Bay checkerspot butterfly
(*Euphydryas editha bayensis*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

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5-YEAR REVIEW

Bay checkerspot butterfly (*Euphydryas editha bayensis)*

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

The Bay checkerspot butterfly is a medium-sized butterfly in the family Nymphalidae, the brush-footed butterflies; its forewings have black bands along the veins in the upper wing with bright red, yellow, and white spots. Historically, the subspecies occurred in the vicinity of the San Francisco Bay area from San Bruno Mountain (west of the Bay), Mount Diablo (east of the Bay), to Coyote Reservoir (south of the Bay) (Murphy and Ehrlich 1980, p. 318). The current range of the subspecies is greatly reduced and is patchily distributed in serpentine grasslands or grasslands occurring on similar soil types. Aside from an attempt to reintroduce the subspecies to Edgewood Park (San Mateo County) in early 2007, the butterfly is currently restricted to Santa Clara County, California. The subspecies is described as having a metapopulation dynamic (Ehrlich *et al*. 1975, pp. 221-228), which is a group of spatially distinct populations that occasionally exchange individuals (Service 1998, p. II-177; 2007, p. 48179) and sites that are unoccupied one year may be occupied the next, and vice versa (Wilcox and Murphy 1985, p. 882; Harrison 1994, p. 114). The primary larval host plant for the butterfly is a small, annual, native plantain (*Plantago erecta*). The butterfly also frequently requires the presence of a secondary host plant, either purple owl's-clover (*Castilleja densiflora*) or exserted paintbrush (*Castilleja exserta*) (Singer 1972, p. 76; Murphy and Ehrlich 1980, p. 316; Weiss 1999, p. 1478) since owl's clover and the paintbrush remain edible longer than the plantain. Once reaching their fourth instar (larval development stage/molt), larvae enter diapause (dormancy) and spend the summer in cracks and crevices or under rocks.

Methodology Used to Complete This Review:

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO) of the U.S. Fish and Wildlife Service (Service) using information from the *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (Recovery Plan) (Service 1998), survey information from experts who have been monitoring various localities of this subspecies, the California Natural Diversity Database (CNDDB) (CNDDB 2006, 2008), maintained by the California Department of Fish and Game (CDFG), Geographic information system (GIS) data provided by Jones and Stokes and Associates (JSA 2007), the 2007 proposed revised critical habitat for the Bay checkerspot butterfly (Service 2007), and the 2008 final revised critical habitat for the Bay checkerspot butterfly (Service 2008a).

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Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on March 5, 2008 (Service 2008b). We received two letters from the public in response to our Federal notice initiating this 5-year review.

Listing History:

> **Original Listing**
> **FR Notice:** 52 FR 35366
> **Date of Final Listing Rule:** September 18, 1987
> **Entity Listed:** *Euphydryas editha bayensis*, an insect subspecies
> **Classification:** Threatened

Associated Rulemakings: Critical habitat for the Bay checkerspot butterfly was first finalized on April 30, 2001 (Service 2001). A proposed revised designation of critical habitat was published on August 22, 2007 (Service 2007) and a final revised critical habitat was published on August 26, 2008 (Service 2008a).

Review History: We have not conducted any status reviews for this subspecies since the time of listing. Updated information on its status and threats was included in the 1998 Recovery Plan, 2001 designation of critical habitat, and the 2008 final revised designation of critical habitat; however, these documents did not include a five-factor analysis of threats or make recommendations on the subspecies' classification under the Act.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Euphydryas editha bayensis* is 3C according to the Service's 2008 Recovery Data Call for the Sacramento Fish and Wildlife Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that the taxon is a subspecies that faces a high degree of threat, but has a high potential for recovery. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

Recovery Plan or Outline

> **Name of Plan or Outline:** *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area*
> **Date Issued:** September 20, 1998

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable, and the application of the DPS policy to the species' listing is not addressed further in this review.

Information on the Species and its Status

Species Biology and Life History

Spatial Distribution: Historically, the Bay checkerspot butterfly occurred in several locations around the San Francisco Bay. West of the Bay the checkerspot occurred at San Bruno Mountain (San Mateo County), and Twin Peaks and Mount Davidson (San Francisco County). East of the Bay the checkerspot occurred at Franklin Canyon and Mount Diablo (Contra Costa County), and the Oakland Hills (Alameda County). South of the Bay the checkerspot occurred in several locations in Santa Clara County (Murphy and Ehrlich 1980, p. 318). At the time of listing in 1987, the butterfly was known from two primary areas (core populations) (serpentine grasslands generally larger than 800 acres that support persistent populations), Edgewood Park (San Mateo County) and along the eastern ridgeline in Santa Clara County stretching from San Jose south to Morgan Hill (here on referred to as Coyote Ridge) (CNDDB 2008; Service 1998, p. 35376). The listing rule also stated that three secondary (satellite) areas (serpentine grasslands generally less than 800 acres) were likely occupied and three other areas were known to be occupied (Service 1998, p. 35366). Satellite areas that supported the butterfly at listing included Jasper and Pulgas Ridges (San Mateo County) as well as several areas in Santa Clara County (near Calero Reservoir, 2.5 miles west of San Martin, Tulare Hill, and one site near Kalana Avenue) (Harrison 1989, p. 1237; Service 1998, p. 35376). According to the listing rule, there

were approximately 15 other sites in Santa Clara County that probably supported satellite colonies at one time or another and included: a site south of the City of Saratoga, one site east of Lexington Reservoir, four sites between Guadalupe Reservoir and the City of New Almaden, three sites in the vicinity of Chesbro Reservoir, two sites in Santa Teresa County Park, and four sites near the City of Gilroy (Service 1998, p. 35376); although the listing rule stated that these areas likely supported populations the rule notes that many of the areas had been surveyed in 1985 without documenting the presence of the butterfly. San Bruno Mountain (San Mateo County) was noted as the only tertiary habitat (area of non-serpentine grassland) that still supported the butterfly.

The Bay checkerspot butterfly is patchily distributed and because it occurs as a metapopulation, the exact distribution of the butterfly varies through time: sites that are unoccupied one year may be occupied the next, and vice versa (Wilcox and Murphy 1985, p. 882; Harrison 1994, p. 114). The Coyote Ridge core population has historically been referred to as four separate populations (Silver Creek Hills, San Felipe, Metcalf, and Kirby Canyon), but what constitutes a population has not been defined and Coyote Ridge may be comprised of many populations. Aside from Metcalf Road, a two-lane road that divides the ridge line in half, Coyote Ridge is primarily contiguous grassland.

At the time the Recovery Plan was finalized in 1998, the butterfly's range had become more restricted. The range at that time still included two core areas (Edgewood Park in San Mateo County and Coyote Ridge in Santa Clara County) (Hellman *et al.* 2003, p. 75; Weiss, pers. comm. 2006; Weiss 2006a, p. 2; CNDDB 2008) as well as a number of smaller satellite areas. Only one satellite area was believed to still occur in San Mateo County at Stanford University's Jasper Ridge Biological Preserve (Jasper Ridge), but only 6 adults were observed in 1997 (McCabe 1997, p. A-18; CNDDB 2008) and none were observed in 1998 (CNDDB 2008). Satellite areas in Santa Clara County that were believed to be occupied were Santa Teresa County Park (H.T. Harvey & Associates, 1998 p. 13; Arnold, pers. comm. 2007), Calero County Park (CNDDB 2008), and Coyote Lake-Harvey Bear Ranch County Park (CNDDB 2008).

The current range of the Bay checkerspot butterfly is even further reduced. Only one core area remains (Coyote Ridge), and all known extant occurrences of the Bay checkerspot butterfly are within a 9-mile radius of Coyote Ridge (Service 2008a, p. 50422) and all are located in Santa Clara County. Prior to an attempted reintroduction at Edgewood Park in 2007, the butterfly had not been observed in San Mateo County since 1997-1998 (Stanford 2006, p. 8; CNDDB 2008). Of all potentially remaining satellite areas in Santa Clara County, butterflies have only recently (since 1998) been observed at Tulare Hill, although not all potential satellite areas are surveyed annually.

Since listing, the number of sites with extant Bay checkerspot butterfly populations has decreased considerably and there are no populations in Alameda, Contra Costa, San Mateo, or San Francisco Counties. The number of individuals in currently occupied sites has also declined in recent years. Fluctuation in the number of populations and the number of individuals within a population varies dramatically from one year to the next based on the population dynamics and life history of the Bay checkerspot butterfly. However, a number of factors have and continue to

contribute to the loss of both populations and the number of individuals within a population and are discussed below.

Abundance: Population size of the Bay checkerspot butterfly is primarily determined by the survival rate of prediapause larvae (see Table 1 below for life cycle table) (Singer 1972, p. 77; Weiss *et al*. 1988, p. 1486). Prediapause larval survivorship is dependent upon the timing of host plant senescence, which in turn is dependent on environmental conditions such as temperature and rainfall. Prediapause larvae experience mortality rates upwards of 95 percent (Murphy 1988, p. 46; Weiss *et al*. 1988, p. 1487; Cushman *et al*. 1994, p. 198; Murphy *et al*. 2004, p. 26), with rates of 98-99 percent common (White 1974, p. 310).

In Santa Clara County, population trends for the Bay checkerspot butterfly are only available for Coyote Ridge (its four historical populations noted above), Tulare Hill, and Coyote Lake-Harvey Bear Ranch County Park. On Coyote Ridge, south of Metcalf Road (Kirby Canyon population), Bay checkerspot butterfly numbers increased from approximately 20,000 postdiapause larvae (see Table 1 below for life cycle table) in 1997 to 700,000 in 2004, but fell to approximately 100,000 in 2005 (Weiss 2006a, p. 1). Between 2006 and 2007 the number of postdiapause larvae in the Kirby Canyon population was down "often by a factor of three or more" (CH2MHILL 2008, p. 8-8). Results from the 2008 survey period are not yet available.

On Coyote Ridge, north of Metcalf Road (Metcalf population), Bay checkerspot butterfly postdiapause larvae increased from approximately 200,000 in 2000 to 400,000 in 2004, but then declined to 45,000 in 2006 (Weiss 2006a, p. 1). Adult surveys were conducted in March and April 2008. WRA (2008, p. 16) observed 636 adults, but no larvae. The Service is not aware of any more recent survey information in this area.

Postdiapause larval estimates from the northern end of Coyote Ridge (Silver Creek Hills population) increased from 75,000 in 1992 to 128,000 in 1993, and then fell to an estimated 58,000 in 1994 following the removal of grazing from portions of the area (Weiss 1996, p. 93; Weiss 1999, p. 1480). No larvae or adults were observed in 1998 (Weiss 1999, p. 1480). Annual surveys at Silver Creek Hills since the construction of a residential subdivision and reintroduction of grazing over portions of the area in 2000-2001 have not detected any larvae. However, surveys have showed an increase in adult butterflies from a low of 11 in 2001 to a high of 53 in 2007 (WRA 2007, p. 8). Results from the 2009 survey period are expected in fall 2009.

