relation to habitat categories, as described above. We defined a population as having a high condition for abundance if it had at least 20 adults sighted per hour, which corresponds to the observation by Hill (2018, p. 32) that in “healthy, robust” populations of *Speyeria callippe* butterflies he was able to net at least 10 per half hour. We note, as did Hill, that counts may actually be higher than the number netted, but feel that the categorization uses the best available information to quantify abundance (based on the comparison of this metric to long-term monitoring observations at San Bruno Mountain).

Table 8. Condition category table describing high, moderate, and low conditions for habitat (contiguous grasslands, RDM, nectar plants, and host plants) and demographic (adult abundance) categories used to assess the resiliency of callippe silverspot butterfly populations.

Condition	Contiguous grasslands	Residual dry matter (RDM)	California golden violet	Nectar plants	Adult abundance
High	Contiguous grassland of at least 486 hectares (1200 acres[1]), including connectivity between habitat needs, with less than 30% coastal scrub or chaparral succession[2]	Grasslands managed to have RDM of 800 to 2100 pounds per acre[3], depending on habitat type (e.g. coastal prairie vs. dry annual grasslands) and in agreement with habitat grazing plan	Sufficient patches of habitat with dense host plants (e.g. , coverage of host plants of 0.36 cm or greater linear cover per linear cm of transect on line intercept transects, or density of greater than 16 violets per meter)[5]	Sufficient numbers of native nectar plants, including preferred nectar plants (e.g. California buckeye, *Monardella* spp.)	Sightings of at least 20 adults per hour[6]
Moderate	Contiguous grassland of at least 243 hectares (600 acres) including connectivity between habitat needs, with less than 40% coastal scrub succession	Grasslands with 300 to 800 or 2100 to 2800[4] pounds per acre RDM	Dense patches of host plants available, but potentially limiting	Sufficient numbers of native and non-native nectar plants	Sightings of at least 10 adults per hour
Low	Contiguous grassland less than 243 hectares (600 acres)	RDM of less than 300 or greater than 2800 pounds per acre	Host plant present in unknown numbers	Abundance of nectar plants is potentially limiting	Species observed

[1] This is the minimum number of acres grassland recommended at SBM (HMP 2007, p. II-7).

[2]Having coastal scrub 70% controlled is a habitat success criteria in the SBM HMP (p. II-7).

[3]These are recommended RDM levels for coastal prairie and annual grasslands from Bartolome 2006.

[4]Host plants persist at SMB with RDM up to 2750 lbs/acre, and Ridge Top Ranch is managed at less than 800 lbs/acre.

[5]Violet densities representative of high quality habitat are taken from Hill 2018 and Damiani 2011

[6]Hill 2018 noted an average of 10 butterflies were netted per half hour in "healthy, robust" populations, although he noted that counts would likely be higher.

The criteria presented in our conditions category table (Table 8) were used to determine the overall current condition of each callippe silverspot butterfly population (Table 9). A detailed assessment of our analysis for each population is provided in Appendix B. To assess overall condition for each population, we assumed that abundance was twice as important as any individual habitat category when assessing population resiliency. Relative weights were assigned to each factor to maintain these relationships: 2x for Abundance, and 1x for all habitat categories. Each analysis unit was given a numeric score relative to each category (1 for low condition, 2 for moderate condition, and 3 for high condition), and a population's overall condition score was then calculated as the sum of all the factor scores multiplied by their relative weights. Categories with unknown conditions were conservatively given a score of 1, assuming that the population was in low condition for that category. We next translated the overall condition score into an overall current condition category of low, moderate, or high. A complex with all low, all moderate, or all high ratings for the factors would have overall conditions scores of 6, 12, or 18, respectively. We took the difference between the lowest and highest possible overall condition scores and divided this into three equal intervals representing the breadth of possible scores. A score of less than 10 means the complex is in overall low condition, a score greater than 14 means the complex is in overall high condition, and scores between 10 and 14 mean that the complex is in moderate condition. We rounded down if a population score fell on the cusp between categories (i.e., a score of 10 or 14). The overall condition represents the current resiliency of each population. Current condition for each of the populations is described below and summarized in Table 9.

Table 9. Current condition table rating callippe silverspot butterfly populations as high, moderate, or low in habitat and demographic categories. The overall ranking is a measure o the current resiliency of the populations.

County	Population	Contiguous grasslands	Residual dry matter (RDM)	Host plants	Nectar plants	Adult abundance	Overall
San Mateo	**San Bruno Mountain**	Moderate	Moderate	High	High	Moderate	Moderate
Solano	**Ferrari Ranch**	High	Moderate	Low	Unknown	Low	Low
	Cordelia Hills	High	Moderate	Moderate	Low/Unknown	Low/Unknown	Low
Sonoma	**Sears Point**	High	Moderate	Moderate	Unknown	Low	Low

San Bruno Mountain (San Mateo County)

The most recent estimate of grasslands at San Bruno Mountain is 944 acres, using visual analysis of aerial imagery. However, this assessment uses a definition from the California Manual of Vegetation (Sawyer *et al*. 2008) to define habitat with greater than 10 percent shrub cover as shrubland (Weiss *et al*. 2015, pp. 57-58). In contrast, the Habitat Management Plan does not have clear definitions for vegetation classification, and specifies as a goal that mountain-wide coastal scrub should be 70 percent controlled within all grassland habitats (further clarifying that in some areas, such as south-facing slopes, that a 90 percent criterion for an appropriate objective for coastal scrub control) (TRA Environmental Sciences 2008, p. II-4). We conservatively assume that the grassland acreage falls within the moderate condition category, which also agrees with the latest San Bruno Mountain annual report identifying scrub encroachment as a management priority until the minimum threshold of 1200 acres is achieved (Ormshaw 2018, p. 54). Lack of disturbance (or grazing) at the site has led to slow but steady succession of grasslands to coastal scrub, and is also associated with high RDM levels. RDM levels were as high as 9,300 pounds per acre, but were 2750 and 2850 pounds per acre in areas known to have host plants for the callippe silverspot butterfly (Weiss *et al*. 2015, p. 81), placing the condition as moderate for this population. The numbers of host plants and nectar plants (including native plants) are thought to be sufficient for the species across the landscape as a whole, although might be limiting in some site-specific areas (Ormshaw *in litt*. 2019). Long-term monitoring at San Bruno analysis shows a fluctuating but stable population (see *Current Population Trends* above), although potential declines in counts on some transects should continue to be monitored to see if this is a real trend. In 2018, the average maximum sightings per hour across transects was 18.9, while the average sightings per hour was 7.9 (Ormshaw 2018, p. 8).

