Species Status Assessment for Smith's Blue Butterfly (*Euphilotes enoptes smithi*)

Photo by Lara Drizd/U.S. Fish and Wildlife Service

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Region 8

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EXECUTIVE SUMMARY

The Smith's blue butterfly (*Euphilotes enoptes smithi*) was listed as an endangered species in 1976 (41 FR 22041). The Smith's blue is a small butterfly endemic to the central coast of California. The Smith's blue is an annual species that primarily uses two species of buckwheat (*Eriogonum latifolium* and *E. parvifolium*) that grow in sand dunes and chaparral habitats. It is unique in that each of its life stages rely upon the buckwheat, with adults sipping nectar from the flowers and depositing eggs on the flowerheads, larvae feeding on the flowers and seeds, and pupae forming directly on the plants before dropping to the ground where they overwinter in the leaf litter.

The occupied range of the Smith's blue is significantly larger than was known at the time the subspecies was listed, and numerous new occupied sites have been found throughout the southern part of its range. At the time of listing, the Smith's blue was thought to inhabit only the coastal sand dunes that extend from the mouth of the Salinas River south to Del Rey Creek in northern Monterey County. The 1984 Recovery Plan noted that since the Smith's blue was listed, extensive surveys had located the butterfly in more abundance and more diverse habitats, including the Carmel Valley and the coastal Big Sur area to the south. Smith's blue is currently thought to occur in scattered colonies in the inland and coastal sand dunes, serpentine grasslands, and cliffside chaparral communities in Monterey and San Luis Obispo Counties in two metapopulations. These two metapopulations are now likely isolated from one another, with one inhabiting the dunes along Monterey Bay and one in the Carmel Valley south into Big Sur, separated by development around the City of Monterey. The northern metapopulation is approximately 23 square miles (mi^2; 60 square kilometers [km^2]). The southern metapopulation is estimated in two parts: the Carmel Valley, which includes the more inland habitat, is approximately 69 mi^2 (179 km^2), and the Big Sur coastal habitat is approximately 108 mi^2 (280 km^2). Buckwheat host plants, coastal habitats with appropriate disturbance regimes for maintenance of buckwheat host plants, and habitat connectivity are needed across the range for long-term viability.

At the time of listing, habitat loss and degradation due to housing developments and highway construction, heavy foot and vehicular traffic on Fort Ord Army Base, and the spread of introduced iceplant were identified as the primary threats to the species (50 FR 48139). Since then, we have learned that the range of the subspecies includes a larger area and this has changed our understanding of the threats. At the time of the last 5-year review, the decline of the Smith's blue butterfly across its range was attributed to degradation and loss of habitat as a result of urban development, recreational activities, sand mining, fire suppression, and encroachment of invasive, nonnative vegetation (Service 2006, p. 14). We now consider the impacts of grazing and factors related to climate change, especially sea level rise and drought, to be threats to the species. Some of the currently occupied habitat is owned by Federal, State, and local agencies with at least some management direction to conserve Smith's blue habitat across its range; however, much of the potential habitat for the Smith's blue is privately owned and at risk of development. Because of its proximity to the coast, much of this habitat is subject to restrictions mandated by local coastal programs, the California Coastal Act, and the California Environmental Quality Act. Some conservation efforts to remove invasive, nonnative vegetation and to restore the habitat have been completed, but large areas remain invadedfested. Consequently, most of the Smith's blue's buckwheat habitat remains vulnerable to development and the persistent encroachment of invasive, nonnative vegetation, and overstabilization of its habitat due to lack of disturbance.

Currently, we do not have data to determine the resiliency of Smith's blue populations. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Buckwheat host plants, coastal habitats and disturbance, and habitat connectivity are threatened by habitat loss and degradation, likely reducing the abundance, survival, and fecundity of the species. Redundancy will always be limited for local, endemic species with a naturally limited range. However, two metapopulations composed of several to many populations and two habitat types provides some level of redundancy in the face of potential catastrophic events, such as wildfire or catastrophic drought. Finally, because of its reliance on buckwheat, nonnative, invasive vegetation must be managed in order for Smith's blues to have sufficient habitat. Given the host-plant specificity, the subspecies has always had some level of limited adaptive capacity. Habitat degradation has reduced the potential for already limited adaptive capacity, which comprises representation for the subspecies.