On Tulare Hill approximately 2,000 postdiapause larvae were observed in 2002. The Tulare Hill population declined significantly in 2003, when only one postdiapause larva was observed (CH2M Hill 2005, p. 8-6). Five adults were observed on Tulare Hill in 2004 (CH2MHill 2005, p. 8-2). Seven adults were observed in 2005, but no larva (CH2MHILL 2006, p. 8-2). One adult and one postdiapause larva were observed in 2006 (CH2MHILL 2007, p. 1-7-9). One adult was observed in 2007, but no larvae (CH2MHILL 2008, p. 8-8). Results from the 2008 surveys are not yet available.

According to the California Natural Diversity Database (CNDDB 2006, 2008), thousands of adult Bay checkerspot butterflies were observed at Coyote Lake-Harvey Bear Ranch County Park in 1994, 6 adults observed in 1997, and 1 adult observed in 1999. According to Santa Clara

County Parks (D. Rocha, pers. comm. 2008) no Bay checkerspot butterflies have been seen at Coyote Lake-Harvey Bear Ranch County Park since 1999 despite annual monitoring.

In spring 2007, an effort was made to reintroduce the Bay checkerspot butterfly to Edgewood Park (San Mateo County) by relocating approximately 1,000 postdiapause larvae collected from Coyote Ridge. However, the reintroduction appears not to have been successful; no larvae and only one adult butterfly were observed at Edgewood Park in 2008 (Weiss, pers. comm. 2008).

<u>Life History:</u> The Bay checkerspot butterfly is univoltine (one generation reaches sexual maturity each year) and generally reproduces and dies within a single year, although some larvae may be capable of diapausing more than once (Singer and Ehrlich 1979, p. 54; White and Levin 1981, p. 355; Harrison 1989, p. 1242; Mattoni *et al*. 1997, p. 106; Kuussaari *et al*. 2004, pp. 139-140). Adults emerge from pupae in early spring (late February to April) and have an average life span of about 10 days with some individuals living up to three weeks (Ehrlich, unpublished data, cited in Baughman 1991, p. 537; Cushman *et al*. 1994, p. 196). Eggs are laid during the 4 to 6 week flight season and hatch within 10 days. Larvae feed for approximately two weeks until they reach their fourth instar and then enter diapause, which lasts through the summer dry season. Larvae break diapause once their host plants germinate with the onset of the rainy season in the fall.

Table 1. Bay checkerspot butterfly generalized life cycle (Murphy *et al*. 2004, p. 25).

	Rainy Season >--->						Summer Dry Period >-->						
Life Cycle Stage													
Diapause							xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx						
Prediapause Larvae					xxxxxxxxxxxxxxxxxxxxxxxx								
Eggs					xxxxxxxxxxxxxxxxxxxxxxxxxxx								
Adults				xxxxxxxxxxxxxxxxxxxxxxxxxxx									
Pupae			xxxxxxxxxxxxxxxxxxxxxxxx										
Postdiapause Larvae	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx												
	November	December	January	February	March	April	May	June	July	August	September	October	November

Murphy *et al*. (1983, p. 261) observed increased longevity and reduced weight loss in adult Bay checkerspot butterflies fed sugar. Increased nectar intake results in longer adult life span and improved adult condition (females produce more and larger egg masses). Females that eclose (emerge as adults from pupae) early in the flight season will contribute more eggs, since nectar availability can be limited later in the flight season. Longer survival is important during wet years for females that lay eggs on cool slopes since larvae from these eggs develop more slowly. Slow-developing larvae may not reach diapause before the larval host plants senesce. The flight season extends from late February to early May (Weiss *et al*. 1988, p. 1487) depending on weather.

Females typically only mate once, but males may mate multiple times (Labine 1964, p. 335; Baughman 1991, p. 538). After mating, females lay 1 to 5 egg masses (Murphy *et al*. 1983, p. 259). Egg masses may contain anywhere from 5 to 350 eggs (Singer 1972, p. 75;Weiss *et al*. 1988, p. 1487; Weiss 1996, p. 6; Murphy *et al*. 2004, p. 25). Eggs hatch in 13-15 days (Singer and Ehrlich 1979, p. 54; Murphy *et al*. 2004, p. 25) and larvae begin feeding. Murphy *et al*. (1983, p. 259) reported average lifetime egg production of 401 to 805; the study also stated an

average lifetime egg production of 426 by females without food. Egg production (both size and number of eggs) significantly increased with the intake of nutrients (Murphy *et al.* 1983, p. 261; Boggs 1997, pp.181, 184). Murphy *et al*. (1983, p. 261) observed that a mixture of amino acids and sugar intake by females produced heavier eggs, which resulted in an increased likelihood of survival. Intake of amino acids and sugar in the lab simulated varying degrees of nectar availability in the wild. Greater availability of nearby adult nectar sources likely results in higher larval survivorship since heavier eggs result in larger larvae. Since the ability to enter diapause is size dependent, large larvae are able to enter diapause sooner after hatching than small larvae. Since population size is most influenced by the number of postdiapause larvae, abundant nectar sources likely results in an increase in the number of individuals at a particular location. However, in dry years when flowers produce less nectar or in areas where there are no mature nectar plants, populations of the Bay checkerspot butterfly may still persist because females are capable of producing eggs even without food.

Larvae feed until they have grown sufficiently to reach their fourth instar and enter diapause. Larvae that are not able to enter diapause prior to host plant senescence starve (Singer and Ehrlich 1979, p. 54; White 1987, p. 209; Weiss 1996, p. 6). Larvae are able to enter diapause when they reach 4 to 20 milligrams (White 1987, p. 209). Larvae break summer diapause and resume feeding with the onset of the rainy season and host plant germination, generally between November–January (Weiss 1996, p. 6). Postdiapause larvae then feed until reaching a mass of 250 to 500 milligrams (Weiss *et al*. 1988, p. 1489) at which time they pupate.

The Bay checkerspot butterfly requires areas with topographic diversity (warm south and west slopes as well as cool north and east slopes), because some slopes become unfavorable depending on annual weather conditions and time of year. Fleishman *et al*. (2000, p. 34) defined warm and very warm slopes as south- and west-facing slopes with a tilt greater than 11 and 17 degrees, respectively, with cool and very cool slopes defined as those facing north or east with a tilt greater than 11 and 17 degrees, respectively. Harrison *et al*. (1988, p. 365) defined warm slopes as those facing south, southwest, and southeast with a tilt greater than 7 degrees and cool slopes as those facing north or northeast with a tilt greater than 7 and 12 degrees, respectively. In hot, dry years, north- and east-facing slopes remain cool and moist longer and larval host plants tend to senesce (reach later maturity, grow old) later than those on other slopes (Weiss *et al*. 1988, p. 1493; Fleishman *et al*. 2000, p. 33). The delayed senescence of plants on cool, moist slopes allows larvae to reach their fourth instar (larval development stage or molt) and enter diapause (dormancy) before host plants become inedible. Larvae that are not able to enter diapause prior to host plant senescence starve and die (Singer and Ehrlich 1979, p. 54; White 1987, p. 209; Weiss 1996, p. 6). Because host plants on cool slopes can flower and senesce 3 or more weeks after those on warmer slopes (Weiss *et al*. 1988, p. 1493), cool slopes are especially important during extremely dry years (i.e., droughts). However, larval feeding and growth tends to increase on warm slopes because they receive more solar exposure than other slopes; this allows postdiapause larvae to grow quickly and pupate earlier than those on cool slopes. Individuals that pupate earlier have a much greater chance of reproductive success (Weiss *et al*. 1988, pp. 1493-1494).

In addition to weather, slope is important relative to the timing of egg lying. As the adult mating season (flight season) progresses, females tend to lay more eggs on cool slopes than on warm

slopes (Weiss *et al*. 1988, p. 1493). The timing of the flight season varies with weather, but can generally be described as occurring from late February to early May (Murphy *et al*. 2004, p. 25). Larvae that hatch late in the flight season on cooler slopes have a greater chance of reaching diapause than those laid at the same time on warm slopes, because host plants remain edible longer on cool slopes. The pattern of larval survivorship across different slopes changes from one year to the next as well as within years; therefore, it becomes important that a variety of slopes and aspects are present to support the butterfly and its host plants.

While varying topography is important to provide the microclimate conditions necessary to ensure some larvae survive each year, elevation does not appear to be an important physical characteristic. The Bay checkerspot butterfly has been observed over a wide range of elevations. In San Mateo County, Bay checkerspot butterflies historically occurred on San Bruno Mountain at elevations of approximately 1,000 feet, at Pulgas Ridge at approximately 550 feet, and at Edgewood Park and Jasper Ridge at approximately 600 feet. In Santa Clara County Bay checkerspot butterflies have been observed at elevations between 300 to 1,100 feet. Portions of Coyote Ridge are as high as 1,100 feet. Tulare Hill ranges from about 300 to 550 feet and the area around Calero Reservoir where Bay checkerspot butterflies have been observed varies from approximately 500 to 800 feet.

The population size of the bay checkerspot butterfly is primarily determined by the survival rate of prediapause larvae (Singer 1972, p. 77; Weiss *et al*. 1988, p. 1486). Prediapause larvae experience mortality rates upwards of 95 percent (Murphy 1988, p. 46; Weiss *et al*. 1988, p. 1487; Cushman *et al*. 1994, p. 198; Murphy *et al*. 2004, p. 26). Larval survivorship is dependent upon the timing of host plant senescence, which in turn is dependent on environmental conditions such as rainfall.

White (1986, p. 58) observed that pupal mortality rates, as well as cause of mortality (predation, parasitism, crushing, or disease), varied significantly depending on location (i.e., microhabitat types). For example, crushing was most likely in areas of bare ground, whereas pupae in areas with dense vegetation had a higher rate of mortality due to mold and viruses. Since prediapause larval mortality is the most significant factor influencing population size, a variety of diapause sites are necessary to ensure adequate numbers of larvae survive diapause. Pupal mortality rates of 26-89 percent have been observed (White 1986, p. 58-59; Weiss *et al*. 1988, p. 1492). Adults eclose in 10-43 days (White 1986, p. 60; Weiss *et al.* 1988, p. 1492), with timing strongly affected by weather.