Ferrari Ranch (Solano County)

Ferrari Ranch is directly bordered by Lynch Canyon Open Space and private property to the west. The north and south of the ranch are bordered by highways, which would reduce movement across these routes. We assessed the current condition of Contiguous Grasslands as high because of the combined acreage of Lynch Canyon Open Space and Ferrari Ranch, although the status of callippe silverspot butterflies or habitat requirements for the species at Lynch Canyon is unknown. Ferrari Ranch is grazed according to a management plan for the Preserve. Monitoring in 2017 at 10 points resulted in RDM estimates ranging from 700 to 3,400 pound per acre. Because we are uncertain where these RDM levels are located related to callippe silverspot butterfly concentrations, we placed the population in moderate condition for the RDM category (we also assume that grazing at Lynch Canyon Open Space results in similar RDM levels at that property). Host plant populations at the preserve have been mapped but are in isolated patches on the property (Westervelt Ecological Services 2016, p. 10), translating to low condition. The condition of nectar sources at the site is unknown. Surveys for callippe silverspot butterfly occur every 5 years (beginning in 2016), resulting in documentation of species presence in low numbers. The overall condition of the Ferrari Ranch populations is Low.

Cordelia Hills (Solano County)

Contiguous grassland habitat connects the populations within the Cordelia Hills populations, and we assume that there are not barriers to habitat requirements for the species across this area. Although habitat at King-Swett Ranches and Ridge Top Ranch is grazed, monitoring reports show that RDM levels tend to be those that we place in moderate or high condition. We are unaware of land use with regard to grazing on the private property inhabited by callippe silverspot butterflies on the hills above Lake Herman, and therefore assume that the overall area has moderate RDM condition. Within the Cordelia Hills population, host plants have been mapped at King-Swett and Ridge Top Ranches, which demonstrate dense patches on these properties although the distribution or amount is potentially limiting. Nectar sources have not been mapped recently, but a report on nectar sources at King/Swett Ranches observed that movements of approximately 1 mile to visits buckeye trees indicates that the quality and abundance of nectar source on the site may be inadequate (Arnold 2007, p. 10; Phytosphere 2007, p. 1). The only area with recent monitoring in the Cordelia Hills population is Ridge Top Ranch, which has low numbers of sightings (WRA, Inc. 2018, p. 11).

Sears Point (Sonoma County)

There are over 1,200 acres of contiguous grassland habitat surrounding the Sears Point population, although not all of this land is protected. The upland habitat of the San Pablo Bay NWR, managed by the Sonoma Land Trust, consists of 900 acres, with the Sonoma Raceway to the east. Tolay Lake Regional Park to the north of Sears Point also offers protected grassland habitat, although the suitability of specific habitat features at this park are unknown. In between Sears Point and Tolay Park is an easement held by the Sonoma County Agricultural Preservation and Open Space District that has no known mandate for biodiversity protection (CPAD 2019). Although Sears Point is grazed and has a grazing management plan (Bush 2006, entire), that document notes variation in grazing levels throughout the property and "high" RDM across a number of pastures (p. 2). We are not aware of more recent RDM estimates, or of the RDM levels in areas where callippe silverspot butterflies have been observed, but based on grazing on the site we assigned the population as being in moderate condition for this category. Host plants are reportedly widespread at the site (Meisler *in litt*. 2019), and we placed the population in moderate condition in this category. However, a recent visit to the site by Service biologists noted low levels of nectar plants in the areas with past callippe silverspot butterfly observations (Lantz *et al*. 2019 pers. obs.). Since the 2017 fire on the property, we are only aware of limited *Speyeria* observations in 2019, and the species is unknown (because of potential for both callippe silverspot butterflies and *S. z. sonomensis* to be at the site) (Rawlinson *in litt*. 2019; Lantz *et al*. 2019 pers. obs.). Overall, the Sears Point population is in low condition.

SYNOPSIS OF CURRENT CONDITION

According to our basic analysis of relevant factors, the callippe silverspot butterfly currently has one population in overall moderate condition and three populations in overall low condition across its range (Figure 14). These populations are distributed across the contemporary range of the species (relative to genetic analysis Hill 2018). As described in *Range and Distribution* above, the species is extirpated in Alameda and San Francisco Counties. While habitat factors (Contiguous Grasslands, RDM, Host Plants, and Nectar Plants) vary from low to high condition among the populations, the demographic factor assessed (Adult Abundance) was Low or Unknown for most populations (with the exception of San Bruno Mountain, which was Moderate) (Table 9). If we summarize these results across the three counties that have the species, Solano County has two populations in low condition, the population in Sonoma County is in low condition, and the population in San Mateo County is in moderate condition. Because of the genetic distinctiveness across these counties, achieving resilient populations within each of these counties is important for species representation.

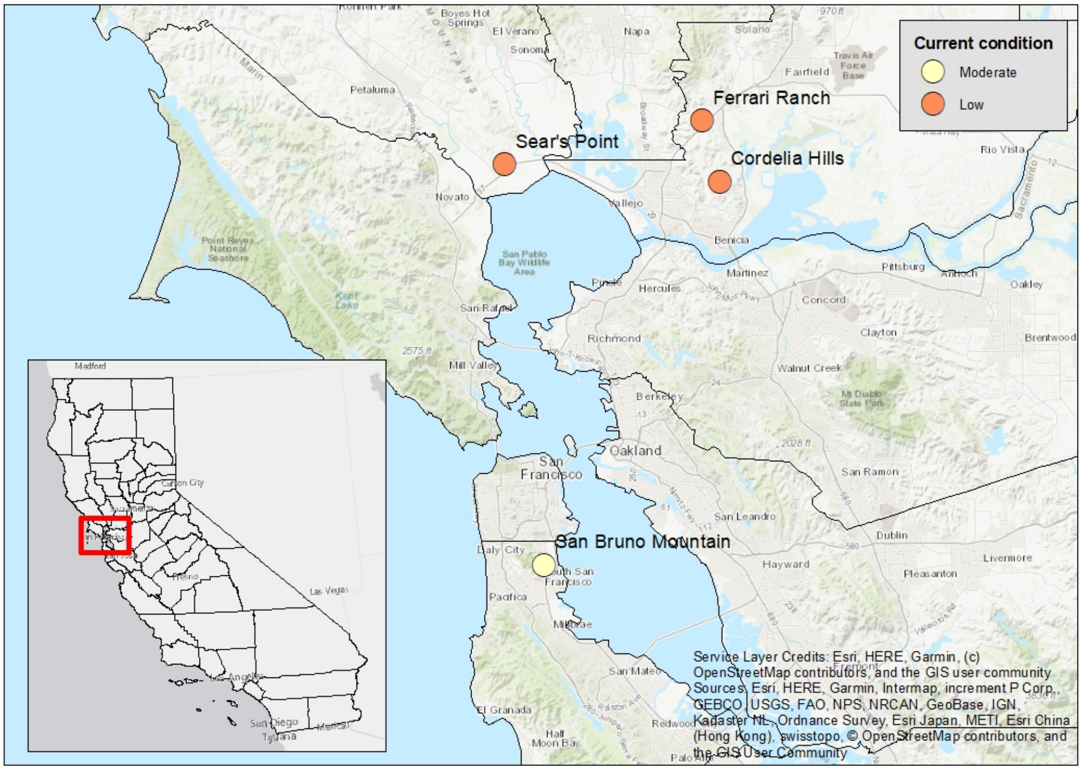

Figure 14. Current condition of callippe silverspot butterfly populations.