Commented [TC1]: There is a risk that the two habitat types house two genetically differentiated populations, maybe not enough to consider them different subspecies but perhaps enough to not consider them necessarily redundant. For instance, could a coastal individual survive if placed in the inland habitat? This seems unknown.

Looking into the future, we developed three scenarios that capture the range of plausible effects to the species from predicted change over 40 years. We chose 40 years because this encompassed projections for each factor influencing viability, where available. Scenario 1 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and effects of Representative Concentration Pathway (RCP) 4.5 scenario for climate change in the California Central Coast region based on California's 4th Climate Change Assessment (Langridge et al. 2018). Scenario 2 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 8.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018). Scenario 3 assumes a continuation of current trends in development, an increase in conservation-related actions for invasive, nonnative vegetation, and RCP 4.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018).

While we do not have data to determine the resiliency of Smith's blue populations, we can forecast that the resiliency for Smith's blue butterfly populations will likely change under each future scenario. Under future scenarios 1 and 2, invasive, nonnative vegetation, drought, and sea level rise are predicted to increase in Smith's blue habitat, more so in Scenario 2 than Scenario 1. The butterfly's ability to persist into the future will be negatively affected by increased overstabilization of is habitat by nonnative, invasive vegetation, habitat degradation due to drought, and loss of habitat due to sea-level rise, all of which will reduce the abundance and availability of their buckwheat host plants, coastal habitats with appropriate disturbance, and habitat connectivity (i.e., the resiliency of populations will be reduced from current conditions). Under future scenario 3, we forecast increased management for invasive, nonnative vegetation, but increased drought and sea-level rise. The butterfly's ability to persist into the future will be negatively affected by habitat degradation due to drought, and loss of habitat due to sea-level rise, but will be positively affected by management for invasive, nonnative vegetation. The abundance and availability of their buckwheat host plants, coastal habitats with appropriate disturbance, and habitat connectivity may be only somewhat reduced from current conditions under this scenario. If habitat loss and reduced resiliency predicted under Scenarios 1 and 2 lead to population extirpations, redundancy for the subspecies will be reduced, increasing extinction risk from catastrophic events, such as wildfire or drought. In future scenarios 1 and 2, habitat degradation is predicted to reduce the potential for already limited adaptive capacity, which comprises representation for the subspecies. In future scenarios 3, in which invasive, nonnative vegetation management actions are funded and implemented, the trajectory for invasive, nonnative vegetation spread could be slowed and areas invadedfested would be reduced. Increased habitat quality would maintain the species' ability to withstand catastrophic events and facilitate the potential for adaptive capacity and long-term viability of the species.

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1.0 INTRODUCTION

1.1 Listing History

Original Listing
FR notice: 41 FR 22041
Date listed: June 1, 1976
Entity listed: Smith's blue butterfly (*Euphilotes enoptes smithi*)
Classification: Endangered

1.2 Purpose

We, the U.S. Fish and Wildlife Service (Service), completed a 5-year review for the Smith's blue butterfly in 2006 (Service 2006, entire) and at that time, found sufficient evidence to recommend downlisting based on the following:

(1) The occupied range of the Smith's blue was found to be significantly larger than was known at the time the subspecies was listed, and numerous new occupied sites had been found throughout the southern part of its range. However, most occupied sites were surveyed only once, and we had no substantial information on the persistence of such occurrences.

(2) We found that the northern portion of the range continued to be threatened by urban development activities, along the coast of Monterey Bay from the Salinas River to Sand City.

(3) We considered threats to the Smith's blue to be less imminent in the larger, southern portion of the subspecies' range. Threats were present but did not appear to be as imminent or large-scale as in the northern portion and a substantial amount of habitat occurred on public lands.

The Species Status Assessment (SSA) framework (Service 2016, entire) is intended to guide an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. For this analysis, we focused on new information available since 2006. This SSA is not a decisional document; rather, it provides a review of available information strictly related to the biological status of the Smith's blue. This report is a summary of the SSA analysis, which entails three iterative assessment stages to characterize species viability: (1) the species' needs (ecology), (2) the species' current condition, and (3) the species' future condition (Smith et al. 2018, entire).

For the purpose of this assessment, we generally define viability as the species' ability to sustain populations in the wild over time. Using the SSA framework, we consider what the Smith's blue needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (referred to herein as the 3Rs) (Service 2016, entire; Smith et al. 2018, entire).

- Resiliency describes the ability of populations to withstand stochastic disturbance. Resiliency is positively correlated to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance.