Sex ratios in the Bay checkerspot butterfly have been reported several times in the scientific literature (Ehrlich 1965; Ehrlich *et al.*, 1984; Launer *et al*. 1993; Hellman *et al*. 2003; Boggs and Nieminen 2004). Ehrlich (1965, p. 330-331) noted sex ratios in the field of 2.73:1 (sex ratios in this review are male:female), while laboratory ratios were closer to 1:1. Ehrlich *et al*. (1984, p. 530) noted an observed sex ratio (sex ratio of captured individuals) in adults of 1.95:1; however, the same study observed that butterflies captured in the field are typically males due to differences in catchability and that sex ratios of butterflies in the lab are closer to 1:1 (Ehrlich *et al.* 1984, p. 527). Ehrlich *et al.* (1984, p. 527-528) discussed differences in the realized sex ratios (the actual sex ratio) and the operational sex ratio (sex ratio of individuals available to mate) and speculated that the bias towards males was due to greater pre-adult mortality of

females, higher rate of emigration of females, and possibly a greater adult mortality of females (Ehrlich *et al*. 1984, p. 537). Ehrlich *et al*. (1984, p. 534) hypothesized that higher female mortality was the result of the longer period of time (approximately 6 days in the study) females spend as pre-adults (likely occurring during the postdiapause stage as a result of longer exposure to predators). Emigration in Ehrlich *et al*. (1984) was between areas 'C', 'G', and 'H' at Jasper Ridge that are separated by only a few thousand feet (Ehrlich *et al*. 1965, p. 328). Launer *et al*. (1993 p. 47) reported variable sex ratios depending on location and time of year. Sex ratios at a creek ranged from 1:25 to 1.3:1 and at a ridge site ranging from 1.6:1 to as high as 11:1 (Launer *et al*. 1993, p. 47). Hellman *et al*. (2003, p. 79) examined historical data and reported average sex ratios at Jasper Ridge of 1.59:1 where the number of males exceeded the number of females in 12 out of 19 years in area 'C' and 24 out of 28 years in area 'H' (Hellman *et al.* 2003, p. 78). Boggs and Nieminen (2004, p. 94) reexamined data from Ehrlich *et al*. (1984) and estimated an operational sex ratio of approximately 0.85:1, which maybe due to differences in adult eclosure (in the study year males were collected 6 days prior to the first female).

The Bay checkerspot butterfly is considered relatively sedentary (Ehrlich 1965, p. 333; Harrison 1989, pp. 50-51; Singer and Hanski 2004, p. 187). McKechnie *et al*. (1975, p. 561) observed that, out of several years of mark recapture studies, only 1.7 percent of males and 4.8 percent of females moved a distance of approximately 1,600 feet. These figures are consistent with observations made by Weiss (1996, p. 93), who reported that adult movement declined with increasing distance with only about 5 percent moving between 656 to 984 feet. Harrison (1989, p. 1239) observed movements of 3.5 miles for one male and 2 miles for one female. Murphy (Service 2001, p. 21451) reported movement of Bay checkerspot butterflies of 4.7 miles. Harrison *et al*. (1988, p. 371) hypothesized that habitats greater than 4.3 to 5.0 miles from a source population (Coyote Ridge in the study) were unlikely to ever sustain populations of the Bay checkerspot butterfly. This hypothesis was based on the presence or absence of adult Bay checkerspot butterflies in Santa Clara County in apparently suitable habitat and their relative distance from Coyote Ridge. The study was not designed to predict the Bay checkerspot butterfly's upper limit of dispersal.

Habitat or Ecosystem: The Bay checkerspot butterfly inhabits areas around the San Francisco Bay with soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar non-serpentine soils (such as Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) in areas ranging from a few acres to thousands of acres. Serpentine or serpentine-like soils are characterized as shallow, nutrient poor (typically lacking in nitrogen, phosphorous, and calcium), containing high magnesium (and other heavy metals), and with low water holding capacity. All currently occupied habitats of the Bay checkerspot butterfly occur on serpentine or serpentine-like grasslands that support at least two of the subspecies' larval host plants, although the range of all the host plants is greater than that of the Bay checkerspot butterfly. Due to poor nutrient availability, as well as the other characteristics noted above, serpentine and serpentine-like grasslands are, for the most part, inhospitable to the non-native grasses and forbs that dominate other California grassland ecosystems; these areas are essentially isolated patches where native grassland vegetation is capable of persisting in a landscape that is otherwise dominated by non-native and invasive plant species. A number of researchers believe that the Bay checkerspot butterfly likely occurred more widely in non-serpentine grasslands in the San Francisco Bay area prior to the invasion of non-native invasive

grasses and forbs (Murphy and Weiss 1988, p. 197; McLaughlin *et al*. 2002, p. 6074; Murphy *et al*. 2004, p. 26), but have subsequently been relegated to these fragmented habitats due to plant competition. Some researchers have noted that the Bay checkerspot butterfly does not feed on its larval host plants when those plants occur off serpentine soils (Johnson *et al*. 1967, p. 423). Johnson *et al*. (1967, p. 423) observed a patch of larval host plants spanning both serpentine and non-serpentine soils and noted larvae feeding on host plants only on plants within the serpentine area, even though the patch was contiguous. However, anecdotal evidence indicates that in laboratory conditions, larval Bay checkerspot butterflies will feed on host plants grown on non-serpentine soils (Murphy *et al*. 1983, p. 258; Boggs 1997, p. 185).

Changes in Taxonomic Classification or Nomenclature: Some authors have advocated renaming the Bay checkerspot butterfly from *Euphydryas editha bayensis* to *Euphydryas editha editha* for reasons of historical precedence (Mattoni *et al*. 1997; Emmel *et al*. 1998, p. 17)); however, this name has not been adopted in any subsequently published literature on the subspecies, nor in the majority of the published literature prior to this article. Occasionally the butterfly is placed in the genus *Occidryas*, but this is viewed as taxonomically incorrect (Zimmerman *et al*. 2000, p. 352). Mattoni *et al*. (1997, p. 100) suggested that *Euphydryas editha editha* ranges from the San Francisco Bay area south to Santa Barbara County in California, and includes the populations known as the Bay checkerspot butterfly and several populations south of Santa Clara County whose subspecific status has been uncertain, and which if recognized would be a range extension for the Bay checkerspot butterfly. The listing rule discussed the taxonomic status of the butterfly extensively, including butterflies in Santa Barbara County (Service 1987, p. 35370). A review panel assembled by the Service to address the taxonomic status of the butterfly concluded that *Euphydryas editha bayensis* is a valid subspecies and that it has been continuously recognized as such in the scientific literature (Service 1987, p. 35370). Aside from the two studies above (Mattoni *et al*. 1997; Zimmerman *et al*. 2000) and one non-peer reviewed book (Emmel *et al*. 1998), all subsequent literature on the Bay checkerspot butterfly published since it was listed recognizes the name *Euphydryas editha bayensis* as correct and no other published literature extends the subspecies' range south of Santa Clara County; this corresponds to the vast majority of published literature on the butterfly, spanning more than six decades.

Genetics: A number of genetic studies (McKechnie *et al*. 1975; Mueller *et al*. 1985; Slatkin 1987; Baughman *et al*. 1990) have been conducted on *Euphydryas editha*, and some specifically on the Bay checkerspot butterfly. However, well-resolved phylogenies for many butterfly species do not exist despite their well-studied biology (Wahlberg *et al*. 2004, p. 221), including the Bay checkerspot butterfly. In addition, what constitutes a population of Bay checkerspot butterflies was not defined in any of the genetic studies identified below. McKechnie *et al*. (1975, p. 571) studied 21 *Euphydryas editha* populations (including the Bay checkerspot butterfly) for differences at eight polymorphic enzyme loci and found that some loci were highly variable between populations, while other loci were almost identical; they concluded that strong selection pressures were in operation despite obvious migration between populations at Jasper Ridge. Historically the Bay checkerspot butterflies at Jasper Ridge were grouped into three separate populations, 'C', 'G', and 'H'. Mueller *et al*. (1985, p. 495) examined allele frequencies at six polymorphic loci in two of the populations at Jasper Ridge and found substantial variations between observed values and those predicted by computer modeling, which indicated fluctuating selection pressures from one year to the next. Slatkin (1987, p. 791) reexamined the data from

McKechnie *et al*. (1975) and concluded that there was genetic similarity at seven of eight loci. Baughman *et al*. (1990, p. 1967) examined the genetic structure of 41 populations of *Euphydryas editha* (including the Bay checkerspot butterfly) at 19 loci; the study divided the 41 populations into groups based on similar alleles, but found that the genetic groupings did not associate with observed morphological differences such as size, color pattern, flight season, or host plant. One possible explanation is that the various subspecies were recently interconnected, as early as the last ice age (8,000-10,000 years ago) and that gene frequency distributions are more reflective of historical gene flow rather than current gene flow (Baughman *et al*. 1990, p. 1973). Baughman *et al*. (1990, p. 1973) notes that this hypothesis may be speculative but is supported by historical factors including changes in habitat over the last 10,000 years (areas that were previously mesic woodland and grasslands are now arid basins); the current disjunction between patches of suitable habitat may not have existed 5,000 years ago, since fragmentation of much of the habitat by agriculture, urbanization, and non-native vegetation has occurred in the last 100 years. Baughman *et al*. (1990, p. 1973) stated that the current distribution of *Euphydryas* butterflies are small discrete populations and the distribution of many of these butterfly populations may have been different as recently as 300 butterfly generations ago. The majority of genetic studies on the Bay checkerspot butterfly occurred in the 1970s and 1980s prior to the advent of more advanced molecular techniques. Additional genetic studies are necessary to characterize the relationships between and among different populations of Bay checkerspot butterflies.

Species-specific Research and/or Grant-supported Activities:

As noted above, the Bay checkerspot butterfly is one of the most well-studied insects in biology (Murphy and Ehrlich 1980, p. 319). Dr. Paul Ehrlich of Stanford University and his laboratory have been studying the Bay checkerspot butterfly since 1959 and the study of the butterfly's population dynamics was influential in developing the metapopulation concept. Research regarding the genetics of the Bay checkerspot butterfly was noted in the previous section. McLaughlin *et al*. (2002a) examined how climate change hastened the extinction of the Bay checkerspot butterfly at Jasper Ridge; this study is detailed below under Factor E. The following is a summary of recent research.

Microclimate: Weiss *et al*. (1988) examined thermal environments on topographically diverse serpentine grasslands and observed that larvae and pupae developed faster on warm slopes than on cooler slopes. In the same study microclimate was observed to affect the phenology of host plants and adult nectar plants. The relationship between larval and pupal development and host plant phenology was used to determine prediapause mortality rates of larvae; females that pupated earlier in the season could have offspring that survived on almost all slopes; however, larval survivorship from females that pupated in the middle of the flight season was restricted to cooler slopes and larvae from females that pupated late did not survive on any slope.

Weiss *et al*. (1993) developed models that examined patterns of adult emergence in relation to topography and microclimate from 1985-1989. The model used slope-specific insolation as the rate-controlling variable and accounted for solar exposure and cloud cover (Weiss *et al*. 1993, p. 261). The model accurately predicted postdiapause larval mass and observed mass to within 4-6 days in most microclimates (Weiss *et al*. 1993, p. 265).