Chapter 5. Future Condition

In this chapter, we predict the future conditions of the four callippe silverspot butterfly populations under three potential scenarios of changes in threats and management efforts. This analysis will help us predict how viability of the callippe silverspot butterfly may change in the future. We discuss callippe silverspot butterfly resiliency, representation, and redundancy in the context of these scenarios.

Before discussing the scenarios and analysis results, we first describe how factors influencing viability are expected to change in the future, assessing current factors in the context of climate change.

Factors influencing viability in the future

In this section we discuss climate change and the potential interaction between climate change and current threats to the species. We use the best available science to assess the interplay between climatic changes and other ongoing threats may influence callippe silverspot butterfly resiliency.

Climate Change

There is consensus that the increase in greenhouse gas (GHG) emissions during the 20th century resulted in global climate change characterized by: warming atmospheric and ocean temperatures, diminishing snow and ice, and rising sea levels (Intergovernmental Panel on Climate Change (IPCC) 2014, pp. 2-3). Climate models for California under various emissions scenarios predict an overall warming of 1.7 to 5.8 degrees Celsius (3.0 to 10.4 degrees Fahrenheit) from 2000 to 2100 (Cayan *et al.* 2008, p. 7). Climate change is also associated with changes in precipitation. Total annual precipitation did not significantly change from 1950 to 2010, but models in general show an increase in precipitation under various emissions scenarios. Despite overall predictions of increased precipitation, hotter temperatures are expected to increase the probability of drought (Diffenbaugh *et al.* 2015, pp. 3932-3933). Moreover, precipitation extremes are expected to increase, as evidenced by a prediction for higher frequency of both extremely wet and extremely dry years (Swain *et al.* 2018, pp. 427-433).

The number of wildfires in California has increased greatly since the 1970s, with increasing numbers of large and destructive fires and a link to human-induced climate change. Increases in wildfire activity were especially pronounced in forested areas. Although the correlation between burned area and climate was relatively weak in the Central Coast, the relationship between aridity and burned area in the state make it likely that the affects from wildfire will continue to increase (Williams *et al*. 2019, entire).

Climate change impacts in National Parks in the San Francisco Bay Area are summarized, including original analyses, in Gonzalez 2016 (entire). Models summarized in Gonzales (2016) predict increased temperatures and tend to predict increased precipitation (two-thirds of models, although one-third predict reduced precipitation). It is likely that the data and trends presented in Gonzalez (2016) are representative of expected impacts for callippe silverspot butterflies in San Mateo and Sonoma Counties, although we note that climate change impacts may change slightly as distance from the coast increases. For example, temperature changes are expected to increase further from the coast, while precipitation increases are expected to decrease (Gonzalez 2016, p. 7). Other documents referenced in this section also provide more details about expected changes under various general circulation models (GCMs) and Representative Concentration Pathway greenhouse gas trajectories.

Direct changes to callippe silverspot butterflies from climate changes are difficult to predict. In warmer temperatures, adults may be able to warm up earlier and spend more time at optimal foraging temperatures. In other butterfly species, such as the bay checkerspot (*Euphydryas editha bayensis*), larvae on warmer slopes developed faster than larvae on cooler slopes (Weiss *et al.* 1988, pp. 1490-1491). Indirect affects to callippe silverspot butterfly habitat, or interactions between callippe silverspot butterflies and their habitat, are more likely to have potential consequences for the species.

One of the most serious potential changes that could result from climate change would result from a mismatch between phenology of the callippe silverspot butterfly relative to its host plant. Phenological shifts have been demonstrated across a variety of taxa, with accelerated changes associated with climate change (reviewed in Thackeray *et al.* 2010, entire). Potential for phenological mismatch related to host plant availability for bay checkerspot butterfly, and the relationships between microtopography, thermal environment, and larval growth, can influence survival for that species (Weiss *et al.* 1988, p. 1491). Before further discussing the bay checkerspot butterfly phenology mismatch, it is important to note that the bay checkerspot butterfly has a very different life cycle from callippe silverspot butterfly. Adult bay checkerspot butterflies emerge from pupa in early spring and lay eggs which hatch within ten days. These larva feed on host plants and reach their fourth instar after approximately two weeks, after which they enter diapause (Service 2009c, p. 7). Temporal asynchrony in some years between bay checkerspots and their host plants meant that some adults emerged too late to successfully oviposit, or that some larvae were unable to grow large enough to enter in to diapause before their host plants senesced (Weiss *et al.* 1988, p. 1492), which in some months and years can lead to severe declines (Singer 1972, p. 75). Although callippe silverspot butterflies undergo diapause at a different time in their life cycle, the potential for disconnect between larvae and their hosts plants is of concern. Likewise, differences in phenology could lead to adults emerging when there are fewer nectar plants available to provide the necessary energy for egg development and oviposition. Evidence of variation in the length and timing of the flight period for callippe silverspot flight period (see *Life History* above) suggests additional potential for temporal asynchrony of callippe silverspot butterflies and its habitat (but also potential flexibility).

Other potential effects of climate change are also a result of indirect changes to callippe silverspot habitat and exacerbation of existing threats. For example, increased precipitation could lead to increases in non-native annual grasses and native scrub encroachment. In turn, this has the potential to: increase competition with nectar and host plants; decrease larval movement; decrease survival in larva if they are unable to find sufficient numbers of host plants; decrease ability of adult females to find oviposition sites; increase potential for fire, which could lead to catastrophic fires that could reduce callippe silverspot butterfly abundance, particularly having the potential to affect the egg, larval, and pupal life stage. These changes would be less severe in habitat with active grazing as management, as flexibility in the managing the number of cattle on the land could mitigate some of these changes.

Another habitat feature associated with callippe silverspot butterfly habitat with potential to change in the future is fog. Studies demonstrate that Pacific coast and Bay Area fog has decreased in recent years relative to the beginning of the century (Johnstone and Dawson 2010, p. 4534), potentially associated with urbanization and pollution (summarized in Ackerly *et al.* 2018, pp. 25-27). Future changes in the fog belt related to climate change are possible, but there is a lot of uncertainty because of the interplay between heat and humidity across various sources (i.e., land, ocean, air). Weiss *et al.* (2015, p. 101) identifies the ways in which summer fog can affect callippe silverspot habitat, including: reducing and diffusing solar radiation; increasing humidity; and providing local fog drip (Weiss *et al.* 2015, p. 101). Although the range of callippe silverspot butterfly at San Bruno Mountain is generally outside the fog line (Weiss and Murphy 1990, p. 56), changes in fog levels across the Bay Area can influence soil and vegetative characteristics that have the potential to influence eggs, larvae, or pupae. For example, in areas where callippe silverspot butterflies have been observed ovipositing along oak tree drip lines (Hill 2018, pp. 29-30), changes in fog levels could influence larval survival because reduction in local drip along those lines could alter soil moisture or otherwise affect the species. The melanic coloration associated with the callippe silverspot butterfly phenotype is also likely influenced by fog and associated climatic conditions; decreases in fog could potentially select for lighter-colored butterflies. However, the range of *Speyeria callippe* throughout the United States and in a variety of climates suggests that the species does not rely on fog per se. The presence of Comstock's silverspot butterfly in areas directly adjacent to the fog belt emphasize the ability of the *Speyeria callippe* species to persist in areas without fog.

Descriptions of Future Scenarios

For our analysis of the callippe silverspot butterfly's future condition, we constructed two future scenarios focused on changes in threats and management efforts. We projected each scenario 30 years into the future because species experts recommended a short time frame for evaluation (Service 2019), because of the current uncertainty in adult abundance for several populations, and because of uncertainty in how climate change affects to habitat will influence the species. Despite the discussion above in how climate change will affect local habitats and influence the species, we do not carry these potential changes into our analyses because of uncertainties in the species' response in relation to the magnitude of climate changes expected within this time frame. Although the risk of wildfires is expected to increase across California, we do not carry this risk forward in our analysis because of the weak trend within the species range between summer wildfires and anthropogenic climate change so far, but acknowledge that large-scale wildfires in any of the populations would be a huge threat to any given population.

The first scenario assumes "business as usual." We assume that management practices (including grazing, habitat management, etc.) are maintained at current levels and that threats to the species also continue at current levels. In the second scenario, we assume that management increases from current levels, which has the potential to counteract some of the current threats to the species.

Future Condition Summary

San Bruno Mountain (San Mateo County)

Scenario 1

In this scenario, we assume that despite ongoing management actions to limit succession, the transition from grasslands to coastal scrub continues at a slow rate such that the condition for contiguous grasslands continues to be in moderate condition. Given this "business as usual" scenario, we do not predict changes to the other categories, as evidenced by an assessment of 30 years of maintenance and monitoring associated with the San Bruno Mountain Habitat Conservation Plan. Overall, the San Bruno Mountain population remains in Moderate overall condition in this scenario.

Scenario 2

Even with effective habitat management, given current funding and trends it seems unlikely that grassland habitat would increase to the minimum recommended threshold of 1200 acres recommended in the Habitat Management Plan. However, if the cattle grazing experiment proposed at San Bruno Mountain is successful, it is possible that grazing in some areas could increase the condition related to RDM. We tentatively increased condition of RDM in this scenario, although we acknowledge that this is reliant on funding which at this stage is unclear if it will be available. The population overall condition increases to high in this scenario.

Ferrari Ranch (Solano County)

Scenario 1

Because both Ferrari Ranch and Lynch Canyon Open Space are on protected lands, the contiguous grassland category condition in this scenario remains high. However, we note that the presence of highways to the north and south of Ferrari Ranch could be a barrier for callippe silverspot butterflies if they travel in either of these directions to access high quality nearby habitat (although the presence of such habitat, and callippe silverspot butterfly movements and use of the area, are unknown). We assume that grazing would continue and that RDM levels would remain similar to current levels. Without targeted management for nectar and host plants, it is unlikely that the condition of these habitat factors would increase. We assumed that abundance would remain low in this scenario. The population overall condition remains low in this scenario.

Scenario 2

Assumptions under this scenario were similar to those under Scenario 1, therefore the overall population resiliency remained low. The only change between the two scenarios was to nectar plant conditions, which are currently unknown. We assumed that there was restoration targeting host plants (or surveys identified sufficient numbers) so that this habitat factor increased to moderate condition. We did not change host plant condition or adult abundance under this scenario. Despite successful seed germination in lab studies, propagation techniques for the host plant in the field are still unclear and require further study. We assumed that increases to adult abundance were unlikely until host plant numbers increase.

Cordelia Hills (Solano County)

Scenario 1

Because of the large extent of contiguous grasslands in the area, we assume that in the "business as usual" scenario that this category remains in high condition. We assume that grazing continues at current levels and that there is no management targeted towards nectar or host plants, with no changes to the condition in these categories. We assumed that Abundance would remain low in this scenario. The population overall condition is low in this scenario.

Scenario 2

Conditions for contiguous grasslands and RDM are unchanged in this scenario. However, we assume that management for nectar and host plants increases habitat conditions for these categories into moderate condition. We conservatively assume that callippe silverspot adult abundance remains low within this timeframe, but improvements to habitat features improve the overall condition of this population to moderate.

Sears Point (Sonoma County)

Scenario 1

Because the area to the north of Sears Point does not have a known mandate for biodiversity protection (CPAD 2019), there is moderate probability in the next 30 years that connectivity among habitat features between the properties could be reduced. Therefore, we moved contiguous grassland condition into moderate condition in this scenario. We assumed that in this scenario that conditions in other habitat categories would remain unchanged. Due to the recent observations that nectar sources appear limited, combined with the large-scale recent fire on the site and limited observations in recent years, we assumed that without targeted management at the site that this population would remain low or could become extirpated in this scenario.

Scenario 2

In this scenario, we assume that there are no changes in condition for the contiguous grassland category, assuming that connectivity remains high across Sears Point and land to the north. We assume that coordination with partners targets grazing in areas occupied by callippe silverspot butterflies, raising the condition in the RDM category to high. We did not change the condition for host plants in this scenario. Despite recent studies related to germination in violets, the habitat conditions in the field related to host plant success are still unclear, and it is not clear if management would improve host plant condition at the site. However, planting nectar sources in areas used by the butterflies could improve the habitat condition in this category. Improved habitat conditions at the site (for RDM and nectar plants) could lead to modest increases in callippe silverspot abundance, but we conservatively leave the abundance condition as low in this scenario. However, the increases in several habitat conditions as described raise the overall condition to moderate condition in this scenario.