Fleishman *et al*. (2000, p. 36) examined the effects of microclimate on oviposition of Bay checkerspot butterflies and observed that senescence of larval host plants (*Plantago erecta*) varied significantly with microclimate. The study did not find a significant effect on larval survival (Fleishman *et al*. 2000, p. 40); however, the authors note that this may have been an artifact of their study design because they were not able to track survival of individual larvae and their estimates were based on survival of any individual from the same egg mass (Fleishman *et al*. 2000, p. 41).

McLaughlin *et al*. (2002b) examined variation in population size between two subpopulations ('C' and 'H') at Jasper Ridge. The Jasper Ridge 'C' population occupied in a largely flat homogeneous area, while the 'H' population included areas of topographic diversity. The 'C' population varied more widely than 'H' and became extirpated earlier than 'H' (McLaughlin *et al.* (2002b, p. 545). McLaughlin *et al*. (2002b, 538) concluded that extirpation of the Bay checkerspot butterfly in areas protected from disturbance was driven by climate variability and that topographic diversity buffered the population from some of the effects of climate.

Nitrogen deposition and invasive species: The process of combustion of fossil fuels (from vehicles, power plants, etc.) results in the production of a number of emissions, including various nitrogen based substances such as nitrous oxides (N_2O), ammonia (NH_3), nitrogen oxides (NO_x), nitric acid (HNO_3), nitrate (NO_3-), and ammonium (NH_4). Nitrogen is the primary limiting factor in plant growth. Weiss (1999, p. 1476) investigated the role of atmospheric nitrogen deposition on butterfly and plant populations across different grazing regimes, and found that populations of the Bay checkerspot butterfly in south San Jose declined dramatically after removal of cattle grazing at several locations, while other nearby populations under continued grazing did not suffer the same decline in butterfly numbers. Weiss (1999, p. 1476) determined that while the initial cause of the butterfly declines were the result of rapid invasion by non-native annual grasses that crowded out the butterfly's larval host plants, the evidence indicated that dry nitrogen deposition from smog was responsible for creating soil conditions that allowed the observed grass invasion. Weiss (1999, p. 1482) estimated nitrogen deposition rates south of San Jose to be 10-15 kg of nitrogen per hectare per year (kg-N/ha/yr). Weiss (2002, p. 31) further demonstrated these effects by analyzing the pattern of non-native grass invasion resulting from nitrogen deposition at Edgewood Park, and observed that the cover of non-native Italian ryegrass (*Lolium multiflorum*) decreased with distance from Interstate Highway 280 (I-280), while *Plantago erecta* cover increased with distance. *Plantago erecta* cover was also higher upwind of I-280 than downwind.

Vegetation management: Weiss (2002, p. 36) examined the effect of mowing, goat grazing, raking, and fall seeding of *Plantago erecta* at Edgewood Park and found that species richness increased in mowed plots and *P. erecta* cover increased from 3 to 9 percent in mowed plots vs. no change in control plots, while non-native grass (*Lolium multiflorum)* decreased from 50 to 15 percent. Percent of *Castilleja densiflorus* (secondary host plant) cover was unaffected by mowing, but *Lasthenia californica* (adult nectar plant) increased from 4 to 8 percent cover in mowed vs. control plots. Mowing was the only factor that had a significant effect on cover.

In 2004, the Service provided funding for a 3 year study to examine the effect of various vegetation management scenarios (ambient grazed (1 cow and calf per 10 acres), partial grazed,

ungrazed/untrimmed, and ungrazed/trimmed) on the food plants of the Bay checkerspot butterfly and several other plant species on portions of Tulare Hill and Coyote Ridge (Weiss *et al*. 2007, p. 4). Non-native vegetation was tallest in both 2006 and 2007 in ungrazed/untrimmed plots and shortest in the ambient grazing plots, and annual forbs (such as native host plants) declined in all treatments except ambient grazing (Weiss *et al*. 2007, p. 10).

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

When the butterfly was listed as threatened in 1987 (Service 1987), we identified urban development (i.e., residential development), highway construction (and its associated habitat fragmentation), and overgrazing as threats to the subspecies. Additional threats were noted in the Recovery Plan (Service 1998, pp. II-191-197) and included habitat degradation caused by non-native vegetation as a result of nitrogen deposition.

Non-native plant species: Invasion of native grasslands by non-native plants is widely seen as one of the major causes of decline of a number of native species including the Bay checkerspot butterfly. Serpentine habitats are not immune to invasion by non-natives. For example, non-native grass growth in the Silver Creek Hills area was observed to choke out the host plants of the Bay checkerspot butterfly (Service 1998), and yellow star thistle (*Centaurea solstitialis*) invaded some serpentine areas at Edgewood Park Natural Preserve. Some eucalyptus species (*Eucalyptus* spp.) can grow in serpentine areas, and destroy butterfly habitat due to leaf litter and shading. New invasive plants continue to be introduced to northern California through gardens, landscaping, and accidental means.

Coupled with the threat from invasive and non-native species is nitrogen deposition (including NOx and NH_3) that enriches serpentine and serpentine-like soils that are usually nutrient poor. Increased nitrogen (typically a limiting factor in plant growth) in these areas has resulted in the accumulation of a thick carpet of vegetative material, commonly referred to as thatch. Dense thatch inhibits the growth of native forbs (Huenneke *et al*. 1990, p. 488). Italian ryegrass is the major invasive grass in degraded sites in Santa Clara County (Weiss 2002, p. 6). The increased density of non-native vegetation negatively affects the Bay checkerspot butterfly's host plant due to competition and crowding (Weiss 1999, p. 1481). Huenneke *et al*. (1990, p. 489) found that areas that were fenced to prevent grazing resulted in an increase in native perennial and non-native annual grasses, but in grazed areas, forbs continued to represent an important component. Low and moderate grazing regimes (approximately one cow per 10 acres) have been implemented on portions of Tulare Hill and Coyote Ridge. Because cattle tend to select non-native grasses over native forbs (Weiss 1999, p. 1484), the result of these grazing regimes has been local increases of the Bay checkerspot butterfly's larval host plants.

Nitrogen deposition rates in portions of Bay checkerspot butterfly habitat in Santa Clara County have been estimated to be between 10 and 15 kg-N/ha/yr (Weiss 1999, p. 1482-1483). On Tulare Hill, nitrogen deposition rates have been estimated at 17 kg-N/ha/yr (CH2MHILL 2008, p. 4-2). Although there is no empirical threshold for effects associated with nitrogen deposition, the U.S. Department of Agriculture estimates the threshold of annual nitrogen deposition rates that can potentially impact sensitive plant communities is 3-10 kg-N/ha/yr (USDA 1992, p. 10). Although these are vague guidelines and should not be interpreted as a critical load, it is consistent with estimates for the threshold for effects to serpentine ecosystem structure and diversity at Edgewood Park, which was 5 kg-N/ha/yr (Weiss, pers. comm. 2007).

In summary, annual grasses that have dominated native grassland habitat in California since European settlement have displaced numerous species, and now due to increased nitrogen deposition annual grasses are able to colonize the otherwise nutrient poor, native serpentine bunchgrass communities. Continued spread of non-native vegetation threatens to degrade and eliminate areas that are occupied by the Bay checkerspot butterfly by reducing or eliminating both larval and adult host plants as well as increasing the distance of unsuitable habitat between extant occurrences of the butterfly.

Development: Development pressure in Santa Clara County is likely to increase. The City of San Jose has developed a General Plan to guide development into the year 2020. Portions of the general plan share boundaries with Bay checkerspot butterfly critical habitat units, including Units 5, 6, 7, and 9. In 1997, the California Court of Appeals found that the City of San Jose's zoning did not have to be consistent with the City's General Plan (*Juarez et al*. v. *City of San Jose et al*. (6th District, Case No. CV736436 H014755)); this may result in areas not currently within the urban growth boundary still being proposed for development, including those areas that are environmentally sensitive such as serpentine grasslands. In 1977 the Calero Lake Estates, a 270-acre (27 lots) residential development, was authorized in the hills south of Santa Teresa County Park and north of Calero Reservoir. In 1998, H.T. Harvey and Associates (H.T. Harvey & Associates 1998, p. 11-12) documented larval and adult Bay checkerspot butterflies within the Calero Lake Estates. To date, only one residence has been constructed; however, the Service is currently reviewing a low-effect habitat conservation plan (HCP) for development of a second lot that will result in the loss of 1.3 acres and protection and management of 6.8 acres of serpentine grassland.

Activities at United Technologies Corporation's (UTC) San Jose site were discussed in the listing rule, but activities at UTC were not identified has posing a significant threat. In addition, at the time of listing no urban or commercial development had been proposed on lands owned by UTC that would "seriously alter" Bay checkerspot butterfly habitat (Service 1987, p. 35371). All work conducted at UTC (aside from grazing to control hazardous fuels) was outside Bay checkerspot butterfly habitat. Since grazing is one of the primary tools for managing Bay checkerspot butterfly habitat, UTC's actions within butterfly habitat have been beneficial. UTC is currently in the process of closing their San Jose plant (i.e., removing structures, soil remediation, etc.) and no work is currently planned in Bay checkerspot butterfly habitat aside from continued grazing. There has been no change in the status of the habitat owned by UTC.

Historically development of serpentine grasslands, and the resulting fragmentation, was a significant threat to the Bay checkerspot butterfly. Several sites with documented Bay checkerspot butterfly occurrences were lost as a result of development activities in San Mateo County. The population of Bay checkerspot butterflies near Hillsborough (San Mateo County), where the type locality was described, was lost in 1977 due to habitat loss (Service 1987, p. 35376). The Bay checkerspot butterflies at Woodside (San Mateo County) were lost after a housing development reduced the amount of habitat to approximately 26 acres (Service 1987, p. 35376) in the early 1980s. Several other populations in San Mateo County were splintered into smaller populations after construction of Interstate 280 and eventually became extirpated. Approximately 334 acres of habitat on the northern portion of Coyote Ridge in Santa Clara County was developed for a housing development (Ranch on Silver Creek) in the early 2000s and the population of Bay checkerspot butterflies at this site nearly disappeared. Establishment of a 473-acre on-site butterfly preserve and implementation of a grazing regime has improved the size of the population in recent years (53 adults, but no larvae in 2007), but the population is still not as robust as it was prior to the housing development (approximately 128,000 larvae in 1993). No larvae have been observed within the 473-acre on-site preserve since 1998 despite annual monitoring. It is uncertain whether the adults observed on the preserve are emigrants from other occupied areas on Coyote Ridge or if annual monitoring is simply not effective at locating larvae.