Synopsis of Future Condition

In Scenario 1, one population would be in moderate condition, two populations would be in low condition, and one population would be low or extirpated (Table 10, Figure 15). Three populations had the same overall resiliency as they do currently, with some changes to condition within individual habitat categories that suggest subtle decreases in resiliency across the populations. The recent wildfire at Sears Point, combined with low condition across several habitat categories for this population, makes it likely that in this scenario the Sears Point population would either remain in low condition or be functionally extirpated. If the Sears Point population were to become functionally extirpated, this would significantly reduce representation and redundancy for the species.

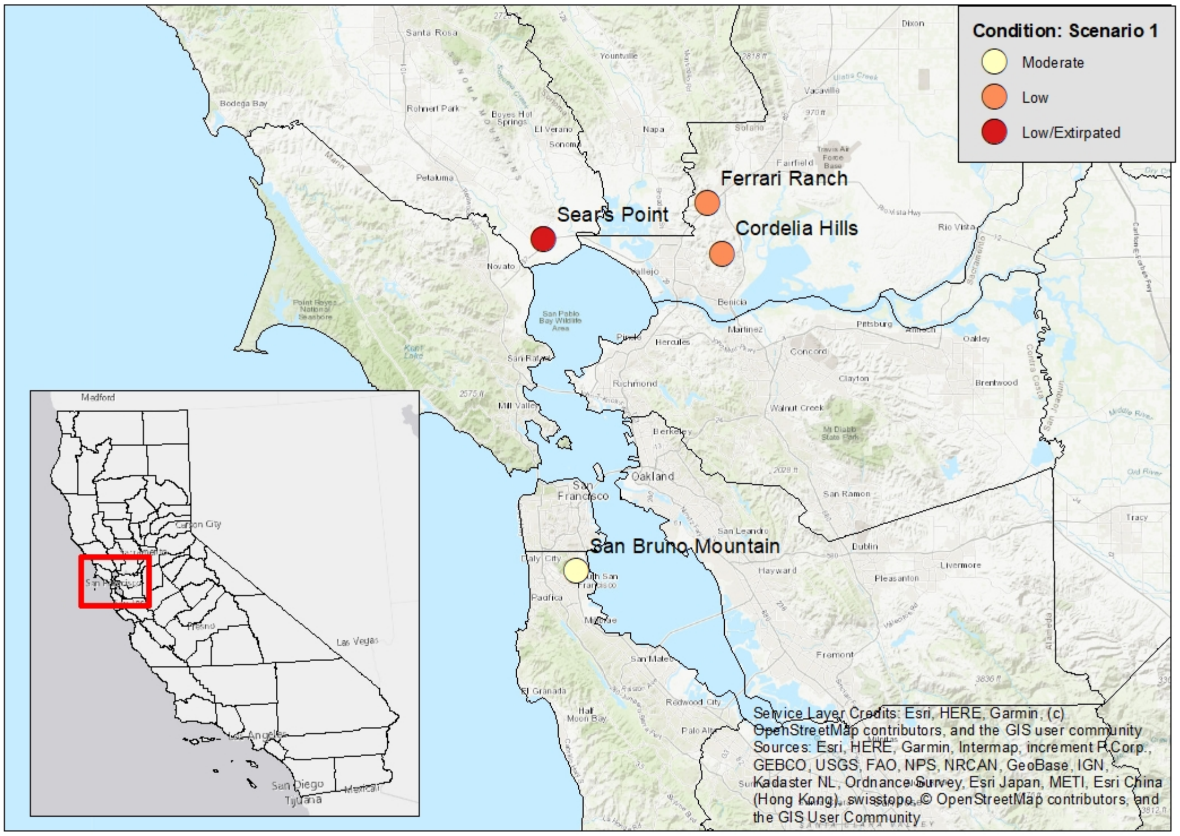

Figure 15. Potential future condition under Scenario 1.

In Scenario 2, three populations have increases in overall resiliency; one population is in high condition, two populations are in moderate condition, and one population remains in low condition (Table 11, Figure 16). The increases in resiliency are spread across the three counties that have callippe silverspot butterflies, signaling an increase in representation in this scenario. Redundancy stays the same, but the increases in population health make the continued redundancy of the species more likely.

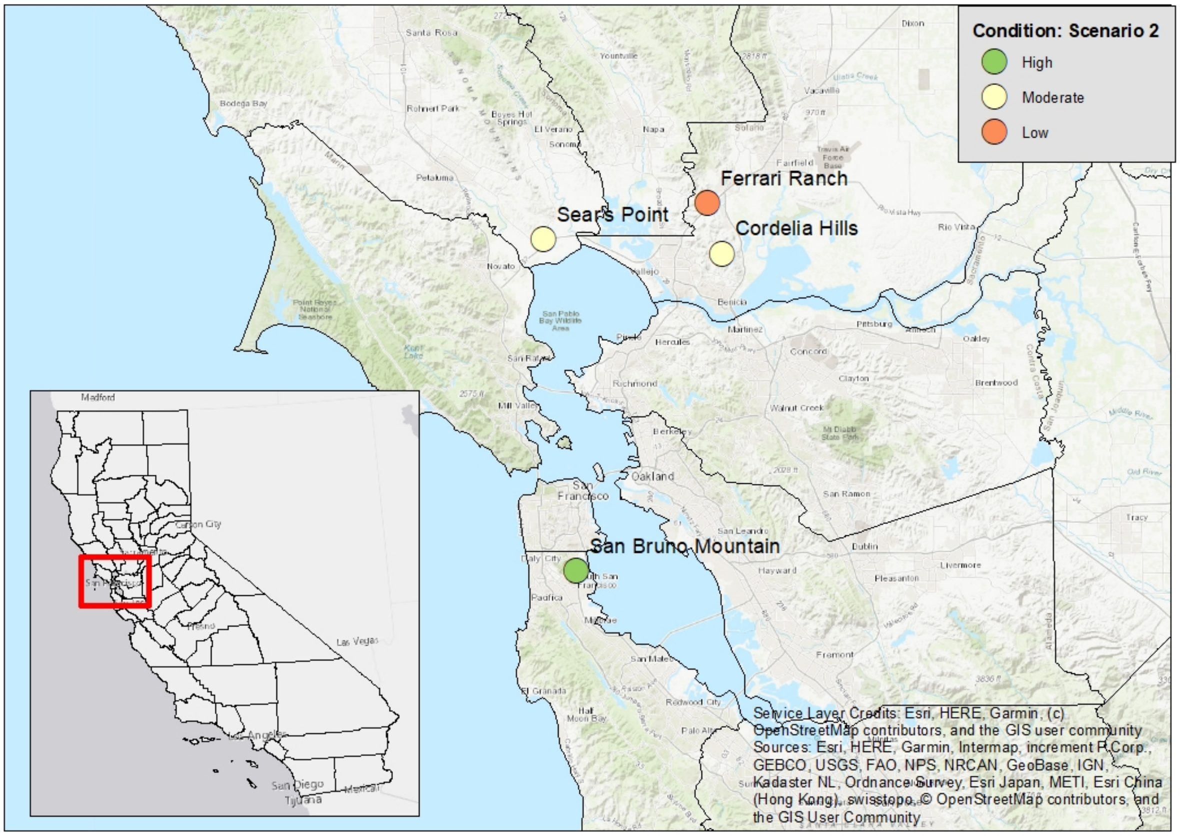

Figure 16. Potential future condition under Scenario 2.

Table 10. Potential future condition under Scenario 1.

County	Population	Contiguous grasslands	Residual dry matter (RDM)	California golden violet	Nectar plants	Adult abundance	Overall
San Mateo	San Bruno Mountain	Moderate	Moderate	High	High	Moderate	Moderate
Solano	Ferrari Ranch	High	Moderate	Low	Unknown	Low	Low
	Cordelia Hills	High	Moderate	Moderate	Low	Low	Low
Sonoma	Sears Point	Moderate	Moderate	Moderate	Unknown	Low/Extirpated	Low/Extirpated

Table 11. Potential future condition under Scenario 2.

County	Population	Contiguous grasslands	Residual dry matter (RDM)	California golden violet	Nectar plants	Adult abundance	Overall
San Mateo	San Bruno Mountain	Moderate	Moderate	High	High	Moderate	High
Solano	Ferrari Ranch	High	Moderate	Low	Moderate	Low	Low
	Cordelia Hills	High	Moderate	Moderate	Moderate	Low	Moderate
Sonoma	Sears Point	High	High	Moderate	Moderate	Low	Moderate

Chapter 6. Species Viability

We have considered what the callippe silverspot butterfly needs at the individual, population, and species-level and how these habitat and demographic requirements relate to species viability (Chapter 3), and we evaluated the species' current condition in relation to those requirements (Chapter 4). We also forecast how the species' condition may change in the future under two plausible scenarios (Chapter 5). In this chapter, we synthesize the results from our historical, current, and future analyses and discuss potential consequences for the future viability of the callippe silverspot butterfly, with emphasis on resiliency, redundancy, and representation.

Resiliency

Resiliency describes the ability of the species to withstand stochastic disturbance events, an ability that is associated with population size, growth rate, and habitat quality.

Historically, the callippe silverspot butterfly experienced habitat loss and degradation which led to the extirpation of populations in two counties: San Francisco and Alameda. Surveys and genetic analyses since listing the species have identified additional callippe silverspot occurrences in Sonoma and Solano Counties. Currently, the populations continued to be threatened by habitat degradation to their grassland habitat, including competition with non-native species that threaten nectar and host plants for callippe silverspot butterflies and thatch build-up that can reduce survival in callippe silverspot butterfly larvae. We used the best available science to assess the resiliency of current populations across the species range. Based on the habitat and demographic factors in our analysis, the species has one population in moderate condition and three populations in low condition.

Analysis of condition across two plausible scenarios showed different outcomes for the populations. In the "business as usual" scenario, there were subtle decreases to habitat factors for the species, but the overall condition of three of the populations did not change. The Sears Point population has the potential to remain low or become functionally extirpated in this scenario. Importantly, there is ongoing management within habitat occupied by all of the current extant populations, and the continuation of this management is necessary to avoid significant losses to population resiliency. In the second scenario, three of the populations had increases in overall condition, signifying potential increases in population resiliency. These changes assume increases in management, with specific activities including planting nectar plants and lowering RDM.

Redundancy

Redundancy describes the ability of a species to withstand catastrophic events, an ability that is related to the number, distribution, and resilience of populations.

Callippe silverspot butterfly populations in three different counties are all genetically distinct, making it important to maintain resilient populations within each of these counties. The loss of populations in Alameda and San Francisco Counties reduced redundancy for the population both by lowering the number of populations and limiting the spatial distribution. Currently, redundancy is low: none of the populations are highly resilient, and only one county has two populations, both of which are in low condition. Increases in resiliency of populations is important to improve redundancy for the species. Although it is unlikely that a catastrophic event could extirpate the species entirely, the genetic distinctiveness within each county makes it possible that a large catastrophic event (such as an intense fire) could eliminate the species from one of these areas.

In two plausible future scenarios, the first does not improve redundancy for the species. However, Scenario 2 increases resiliency of a population in two of the three counties, therefore signifying the potential for restoration to improve redundancy.

Representation

Representation describes the ability of a species to adapt to changing environmental conditions, which is related to the breadth of genetic and ecological diversity within and among populations.

The callippe silverspot butterfly currently has low representation. Although it maintains populations across all three genetically distinct areas in the species range, the resiliency of populations within two of these counties is low. Loss of populations in Alameda and San Francisco Counties also likely reduced the representation for the species by lowering genetic diversity, and a large-scale disturbance such as a fire could reduce representation further by eliminating another population. Maintaining resilient populations across all three counties where the species occurs is important in maintaining the current genetic diversity of the species. In one future scenario, the population in one county has the potential to be extirpated, which would reduce representation by eliminating the genetic diversity in that region. In the second future scenario, resiliency of populations tends to increase which would also increase representation by making it less likely that genetic diversity would be lessened. Continuation of management and specific actions targeted towards increasing populations, particularly within Solano and Sonoma Counties (where the populations are currently in low condition), will be critical for population representation and species viability.

Status Assessment Summary

We used the best available information to evaluate the current condition and forecast the likely future condition of the callippe silverspot butterfly. Our goal was to describe the viability of the species in a manner that will address the needs of the species in terms of resiliency, representation, and redundancy. We considered the possible future condition of the species by considering two potential scenarios that we think are plausible in the near future (30 years). Our analysis of current condition in comparison with future condition in these potential scenarios is shown in Table 12.

The callippe silverspot butterfly faces a variety of risks at the individual, population, and species levels. The main factors influencing viability are likely habitat degradation, fire, and small population size, although pesticides may also have a population-level affect. Currently, one population has moderate resiliency and the other three populations have low resiliency. Because the species has distinct genetic differences throughout the three counties where it occurs, both representation and redundancy are relatively low for the species. In the future, continued threats from habitat degradation in particular threaten to reduce population resiliency. Results of our analysis across two scenarios present two alternatives for the species, one with potential decreases in resiliency, representation, and redundancy and one with increases in resiliency and representation. Both scenarios rely on continued management of species' habitat. If the population in one of the counties were to become functionally extirpated, this would have significant effects on species representation and redundancy. However, continued and focused management actions have the potential to increase resiliency throughout the range.