The distance between extant populations has increased due to loss of populations resulting from habitat modification (from development and conversion of native grasslands to non-native annual grasslands) that in turn reduces the likelihood that individuals from core populations can recolonize extirpated sites. Harrison *et al*. (1988, p. 371) hypothesized that habitats greater than 4.3 to 5.0 miles from a source population (Coyote Ridge in that study) were unlikely to ever sustain populations of the Bay checkerspot butterfly because the rate of extinction at small distant sites was more frequent than the rate of recolonization. Small populations at distances of more than 5 miles from core populations are unlikely to persist over time. As noted in the "Abundance" section above, the majority of historical populations are extirpated. The remaining populations have continued to decline in recent years, and Coyote Ridge is the only remaining core population. The population on the southern half of Tulare Hill, where habitat quality is higher than on the north side, has decreased to only one adult during the last two years of surveys and no observed larvae.

The Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP) is expected to be completed and submitted for Service approval and permit issuance in 2010. According to the second Administrative Draft, the HCP/NCCP includes 519,506 acres (JSA 2009, p. 1-7) in Santa Clara County and encompasses all remaining populations of the Bay checkerspot butterfly. Development activities associated with the HCP/NCCP are expected to result in permanent impacts of no more than 550 acres of serpentine bunchgrass and 28 acres of serpentine rock outcrop (JSA 2009, Table 4-2). Development activities are also expected to result in no more than 67 acres of temporary impacts to serpentine bunchgrass and 1 acre of serpentine rock outcrop (JSA 2009, Table 4-3). A draft analysis of nitrogen deposition resulting from activities covered under the HCP/NCCP has been prepared, and once finalized and incorporated into the draft HCP/NCCP the above estimate of impacts is expected to increase. However, while impacts from nitrogen deposition are currently the most

significant threat to the Bay checkerspot butterfly due to the resulting increase in non-native plant cover, they are indirect impacts and do not typically result in the permanent loss of habitat. For example, at existing nitrogen deposition rates, appropriate cattle grazing is an effective method of restoring and maintaining serpentine grasslands. Once fully implemented, the HCP/NCCP is expected to preserve approximately 6,742 acres of Bay checkerspot butterfly habitat as a Conservation Reserve, including the purchase of approximately 4,400 acres of currently unprotected Bay checkerspot butterfly habitat (JSA 2009, Table 5-20). While some impacts to Bay checkerspot butterfly habitat will occur under the HCP/NCCP, implementation of the HCP/NCCP is expected to contribute to the conservation of the Bay checkerspot butterfly in Santa Clara County because much of the habitat will be protected and managed (including implementation of grazing, invasive species control, and population monitoring) for the butterfly as well as other serpentine species, including the federally endangered Santa Clara Valley dudleya (*Dudleya setchellii*) and Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*). Permanent and temporary impacts are also expected from implementation of management and monitoring actions associated with the HCP/NCCP's Conservation Reserve area. Although these actions may result in some small amount of take of Bay checkerspot butterflies, overall the actions are expected to benefit the butterfly, as well as other species covered under the HCP/NCCP, by protecting, enhancing, and restoring Bay checkerspot butterfly habitat.

County Park improvements are proposed for coverage under the HCP/NCCP and are likely to occur in Santa Teresa Hills, Calero, and Coyote Lake-Harvey Bear Ranch County Parks, all of which have habitat for the Bay checkerspot butterfly and include historical occurrences. Potential effects to the Bay checkerspot butterfly in County Parks will primarily be related to new trail development and vegetation management, although specific plans identifying where these actions will occur have not yet been prepared. Expansion of the Kirby Canyon Landfill, located on Coyote Ridge south of Metcalf Road, is also proposed for coverage under the HCP/NCCP. The impact of the proposed landfill expansion on the Bay checkerspot butterfly was previously consulted on under section 7 of the Endangered Species Act (Service 1985; 1993; 1997; 2003); however, the applicants are seeking coverage under the HCP/NCCP to include species that may be listed in the future.

Today, development and fragmentation are less of a threat to the Bay checkerspot butterfly because much of the remaining habitat is protected in one form or another (conservation easements, State and County Parks, etc.) or will be protected. Much of the remaining occupied habitat in Santa Clara County is expected to be preserved and managed for the Bay checkerspot butterfly and other serpentine species under the Santa Clara Valley HCP/NCCP. However, a relatively small amount of habitat in Santa Clara County will be lost to development under the HCP/NCCP. If habitat that is impacted under the HCP/NCCP is located between two large populations or in the middle of a single large population, movement between or among the populations may be reduced. However, the Service is not aware of any specific plans for development that would fragment the remaining populations in Santa Clara County.

Vegetation Management: Overgrazing has previously been identified as a threat; however, a more common threat today is lack of or undergrazing. Grazing is frequently used as a management tool to reduce standing biomass of non-native vegetation; however, overgrazing can

be a potential threat if grazing densities are not appropriately managed. Huenneke *et al*. (1990, p. 489) and Weiss (1999, p. 1480) found areas fenced to prevent grazing or where grazing had been removed, resulted in an increase in annual grasses, which crowd out forbs including those essential to the Bay checkerspot butterfly. Forbs continued to be an important component in areas that included limited grazing. Therefore, we consider a limited amount of grazing to be beneficial to Bay checkerspot butterfly habitat.

Gopher control: Gopher control may also be a threat, since larval host plants have been observed to stay green and edible longer when located on or near soils recently tilled by gophers (*Thomomys bottae*) (Singer 1972, p. 75; Murphy *et al*. 2004, p. 26). Huenneke *et al*. (1990, p. 490) hypothesized that soil disturbance by gophers may limit the growth of grasses similar to results of grazers reducing the standing grass biomass in a system, which allowed the persistence of small forbs. Larval host plants that stay green longer into the dry season may allow more prediapause larvae to reach their fourth instar and enter diapause. However, gopher control measures are not widely implemented in areas currently occupied by Bay checkerspot butterfly and the potential threat is low.

Summary of Factor A: In summary, the threat from invasion of non-native plant species (associated in part from nitrogen deposition) is one of the most significant current threats to the Bay checkerspot butterfly. The listing rule noted habitat loss from urban development (i.e., road construction, subdivisions, etc.) was a threat to the Bay checkerspot butterfly. The threat from development still exists, but is not as significant as it was historically, since a number of historical butterfly locations are currently under some form of protection (i.e., all historical occurrences in San Mateo County). In addition, completion of the Santa Clara Valley HCP/NCCP is expected to protect and manage several thousand acres of Bay checkerspot butterfly habitat, including areas on Coyote Ridge. Management of conserved lands under the Santa Clara Valley HCP/NCCP will include grazing and invasive species management programs to minimize the impacts of nitrogen deposition. The HCP/NCCP will also include an adaptive management plan that will allow for adjustments to grazing and invasive species programs to account for changes in these threats (such as new invasive species, or increased/decreased nitrogen deposition). See the discussion of "Recovery Criteria" below for information on conservation areas for the Bay checkerspot butterfly.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial, recreational, scientific, or educational purposes was noted in the listing rule. Overcollection was noted, but was described as not being a threat to any population. However, the Recovery Plan identified overcollection as likely having a significant negative impact on the subspecies. Collection of Bay checkerspot butterflies on San Bruno Mountain in the early 1980s, when collectors captured and kept all individuals encountered, in conjunction with the wildfire in 1986 likely contributed to the extirpation of the butterfly at this location (C.D. Nagano, Service, pers. comm. 2008). Adult specimens of rare butterflies are highly valued by private collectors, and an international market exists for illegally collected specimens, as well as other listed and rare butterflies (Ehrlich 1984). Butterflies in small populations are vulnerable to harm from collection of adult butterflies (Gall 1984a, 1984b). A population may be reduced

to below sustainable numbers by removal of females, thereby reducing the probability that new populations will be founded. Collectors pose a threat because they may be unable to recognize when they are depleting colonies below the threshold of survival or recovery (Collins and Morris 1985; Hayes 1981). While the Service is not aware of recent instances of illegal collection, we still consider illegal collection a threat to Bay checkerspot butterfly populations because of the small size of many of the remaining populations.

Ehrlich and Murphy (1987, p. 128) reported that foot-traffic associated with intensive study of one Jasper Ridge population had a significant impact on the area's vegetation, and suggested that butterfly eggs, larvae, and pupae also may have been destroyed by the trampling. We do not have any additional information regarding the impact of foot-traffic on the Bay checkerspot butterfly.

Harrison *et al*. (1991, p. 227) examined the effects of scientific collection of the Bay checkerspot butterfly in two populations on Jasper Ridge. Harrison *et al*. (1991, p. 241) concluded that the effects of sampling are small (statistically undetectable) in comparison to variation in population size due to environmental factors; however, they did note that sampling appears to have increased the chances of extinction (as high as 15 percent) of two of the three populations at Jasper Ridge. Orive and Baughman (1989, p. 246) studied the effects of a mark-and-recapture study on the Bay checkerspot on Jasper Ridge, and found that handling by experienced researchers did not significantly increase observable wing-wear. However, Singer and Wedlake (1981, pp. 216-217) found that butterfly recapture rates were higher (21 percent) for the common bluebottle swallowtail (*Graphium sarpedon*) if they were marked without being handled, while handled butterflies were recaptured at a rate of only 2 percent. Currently the Service is not aware of any mark-and-recapture studies being conducted on the Bay checkerspot butterfly, as such mark-recapture studies are not currently viewed as a significant threat.

FACTOR C: Disease or Predation

At the time of the listing, parasitism by three species of parasitoids was not a major factor in determining the size of any Bay checkerspot butterfly population (Service 1987, p. 35376). The Service does not have any additional information on disease, predation, or parasitism in Bay checkerspot butterflies.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

Federal Protections:

At the time of listing, there were no regulatory mechanisms thought to adequately protect the butterfly from habitat loss, illegal collection, or harm resulting from other threats. Below is a summary of those Federal mechanisms that afford some protection to the Bay checkerspot butterfly.

Endangered Species Act of 1973, as amended (ESA): The ESA is the primary Federal law providing protection for this species. The Service's responsibilities include administering the Act, including sections 7, 9, and 10 that address take. 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. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project.

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(18) defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Service regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that result from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). 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). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan (HCP) that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and many of these HCPs are coordinated with California's related Natural Community Conservation Planning program (such as the Santa Clara Valley HCP/NCCP in preparation).

National Environmental Policy Act (NEPA): NEPA (42 U.S.C. 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

The Lacey Act**:** The Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of "wild animal" includes parts, products, eggs, or offspring. Since populations of the Bay checkerspot butterfly are known to have been impacted by illegal collection in the past (before listing), the Lacy Act affords some protection to the butterfly.