Table 12. Current and future condition summary.

County	Population	Current Condition	Scenario 1 Condition	Scenario 2 Condition
San Mateo	**San Bruno Mountain**	Moderate	Moderate	High
Solano	**Ferrari Ranch**	Low	Low	Low
	Cordelia Hills	Low	Low	Moderate
Sonoma	**Sears Point**	Low	Low/Extirpated	Moderate

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APPENDIX A

Summary of Peer Review Comments

We solicited independent peer review between the draft and final revisions in accordance with the requirements of the Act from local, state, and federal agencies; academic researchers, and scientific groups. Criteria used for selecting peer reviewers included their demonstrated expertise and specialized knowledge related to the callippe silverspot butterfly. The qualifications of the peer reviewers are in the decision file and the administrative record for this Species Status Assessment. In total, we solicited review and comment from three peer reviewers and we received comments from one peer reviewer. The peer reviewer that responded was a representative from a university. In general, the draft Species Status Assessment was well-received by the peer reviewer and garnered supportive comments. The reviewer also provided additional information; we thank the reviewer for these observations and we have added the information where appropriate. Peer review comments ranged from providing minor editorial suggestions to specific recommendations on SSA content and analysis. We considered all substantive comments, and to the extent appropriate, we incorporated the applicable information or suggested changes into the final revised Species Status Assessment. In addition, there were minor editorial edits throughout the document that were incorporated into the revised SSA but did not warrant an explicit response and, thus, are not presented here. Below, we provide a summary of specific comments received from the peer reviewer with our responses. We appreciate the input from the commenter, which helped us to consider and incorporate the best available scientific and commercial information during development and approval of the final Species Status Assessment.

Peer Review:

Peer Review Comment (1): The reviewer suggested we change "A recent phylogenetic analysis created the monophyletic (descended from a common evolutionary ancestor) taxonomic phylogeny for the genus *Speyeria*" to "A recent phylogenetic analysis confirmed the monophyletic (descended from a common ancestor) nature for the genus *Speyeria*."

Response: We have made the suggested change.

Peer Review Comment (2): The reviewer suggested that we remove "evolutionary" from a parenthetical definition of paraphyletic as "descended from a common evolutionary ancestor, but not including all of the descendant groups".

Response: We removed evolutionary as suggested, and also removed the term from the parenthetical definition of polyphyletic.

Peer Review Comment (3): The reviewer commented that it made sense to reference Thompson *et al*. (2019) in the genetics section, discussing confirmation of the 16 canonical *Speyeria* species, in addition to the taxonomy section.

Response: We have added text in accordance with this suggestion.

Peer Review Comment (4): The reviewer suggested that we add in our discussion of Hill *et al*. 2018a that the mtDNA analysis recovered each *Speyeria* species including *S. callippe*.

Response: We have added the suggested text.

Peer Review Comment (5): The reviewer suggested that we edit a sentence saying "butterflies from some populations that have been previously phenotypically identified as callippe silverspot butterflies instead genetically grouped more closely with Comstock's silverspot butterfly", replacing "butterflies instead genetically grouped more closely with..." with "show more mixing with..."

Response: We have made the suggested change.

Peer Review Comment (6): The reviewer suggested that we add that San Bruno Mountain (in addition to Solano County) had butterflies that resembled *callippe* as well as *comstocki*.

Response: We made the suggested addition.

Peer Review Comment (7): The reviewer suggested that we add Hill *et al*. 2018a as a reference when we mention *Speyeria zerene sonomensis* at Sears Point.

Response: We have added the suggested reference.

Peer Review Comment (8): The reviewer suggested that we change "were not included" to "could not be included" when referring to why extirpated populations were not part of the genetic study.

Response: We did not make this change because it is not clear if museum specimens could be included in a future genetic study at some point (if desired). For example, Hill *et al*. (2018a, p. 8) discusses genetic analyses as a potentially useful conservation tool for comparing rare or extinct taxa from museum specimens.

Peer Review Comment (9): The reviewer suggested that in the caption of Figure 2 we mention that populations in the Diablo Range can strongly resemble callippe silverspot butterflies but that they show much more mixing with *S. c. comstocki*. They further commented that these butterflies resembling callippe silverspot butterflies could add to redundancy/representation for callippe silverspot butterflies.

Response: We have added text in the caption to this point. In the Genetics section, we acknowledge admixture with other *Speyeria callippe*. In the representation section, we added that "Mixing with other *Speyeria callippe* subspecies, in addition to fragmentation, may have contributed to genetic differences between the callippe silverspot butterfly populations."

Peer Review Comment (10): The reviewer suggested we add a citation for our statement that 2 km was chosen as a cutoff within which habitat must contain all habitat needs for the species.

Response: We added a reference to movements of 1.6 km, editing the statement to say that we assumed that slightly further movements may be made than those observed.

Peer Review Comment (11): The reviewer suggested that we edit that text in our life cycle diagram saying that after diapause the larvae go through five instars to clarify that they go through six instars total. They suggested that we say "After first instar diapause, larvae go through five more instars."

Response: We have made the suggested change.

Peer Review Comment (12): The reviewer suggested that we edit the Gantt chart to extend larval feeding into March using the light shading.

Response: We have edited the table according to this suggestion.

Peer Review Comment (13): The reviewer suggested we change our parenthetical definition of poikilothermic from "cold-blooded" to "have a variable body temperature."

Response: We have made the suggested change.

Peer Review Comment (14): The reviewer commented that males eat less than females so they pupate sooner and are smaller.

Response: We have added this information into our life history section, and also added that increased time spent in immature life stages could increase mortality for immature females relative to males.

Peer Review Comment (15): The reviewer commented that there is no indication that female callippe silverspot butterflies undergo reproductive diapause, pointing out that *S. coronis* in the Bay Area don't oviposit until September, whereas callippe oviposit in May-July.

Response: We have added this information to the life history section.

Peer Review Comment (16): The reviewer suggested that we add Zaman *et al*. 2014 as a reference for the statement that some *Speyeria* butterfly butterflies lay their eggs near, but not on, the hostplants.

Response: We made the suggested addition.

Peer Review Comment (17): The reviewer suggested that we add a citation (Zaman *et al*. 2014) related to the number of eggs laid by *S. adiaste*.

Response: We made the suggested addition.

Peer Review Comment (18): The reviewer suggested that we add that mortality during larval diapause may also be due to dry hot summer conditions (not just winter conditions).