The Clean Air Act (CAA): The CAA (P.L 101-549) relates to the reduction of smog and air pollution and is under the authority of the Environmental Protection Agency (EPA), although individual States generally implement the CAA. Vehicle emissions are regulated under the CAA and in the mid 1970s catalytic converters began to be installed in vehicles to reduce harmful emissions such as hydrocarbons. However, installation of catalytic converters resulted in an increase in the emission of nitrous oxides and ammonia. Other substances produced from internal combustion of fossil fuels include nitrogen oxides, nitric acid, nitrate, and ammonium. According to a report prepared for the California Energy Commission nitric acid and ammonia "have the highest deposition velocities, because they are highly soluble in water" (Weiss 2006b, p. 11). Ammonia is currently an unregulated emission (Weiss 2006b, p. 55). The current emission standards still result in the deposition of 10-15 kg N/ha/yr along portions of Coyote Ridge (Weiss 1999, p. 1482). Serpentine grasslands are believed to experience adverse impacts as a result of nitrogen deposition at rates of 5 kg N/ha/yr. Therefore, the existing air quality standards are inadequate to protect the butterfly from habitat degradation resulting from invasion by non-native vegetation due to excessive nitrogen.

State Protections:

The State's authority to conserve rare wildlife and plants is comprised of four major pieces of legislation: the California Endangered Species Act, the Native Plant Protection Act (NPPA), the California Environmental Quality Act, and the Natural Community Conservation Planning Act. Adult and larval host plants for the Bay checkerspot butterfly are not considered rare and therefore are not protected by the NPPA.

California Endangered Species Act (CESA): The CESA (California Fish and Game Code, section 2080 *et seq.*) does not provide protection to insects (sections 2062, 2067, and 2068, California Fish and Game Code).

California Environmental Quality Act (CEQA): The CEQA requires full public disclosure of the potential environmental impact of proposed projects. The public agency with primary authority or jurisdiction over the project is designated as the lead agency and is responsible for conducting a review of the project and consulting with other agencies concerned with resources affected by the project. Section 15065 of CEQA guidelines requires a finding of significance if a project has the potential to reduce the number or restrict the range of a rare or endangered plant or animal (including insects). Species that are eligible for listing as rare, threatened, or endangered but are not so listed are given the same protection as those species that are officially listed with the State. Once significant impacts are identified, the lead agency has the option to require mitigation for effects through changes in the project or to decide that overriding considerations make mitigation infeasible. In the latter case, projects may be approved that cause significant environmental damage, such as destruction of endangered species. Protection of listed species through CEQA is, therefore, at the discretion of the lead agency. CEQA provides that, when overriding social and economic considerations can be demonstrated, project proposals may go forward, even in cases where the continued existence of the species may be jeopardized, or where adverse impacts are not mitigated to the point of insignificance.

Natural Community Conservation Planning Act (NCCP): The NCCP is a cooperative effort to protect regional habitats and species. The program helps identify and provide for area wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many NCCPs are developed in conjunction with HCPs prepared pursuant to the Federal ESA. If included as a covered species, a NCCP would afford the butterfly considerable benefits, since the Act requires NCCPs contribute to the recovery of covered species.

Summary of Factor D: In summary, the Endangered Species Act is the primary Federal law that provides protection for this species since its listing as threatened in 1987. Other Federal or State regulatory mechanisms provide some discretionary protections for the butterfly; however, we believe other laws and regulations have limited ability to protect the Bay checkerspot butterfly in absence of the Endangered Species Act.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

At the time of listing habitat damage resulting from drought and overgrazing was noted as having caused the disappearance of four populations of Bay checkerspot butterfly (Murphy and Erlich 1980, p. 319). The listing rule also noted natural climatic changes in association with habitat that has been impaired. An additional threat noted in the Recovery Plan (Service 1998, pp. II-191-197) included pesticide use. Today, wildfire and small population size coupled with pesticides, extreme weather, and anthropogenic climate change are also threats under Factor E.

Pesticides: According to the California Department of Pesticide Regulation (CDPR), 1,388,327 pounds of pesticides were applied in Santa Clara County and 365,491 pounds were applied in San Mateo County in 2006. Use of pesticides (i.e., insecticides and herbicides) in or adjacent to areas with Bay checkerspot butterflies may negatively affect populations. Populations adjacent to areas where there is intensive use of pesticides may be at risk due to pesticide drift and runoff. In 1990 and 1992, De Snoo *et al*. (1998, p. 157) found that the number of butterfly species and number of individuals was significantly greater in the unsprayed margins of a field than in areas adjacent to treated fields. Longley *et al*. (1997, p. 165) observed increased larval mortality of cabbage white butterfly (*Pieris brassicae*) in hedge rows adjacent to conventionally sprayed headlands compared to those with a 6-meter buffer. In at least one instance, Bay checkerspot butterfly larvae appeared to have survived a direct application of malathion by the California Department of Food and Agriculture (to control Mediterranean fruit fly (*Ceratitis capitata*)); however, the application was conducted in the fall of 1981 when larvae were still in diapause. Malathion is a broad spectrum organophosphate insecticide used on a wide variety of agricultural crops. Malathion also has residential uses on ornamental plants, including lawns. Other uses for malathion include outdoor garbage dumps, mosquito control programs, as well as pasture and rangelands (EPA 2006, p. 5). Application of malathion may be by aircraft, irrigation systems, ground fogging, or hand sprayers and spreaders (EPA 2006, p. 5). According to the CDPR, in 2006, 1,626 pounds of malathion was applied in Santa Clara County and 205 pounds were applied in San Mateo County (CDPR 2006). There are more than 89,000 acres of agricultural land on the Santa Clara Valley floor west of Coyote Ridge and south of Tulare Hill. The exposure risk for Bay checkerspot butterflies on Coyote Ridge and Tulare Hill to malathion is likely low, but is dependent on the type of application. Applications that result in drift, such as

that associated with aerial spraying or ground fogging, are the most likely type of application that could result in exposure of Bay checkerspot butterflies. The CDPR has no information regarding the application of malathion in areas currently occupied Bay checkerspot butterfly (CDPR 2006).

Homeowners, businesses, and public agencies make widespread use of organophosphates and *Bacillus thuringiensis* (Bt) (a bacteria) to eradicate pests (lepidopterans, coleopterans, and dipterans) such as the California oakworm (*Phryganidia californica*), light brown apple moth (*Epiphyas postvittana*), and other moth larvae that sometimes defoliate trees and crops. Other uses for Bt include mosquito control programs, maintenance of rights of way, landscape maintenance, and residential use (EPA 1998, p. 54-55). Application of Bt may be by aircraft, irrigation systems, and hand sprayers and spreaders (EPA 1998, p. 5). In 2006, 6,027 pounds of Bt was applied in Santa Clara County and 414 pounds in San Mateo County (CDPR 2006). Since Bt is widely used by State and County officials to control a number of invasive lepidopterans in order to protect agricultural resources, the exposure risk to Bay checkerspot butterflies may be high in occupied areas that are adjacent to application sites, especially if applied by aircraft over large areas (i.e., county-wide spraying). The CDPR has no information regarding application of Bt in areas currently occupied Bay checkerspot butterfly (CDPR 2006).

The following 12 pesticides have been identified as having or potentially having adverse effects on Bay checkerspot butterflies: acephate, azinphos-methyl, bendiocarb, chlorpyrifos, fenthion, naled, permethrin, S-fenvalerate, endosulfan, parathion, phorate, and trifluralin (Service, *in litt.* 1999, p. 3). These pesticides target a wide range of species including, but not limited to: white flies, black flies, beetles, roaches, ants, wasps, termites, grasshoppers, crickets, moths, leafhoppers, aphids, mosquitoes, lice, fleas, ticks, spiders, mites, and nematodes. Trifluralin is an herbicide and targets a range of vegetation including grasses, morning glory, millet, foxtail, nettles, thistles, and wild oats and barley. The majority of these 12 pesticides are used in agricultural operations (fruit, vegetables, nuts, orchards, sod farms, and nurseries to name a few), but they are also frequently used in residential and commercial areas. All 12 pesticides are applied by a variety of methods including by aerial spraying, backpack spraying, ground fogging, dusting, and granular application. Because the 12 pesticides are used to control a wide variety of organisms (including lepidopterans) and application methods include aerial spraying, the exposure risk to Bay checkerspot butterflies is potentially high in certain areas. Given that the majority of these 12 pesticides are used to treat agricultural crops, the risk of direct exposure from application within occupied habitat is relatively low since agricultural operations in Santa Clara County occur on the valley floor, while the Bay checkerspot butterflies occur primarily in the hills. However, the risk may be high in occupied areas that are adjacent to application sites, especially if applied by aircraft over large areas or ground fogging in residential areas adjacent to Bay checkerspot populations (such as the Ranch on Silver Creek).

According to the California Department of Pesticide Regulation (CDPR 2006), a combined total of 16,157 pounds of acephate, azinphos-methyl, chlorpyrifos, naled, and permethrin were applied in Santa Clara County in 2006 and 1,066 pounds of endosulfan and trifluralin were applied in Santa Clara County in 2006. In San Mateo County, approximately 3,292 pounds of acephate, chlorpyrifos, naled, and parmethrin were applied in 2006 and 65 pounds of endosulfan and trifluralin (CDPR 2006). The use of pesticides could result in adverse effects to the listed butterflies if their use occurs within or in close proximity to occupied habitat. Herbicides pose a

threat to these animals if they kill the larval food plants or the adult nectar plants. Larvae of some species of lepidopterans are extremely sensitive to pesticides, and even soil around host plants may remain contaminated after the plant is safe (Mattoon *et al.* 1971, p. 254).

In summary, a variety of pesticides are used within the range of the Bay checkerspot butterfly, but the Service does not have specific information regarding pesticide use within occupied habitat. However, pesticides are known to affect a wide range of organisms and some target lepidoptera in particular. Given the general nature of pesticides the Service considers them to be a current threat to the Bay checkerspot butterfly. However, the Service does not have specific information regarding the use of the individual pesticides mentioned above or their possible adverse affects on the Bay checkerspot butterfly beyond a general understanding that pesticides are harmful to a variety of species, including butterflies.

Wildfire: No Bay checkerspot butterflies were observed on San Bruno Mountain after a wildfire burned portions of the mountain in 1986. However, only about 50 adult Bay checkerspot butterflies were observed on the mountain in 1984 (CNDDB 2006), so their subsequent disappearance may not have been solely related to the fire (overcollection and drought likely contributed to the extirpation at this site). Wildfire may pose a greater risk now than at listing, due to small population size and the current narrow distribution of the butterfly. Wildfires can burn large tracts of grassland habitats and the only remaining core population is on Coyote Ridge in primarily contiguous grassland. A large wildfire at this location could eliminate or result in substantial declines in the core population.

While wildfire poses a significant threat, prescribed fire can be an effective management tool in restoring native grassland ecosystems. The use of fire as a management regime in serpentine grasslands has not been well studied; however, use of prescribed burns may be an effective management tool depending on timing, intensity, and size of the area burned. An experimental prescribed burn was conducted over a small portion of Coyote Ridge in 2006, but the results have not yet been submitted to the Service. A wildfire on the northwest portion of Tulare Hill in 2004 resulted in higher densities of both larval host and adult nectar plants; however, population surveys have not been conducted on that portion of Tulare Hill.