Response: We have made the suggested addition.

Peer Review Comment (19): The reviewer commented that it is likely that all I have six instars, and that early reports that mention five instars likely mean five in addition to the first.

Response: We have edited our life history text to reflect this point.

Peer Review Comment (20): One reviewer suggested we add Zaman *et al*. 2014 as a reference for timing of larval development.

Response: We have made the suggested addition.

Peer Review Comment (21): The reviewer commented that fog is likely the reason for the melanic phenotype, in relation to our statement that we discuss fog as a habitat component but don't consider it a habitat need.

Response: We added the following text in the Grasslands section of Habitat: "Fog is likely related to the melanic phenotype associated with callippe silverspot butterflies (see discussion above about melanic basal suffusion in Life History). However, evidence of multiple phenotypes at several known populations, including individuals without extensive melanic coloration, suggests that the coloration is an adaptation to climate, rather than fog being a need for the species."

Peer Review Comment (22): The reviewer suggested that that we add that callippe silverspot butterflies fly along trees at the grassland border (in addition to riparian areas).

Response: We have edited the text to include this suggestion.

Peer Review Comment (23): The reviewer commented regarding a statement that host plants leaves may be dried up when callippe silverspot butterflies lay eggs that this is true for other *Speyeria* as well.

Response: We have added this information to that statement to make it clear that this is not unique to this species.

Peer Review Comment (24): The reviewer suggested that we add information about leaf consumption by *Speyeria adiaste* when addressing leaf consumption by callippe silverspot butterflies.

Response: We have incorporated this information as suggested.

Peer Review Comment (25): The reviewer commented that the number of leaves and leaf area are important in addition to host plant density.

Response: We agree; this information is included in the paragraph immediately preceding the one about host plant density. All three types of information are presented without the implication that one is a better method of measuring host plant needs/availability.

Peer Review Comment (26): The reviewer suggested that we add a citation to the statement that adult callippe silverspot butterflies rely on nectar to acquire carbohydrates and amino acids.

Response: We broadened this statement to say that adult butterflies need nectar for nutrients, but do not delve into the specific components (e.g., sugar, amino acids, etc.) of nectar.

Peer Review Comment (27): The reviewer commented that in addition to topographical diversity, having diverse nectar plants is important to ensure that nectar is available throughout the flight season.

Response: We already discussed the importance of diverse nectar sources in the paragraph preceding the one where we talk about topographical diversity, and the relationship between nectar sources availability and population resiliency. We added reference to a study on unsilvered fritillary that demonstrates shifts in nectar source use to emphasize the point made by the commenter.

Peer Review Comment (28): The reviewer suggested that we cite work on *Speyeria adiaste* with regard to movements because this species is more similar to callippe silverspot butterflies than regal fritillary (referenced in the draft SSA).

Response: We added information about *Speyeria adiaste* as suggested.

Peer Review Comment (29): The reviewer commented that connectivity is also related to nectar plants and host plants (in addition to grasslands, as shown in the habitat and demographic needs influence diagram).

Response: We have added arrows showing a positive association between nectar and host plants to connectivity in accordance with this comment.

Peer Review Comment (30): Referencing our section on Representation in Chapter 3, the reviewer commented that restoring a population at Joaquin Miller would help with resiliency and redundancy.

Response: We added a sentence stating that extirpation of callippe silverspot populations has reduced redundancy in the Redundancy section in Chapter 3. We agree what additional populations would add to redundancy for the species (based on the definition in the SSA framework, additional populations of any species by default adds to redundancy). Restoring (or reestablishing in this case) a population is something that could be addressed in the Recovery Plan rather than the SSA.

Peer Review Comment (31): The reviewer commented that the caption for Figure 8 should give more meaning about the colors/shapes/arrows in Figure 8.

Response: We have updated the caption of this figure and of Figure 7 to include this information.

Peer Review Comment (32): The reviewer commented that some of the non-native plant species, including thistles and mustards, can be adult nectar sources.

Response: We have added this information into the text. We also added a blue arrow (to denote an association that can be positive or negative) between non-native plants and nectar sources in the influence diagram (Figure 8).

Peer Review Comment (33): The reviewer commented that additional nectar sources to mention include cobweb thistle (*C. occidentale*) and mule's ears (*Wyethia* spp.), specifically adding that mules ears are common at Sears Point and could be important in early emergence years (because it dries up early). The comment was made in reference to our management/nectar plant section in Chapter 4.

Response: We added this information when discussing nectar plants in Chapter 3.

Peer Review Comment (34): The reviewer commented that it was confusing to have 6 extant sites in Table 7 but 4 populations analyzed for condition.

Response: We added a column to Table 7 to identify the 4 populations, but still provide information on threats and management for six sites based on differences in land ownership/management (explained in the text and caption). We also edited Figure 2 to only have 4 populations to be more consistent with the populations analyzed for condition.

Peer Review Comment (35): The reviewer asked for clarification about how we described assessing the condition of host plants in the text.

Response: We have expanded upon our description in order to make this more clear. Although we provided quantitative examples of what we would consider sufficient numbers or density of host plants based on suggestions in Hill (2018, p. 32) and Damiani (2011, p. 10), we acknowledge that the conditions assigned to specific populations were made using qualitative reports and communication with species experts, not quantitative data on host plant abundance (because these data are not currently available).

Peer Review Comment (36): The reviewer suggested that we use more quantitative definitions for assessing condition relative to nectar plants, suggesting that we include suggested quantities for density of buckeye trees and nectar volume of *Monardella*.

Response: We agree with the reviewer that having quantitative definitions would lead to a more repeatable analysis in future assessments or status reviews. However, the best available science right now with regard to nectar plant/nectar abundance is qualitative. Quantitative definitions in the condition category table would lead to all of the populations being in unknown condition, and at this time we felt that qualitatively assessing the relative condition of the populations was more helpful than having identical (unknown) condition across populations. In the future, quantitative assessments of nectar sources at all populations would be helpful, and condition category definitions and condition assignments can be updated to include these data.

Peer Review Comment (37): The reviewer commented that we change a statement in our first paragraph of the description of future scenarios from "Despite the discussion above of how climate change may affect callippe silverspot butterflies and their habitat..." to "Despite the discussion above in how climate change will affect local habitats and influence the species..."

Response: We made the suggested change.

Peer Review Comment (38): The reviewer commented that the future scenarios were too similar as originally described, with Scenario 2 described as management increasing or staying the same.

Response: We changed our description of Scenario 2 to increase management, which had slight changes to the analysis.

Peer Review Comment (39): The reviewer commented that there were some inconsistencies between tables/figures/text about current or future conditions of populations.

Response: This was an error on our part; we have corrected any inconsistencies.