Small population size: Small population size coupled with climate change was noted in the listing rule as a threat. The population size of the Bay checkerspot butterfly is heavily dependent on survival of prediapause larval, which in turn is tied to timing of host plant senescence. Host plant senescence, as discussed in the life history section above, is tied to the annual variation in precipitation and temperature as well as slope aspect (i.e., solar exposure). Populations that are reduced to a small size are less resilient to extreme weather and are prone to local extirpation. Given the Bay checkerspot butterfly's metapopulation dynamic, population fluctuations, local extirpations, and recolonization are normal occurrences for the subspecies (Ehrlich *et al*. 1975, pp. 221-228; 1980; Harrison 1994, pp. 111-128). However, small population size combined with the species' metapopulation dynamics, climate change, nitrogen deposition, development, and habitat fragmentation is likely a significant threat.

Climate change: Climate change is a threat to the Bay checkerspot butterfly as noted in both the listing rule and the Recovery Plan. At the time of listing, natural climate change was identified

in conjunction with habitat damage as reducing carrying capacity. However, since listing the threat from extreme weather (i.e., periods of prolonged drought or excessive rain) has been expanded to include anthropogenic climate change. One of the three populations at Jasper Ridge became extirpated in 1964 and then another in the late 1970s after severe droughts. Several populations of Bay checkerspot butterflies were known to disappear following the droughts in the late 1970s, including two in Alameda County, one on Pulgas Ridge, a site west of Uvus Reservoir (Service 1987, p. 35376; CNDDB 2008), west of Calero Reservoir (CNDDB 2008), near San Martin (CNDDB 2008), portions of the population in the Silver Creek Hills, and near Coyote Reservoir (Murphy and Ehrlich 1980, p. 319). Murphy and Weiss (1992, p. 6) stated that the droughts in the mid to late 1970s and 1980s resulted in extreme population declines including all populations (known at that time) in Santa Clara County except for the largest population on Coyote Ridge. Murphy and Weiss (1992, p. 6) also note in 1981-1983 (El Niño years) prolonged rains resulted in declines due to extended periods of pupal development. Murphy and Weiss (1992) postulated that the Kirby Canyon population (Coyote Ridge south of Metcalf Road) of Bay checkerspot butterflies may not adequately be able to withstand climate changes. The populations in southern Santa Clara County receive the least amount of rainfall in the range of the butterfly. McLaughlin *et al*. (2002a) analyzed precipitation records in the vicinity of San Jose from 1932-1998, which showed an increased variability in precipitation; the study indicated that increased variability in precipitation caused the local extinction of Bay checkerspot butterflies at the Jasper Ridge Biological Preserve (McLaughlin *et al*. 2002a, p. 547).

The Recovery Plan notes that the Bay checkerspot butterfly is very susceptible to climate change (Service 1998, p. II-197), since the butterfly's development (and mortality) is tied to its host plant's development, which in turn is temperature and rainfall dependent. Murphy and Weiss (1992) modeled the impact of four broad climate change scenarios on the Bay checkerspot butterfly in the San Francisco Bay area. According to Murphy and Weiss (1992, pp. 8-9), three out of the four scenarios modeled (warmer/drier, cooler/drier, and colder/wetter) would have negative impacts on the Bay checkerspot butterfly, as well as changes in the timing of rainfall. Seasonal rains that are too early or too late result in larval development being out of phase with their host plants (i.e., host plants senesced prior to larvae entering diapause). In addition, changes in temperature could shift the development period of the butterfly so that it is out of sync with its host plants. Hayhoe *et al*. (2004, p. 12423) estimated temperatures in California would increase by 1.35-1.6 degrees Celsius by midcentury and 2.3-3.3 degrees Celsius by the end of the century under low emission scenarios, and by 1.5-2.0 degrees Celsius by midcentury and 3.8-5.8 degrees Celsius by the end of century under high emission scenarios.

Forister and Shapiro (2003, p. 1131) observed that the mean date of first flight for 16 out of 23 butterfly species in northern California had moved towards an earlier date over 31 years. In four species the shift was significant and in two species the shift was approximately a month earlier (Forister and Shapiro 2003, p. 1132). As summarized by Parmesan (2006), climate variables explained 85 percent of the variation in flight date, with warmer, drier winters driving early flight. While none of the species in the study were in the genus *Euphydrys*, seven of the species were in the Nymphalidae family. The date of first flight was also observed to have increased in 26 out of 35 butterfly species in the United Kingdom (Roy and Sparks 2000 as cited in Parmesan 2006, p. 7). Stefanescu *et al*. (2003, p. 1498) found that 17 species of butterflies examined in their study had advanced first flight dates and eight with significant advances in mean flight

dates. Visser and Holleman (2003, p. 292) observed decreased synchronization between hatching of winter moth (*Operophtera brumata*) eggs and oak bud burst (food plant for the moth) resulting from increased spring temperatures. Visser and Holleman (2003, p. 292) hypothesized that since larvae can only survive 2-3 days without food this mis-timing would lead to mortality or dispersal. Since prediapause larval Bay checkerspot butterflies are small and do not travel far, this would likely result in increased larval mortality.

A second concern with climate change is amount and frequency of rain events, drought, and heat waves. Bell *et al*. (2004, pp. 85-86) noted the frequency, number, and length of heat events would increase and the amount of rainfall would decrease through out most of California (including locations with Bay checkerspot butterflies). Hayhoe *et al* (2004, p. 12426) notes that by the end of the century, the length, frequency, and severity of extreme droughts increases in three out of four scenarios. Murphy and Weiss (1988, p. 189) stated that synchronicity of larvae and host plant senescence was poor in drought years. Increased frequency and duration of drought would likely result in higher larval mortality.

Summary of Factor E: The threats from climate change and wildfire are significant threats especially in conjunction with the current narrow distribution and small population size of the subspecies. Climate change and wildfire in conjunction with other impairment of habitat due to invasive and non-native vegetation, nitrogen deposition, and fragmentation and loss of habitat resulting from development, represent major threats to the Bay checkerspot butterfly. Pesticides were noted as a threat in the Recovery Plan. The Service has no information regarding the impact of pesticides on the Bay checkerspot butterfly beyond a general understanding that pesticides are harmful to a variety of species, including lepidopterans, and that pesticides are being applied in areas adjacent to extant occurrences of Bay checkerspot butterflies and may be applied within areas currently occupied by the butterfly.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough to downlist, or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Delisting: The Bay checkerspot butterfly will be recommended for delisting with the completion of the following criteria (*Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* issued September 20, 1998):

1. *Core population – Adult populations of at least 8,000 butterflies, or populations of at least 20,000 postdiapause larvae, in 12 of 15 consecutive years, at each of the following areas: Kirby, Metcalf, San Felipe, Silver Creek Hills, Santa Teresa Hills, and Edgewood Park. Total population across all core areas should be at least 100,000 adults or 300,000 post-diapause larvae in each of the 12 years, with no recent severe decline.*

   Is criterion still valid: Yes.

   Listing factors addressed: Present or threatened destruction, modification or curtailment of its habitat or range (Factor A). Other natural or manmade factors affecting its continued existence (i.e., small population size, climate change) (Factor E).

   Has criterion been met: Criterion 1 has not been met; in fact, populations have continued to decline since listing. For specific information regarding size of populations in core areas, see the Abundance section above. This criterion is up-to-date and still relevant to the subspecies.

2. *Satellite populations – Adult populations of at least 1,000 butterflies, or populations of at least 3,000 postdiapause larvae, in 10 of 15 consecutive years, at each of at least nine distinct areas: three in San Mateo County, five in Santa Clara County, and one in Contra Costa County. Adult populations of at least 300 butterflies, or populations of at least 1,000 postdiapause larvae, in 8 of 15 consecutive years, at each of at least 18 additional distinct areas: 5 in San Mateo County, 10 in Santa Clara County, 1 in Alameda County, and 2 in Contra Costa County. To be "distinct," populations should be separated by at least 1 kilometer (3,000 feet) of unsuitable, unrestorable habitat.*

   Is criterion still valid: No. Satellite populations in Alameda and Contra Costa Counties are unlikely to be established naturally due to the distance between them and extant populations being several times greater than the known dispersal capabilities of the butterfly. Even if all recently occupied core and secondary habitats in San Mateo and Santa Clara Counties were occupied, the likelihood of recolonization and persistence in sites at distances greater than 5 miles from occupied core areas would be low (Harrison *et al*. 1988, p. 371). One peer reviewer on the proposed revised Critical Habitat designation for the Bay checkerspot butterfly commented that San Bruno Mountain was not within easy dispersal distance for the Bay checkerspot butterfly (Launer, *in litt.* 2008). A second peer reviewer stated that dispersal between San Bruno Mountain and Pulgas Ridge (approximately 10 miles south) is unlikely and should not be counted on as part of the metapopulation dynamics for the butterfly (Weiss, *in litt.* 2008). The historical sites in Alameda County are greater than 15 miles from San Bruno Mountain, 20 miles from Pulgas Ridge, and 40 miles from the nearest recent occurrence of Bay checkerspot butterflies (in Santa Clara County). The historical sites in Contra Costa Counties are

further still. If butterflies were reintroduced to sites in Alameda and/or Contra Costa Counties, given the population dynamics of the butterfly coupled with the distance between potential reintroduction sites and extant populations, it is unlikely they would persist in the long term. Some species with metapopulation dynamics whose habitat has been fragmented due to anthropogenic causes are hardly ever likely to recolonize distant patches (Harrison 1994, p. 114).

Listing factors addressed: Present or threatened destruction, modification or curtailment of its habitat or range (Factor A). Other natural or manmade factors affecting its continued existence (i.e., small population size, climate change) (Factor E).

Has criterion been met: Criterion 2 has not been met. There are no remaining populations in Alameda, San Mateo, or Contra Costa Counties. The Service is only aware of recent survey data for one satellite population in Santa Clara County, Tulare Hill, where only one adult was observed in 2006 and 2007 (the last years for which population data are available). The butterfly has not been observed in Santa Teresa Hills since 1998, when one adult and two larvae were observed (H.T Harvey and Associates 1998, p. 11). The subspecies was last observed near Calero Reservoir in 1994 (CNDDB 2008), near San Martin in 1985 (CNDDB 2008), near Hale Avenue, west of the City of Morgan Hill, in 1997 (two adults) (CNDDB 2008), in the Kalana Hills in 1997 (one adult) (CNDDB 2008), and a site 2.5 miles west of the City of San Martin since 1985 (CNDDB 2008). Historically the butterfly may have occurred on Communications Hill, but the site has since been developed to a large degree for residential housing.

3. *Protection and management of habitat – Permanent protection of adequate primary (core population), secondary (moderate-sized satellite), and tertiary habitat (small-sized satellite) to support long-term persistence of the metapopulations detailed under criteria 1 and 2 above. For satellite populations, because of their natural tendency to wink in and out of existence at various sites, this will mean protecting more habitat areas than the minimum 9 moderate-sized and 18 small-sized populations. It is estimated that nearly all known suitable habitats in San Mateo, central and western Santa Clara, western Alameda, and Contra Costa Counties will be needed to support an adequate constellation of Bay checkerspot butterfly satellite populations. Appropriate adaptive management in perpetuity of the Bay checkerspot butterfly's native ecosystem should be guaranteed in all protected habitat, including secure funding for ongoing management.*

   Is criterion still valid: This criterion only partially reflects the most up-to-date scientific data on the butterfly. As noted above for criterion 2, establishment and sustainability of populations in Alameda and Contra Costa Counties is unlikely due to the distance between them and extant populations. However, protection and management of habitat in Santa Clara County has restored some areas of degraded habitat (i.e., Silver Creek Hills) and allowed recolonization. Along the southern portion of Coyote Ridge (Kirby Canyon), protection and management of habitat has maintained large populations of the butterfly from 1997 to 2006 (Weiss 2006a, p. 1). In the absence of appropriate grazing regimes, the larval host plants would likely be outcompeted by non-native invasive grasses and the butterfly would be unlikely to persist (Huenneke *et al.* 1990, p. 489;

Weiss 1999, p. 1480). However, protecting habitat from development alone does not appear to be sufficient to maintain populations of Bay checkerspot butterflies. Many State and County parks are considered "protected" (i.e., not subject to development), but in the absence of appropriate grazing regimes, the larval host plants have been outcompeted by non-native invasive grasses and the butterfly has disappeared from most historical areas, even those areas that have not been developed and are largely undisturbed. In addition, many parks do not have conservation easements or deed restrictions, and portions of these lands could be subject to transfers to other owners, which could result in their being developed. Finally, the primary mission of many State and County Parks is recreation (trail development, hiking, horse back riding, etc.) and may not afford the same level of protection as areas that are conserved specifically for threatened and endangered species.

Listing factors addressed: Present or threatened destruction, modification or curtailment of its habitat or range (Factor A). Overutilization for commercial, recreational, scientific, or educational purposes (Factor B). Other natural or manmade factors affecting its continued existence (i.e., small population size, climate change) (Factor E).

Has criterion been met: Criterion 3 has been partially met. All known core and satellite areas in San Mateo County are under some form of protection (park open space, conservation easement, natural area, etc.). Approximately 577 acres of Bay checkerspot butterfly habitat is part of the San Bruno Mountain State and County Park and is protected and managed in accordance with the San Bruno Mountain Habitat Conservation Plan (HCP); however, management actions have been underfunded and many have not been carried out. Approximately 467 acres of the Edgewood Park core area is included in the Edgewood Park Natural Preserve; a management plan for the park has not yet been developed. All 179 acres of the Pulgas Ridge satellite area is managed as open space by the San Francisco Public Utilities Commission and may be included under a proposed HCP. All 329 acres of the Jasper Ridge satellite area is contained within Stanford University's Jasper Ridge Biological Preserve; however, the area is not managed for any species and is utilized by Stanford University primarily as a research facility. This area is currently part of a proposed HCP, but the HCP will not include the Bay checkerspot butterfly as a covered species. In total, approximately 1,552 acres of Bay checkerspot butterfly core and satellite habitats have been protected in San Mateo County, but most of these lands are not permanently protected under deed restrictions or conservation easements.

Approximately 308 acres of the Kirby Canyon area (southern portion of the Coyote Ridge core area) in Santa Clara County has been permanently protected and is being managed to benefit listed species, including the Bay checkerspot butterfly. Approximately 473 acres of the Silver Creek Hills area (extreme northern portion of the Coyote Ridge core area) has been permanently protected and is being managed to benefit listed species, including the Bay checkerspot butterfly. The Service is not aware of any areas within the Metcalf or San Felipe areas (northern portions of the Coyote Ridge core area) that are permanently protected or managed for the butterfly. Although the recovery criterion indicates the Santa Teresa Hills area is a core area, it has not been referred to as

such in the literature. In the Santa Teresa Hills, approximately 420 acres are currently owned by Santa Clara County Parks and Recreation; however, the majority of habitat is not managed to benefit the butterfly. Approximately 1,201 acres of Bay checkerspot butterfly core habitat has been permanently protected and is managed for the butterfly in Santa Clara County.

Approximately 298 acres satellite area in Santa Clara County, in the City of San Martin adjacent to the Cordevalle golf club, has been permanently protected and is currently managed for listed species, including the Bay checkerspot butterfly. Approximately 116 acres are permanently protected and managed for the butterfly on Tulare Hill. In total approximately 414 acres of satellite areas in Santa Clara County have been permanently protected and are managed for the Bay checkerspot butterfly.

A third satellite area at Coyote Lake-Harvey Bear Ranch County Park in Santa Clara County is managed, but not permanently protect, for the butterfly and includes approximately 283 acres of Bay checkerspot butterfly critical habitat (Service 2008a). A portion of a fourth satellite area near Calero Reservoir is within the Calero County Park and is managed, but not permanently protected, for the butterfly and includes 875 acres of critical habitat Unit 8.

4. *Investigation and removal of existing or reasonably foreseeable threats to bay checkerspot butterfly populations and habitat.*

   Is criterion still valid: Yes.

   Listing factors addressed: Present or threatened destruction, modification or curtailment of its habitat or range (Factor A). Overutilization for commercial, recreational, scientific, or educational purposes (Factor B). Disease and predation (Factor C). Disease and predation (Factor D). Other natural or manmade factors affecting its continued existence (i.e., small population size, climate change) (Factor E).

   Has criterion been met: Criterion 4 has not been met. Several studies have examined threats to the butterfly or its habitat from invasion of non-native vegetation (Murphy and Weiss 1988; Huenneke *et al*. 1990; Weiss 1999; Weiss 2002; Malmstrom *et al.* 2005), over and under grazing (Weiss 2002; Weiss *et al*. 2007), overcollection (Harrison *et al*. 1991), disease and predation (White 1986), wildfires (CH2M Hill 2006), and climate change (Harrison *et al*. 1988; Murphy and Weiss 1992; McLaughlin *et al*. 2002; Zavaleta *et al*. 2003; Levine and Reese 2004). While none of the studies has resulted in the removal of these threats range wide, they have resulted in more effective vegetation management over portions of Tulare Hill and Coyote Ridge.

The recovery criteria implicitly address all four of the listing factors noted in the final rule to list the subspecies. Factor B, overutilization for commercial, recreational, scientific, or education purposes, was mentioned in the listing rule, but had not been identified as a threat to any population (Service 1987, p. 35376); however, Factor B is mentioned in the Recovery Plan as a threat (Service 1998, p. II-196) and is implicitly addressed in the recovery criteria.

IV. SYNTHESIS

The status of *Euphydryas editha bayensis*, which historically occurred in five San Francisco Bay Counties, has declined dramatically since it was listed as threatened in 1987. At the time the Recovery Plan was finalized in 1998, the butterfly was restricted to San Mateo and Santa Clara Counties, with each county having one core population and a few satellite populations. Since 1998, populations of the butterfly have continued to be lost, including the core population as well as all satellite populations in San Mateo County. Loss of all populations in Alameda, Contra Costa, and San Mateo Counties, despite most being largely protected from development in City, County, and State Parks, and inclusion of some of the areas within existing or proposed HCPs, indicates that habitat protection alone is not sufficient to protect the subspecies. The Bay checkerspot butterfly is now restricted to one core population (Coyote Ridge) and a few satellite populations within an approximate 9-mile radius of Coyote Ridge. None of the threats identified in the listing rule or the Recovery Plan have been reduced or eliminated. The butterfly is still at great risk from invasion of non-native vegetation, exacerbated by nitrogen deposition from air pollution. Despite the use of prescribed burns to control non-native vegetation, wildfires may pose a greater threat now than at the time of listing due to the extremely narrow distribution of the butterfly; a single wildlife across Coyote Ridge could eliminate a large percentage of the remaining individuals. Given the butterfly's much reduced distribution and a life history closely tied to timing of annual rainfall, the butterfly may not be capable of withstanding natural fluctuations in annual weather patterns (periodic droughts) let alone larger variations due to climate change. Finally, the majority of habitat in Santa Clara County is in private ownership and ongoing development pressure will result in additional fragmentation, including fragmentation of the only remaining core population. Considering the continued decline of the butterfly (including loss of all but one core population), continuation of most of the listing threats, and reduced range, we conclude the Bay checkerspot butterfly is at greater risk of extinction now than at the time of listing and warrants reclassification to endangered status.

V. RESULTS

Recommended Listing Action:

____ Downlist to Threatened
_X__ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
____ No Change

New Recovery Priority Number and Brief Rationale: No change is recommended. The recovery priority number for the Bay checkerspot butterfly is 3C, indicating a high threat level and a high recovery potential.

Listing and Reclassification Priority Number and Brief Rationale: The recommendation to uplist of the Bay checkerspot butterfly to endangered is given a reclassification number of 3, indicating it is a subspecies with a high magnitude and imminent threat (Service 1983).

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

Many of the recovery tasks identified in the Recovery Plan focus on securing and protecting serpentine habitats. All historical Bay checkerspot butterfly populations in San Mateo County are now extirpated despite the majority of these sites being protected from development. Protection of historical and existing sites alone appears to be insufficient to recover the butterfly. Management of many of the San Mateo sites is lacking and may have contributed to the loss of the butterfly in these areas. The development and implementation of appropriate management actions at multiple sites (Recovery task 3.1) maybe the most important step in protecting the Bay checkerspot butterfly. Once historical sites have management plans that are being implemented and habitat quality improves (i.e., through the establishment of grazing), initiation of introductions (Recovery task 6.2) should proceed in order to establish core and satellite populations outside of Santa Clara County. A third important task should be the establishment of artificial rearing techniques (Recovery task 5.41). Multiple reintroductions to the same site are likely to be necessary to establish populations (Weiss, pers. comm. 2008). Establishment of artificial rearing techniques for this subspecies including captive populations would allow multiple reintroductions of the butterfly without depleting the only remaining core population.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

Bay checkerspot butterfly (*Euphydryas editha bayensis*)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
_X_ Uplist to Endangered
____ Delist
____ No change needed

Appropriate Listing/Reclassification Priority Number: 6

Review Conducted By: SFWO staff

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 7.16.09

REGIONAL OFFICE APPROVAL:

Lead Regional Director, U.S. Fish and Wildlife Service, Region 8

Approve _____ Date 8/17/09