- Redundancy describes the ability of a species to withstand catastrophic events. Redundancy is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species' range. It can be measured by population number, spatial extent, and degree of connectivity.
- Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, the gene diversity, heterozygosity, or alleles per locus.

This document is a compilation of the best available scientific information (and associated uncertainties regarding that information) used to assess the viability of the Smith's blue butterfly.

2.0 SPECIES BACKGROUND

2.1 Physical Description

The Smith's blue is a member of the Polyommatini tribe (blues) within the Lycaenidae family (gossamer-winged butterflies). Adult Smith's blues have a wingspan of less than one inch (0.8–0.9679 [in]; 2.02–2.42 centimeters [cm]) (Mattoni 1954, pp. 160–161). Like other members of this tribe, Smith's blues have blue on the dorsal (upper) sides of their wings. Males are bright blue, whereas females are more brown-colored with a band of orange marks across the hind wings. The wings of both species have a checkered fringe along the outer edge, which is more pronounced on the forewings (front wings closer to the head) than the hindwings (rear wings). The ventral (under) sides of both sexes are whitish-gray, speckled with black dots, and have a narrow and wavy orange hindwing band (Figure 1).

Smith's blue larvae vary in color from pale yellow or cream to rose, and often resemble the color of the buckwheat flowers on which they feed. Larvae are cylindrical caterpillars and taper towards the head and rear. Because of their small size and cryptic coloration, young larvae can be difficult to detect. They grow to approximately half an inch in length (~1.3 cm). Mature larvae can be found nestled in or on top of the buckwheat flowers.

Figure 1. Adult Smith's blue on seacliff buckwheat (Eriogonum parvifolium). Photo by Lara Drizd/Service

2.2 Taxonomy

The Smith's blue butterfly was originally described as *Philotes enoptes smithi* by Mattoni (1954, p. 160). Shields (1975, p. 1) realigned several genera of butterflies, moving the Smith's blue butterfly into the genus *Shijimiaeoides*, thus the Smith's blue was listed as *Shijimiaeoides enoptes smithi* under the Endangered Species Act in 1976. Mattoni (1977, p. 224) realigned several genera of butterflies, moving the Smith's blue butterfly into the genus *Euphilotes*, resulting in its current scientific name *Euphilotes enoptes smithi*.

Pratt and Emmel (1998, pp. 210–211) proposed splitting a new subspecies from the Smith's blue called *Euphilotes enoptes arenacola*, which was said to inhabit sand dunes along Monterey Bay and feed on coast buckwheat (*Eriogonum latifolium*). They stated that the new subspecies should be defined based on the following differences: 1) use of a different food plant (coast buckwheat, as opposed to seacliff buckwheat (*E. parvifolium*), which is the primary food plant used by Smith's blues in more inland and southern locations); 2) their observation that it has an earlier flight period; and 3) minor differences in wing coloration.

We are aware of no peer reviewed articles that have commented on the proposed taxonomic split and have received evidence that it may not be warranted. Smith's blue individuals have been observed utilizing both ~~species of~~ buckwheat species for nectaring and breeding purposes (White 2000, in litt.; Arnold 1983a, p. 142), indicating that individuals can use both as ~~do not always discern between~~ host plants. We have also received reports indicating that Smith's blues may shift from one host plant species to the other as each species becomes more abundant in an area (Thomas Reid Associates 1987, p. 8; 1999, p. 14).

Commented [TC2]: They may favor one over the other

It is possible that differences in flight period represent phenotypic plasticity within a single subspecies (allowing adults to synchronize their activities with the blooming of available food plants), rather than genetic differences between subspecies (R. White, in litt. 2000). Flight periods have also been observed to vary geographically, such that the flight period of more inland populations feeding on seacliff buckwheat coincides with that of coastal populations feeding on coast buckwheat (Arnold 1991, p. 4). Because of the uncertainty relative to the proposed taxonomic split and the presence of substantial threats to both populations of Smith's blues, at this time we continue to recognize the Smith's blue butterfly as occurring from the mouth of the Salinas River in Monterey County south to San Carpoforo Creek in northern San Luis Obispo County.

Intergrades between the Smith's blue and Tilden's blue butterflies (*E. e. tildeni*) have been observed in inland Santa Cruz County (Service 1986, entire) and possibly in the Carmel Valley, Monterey County (Arnold 1991, p. 10). However, some confusion exists as the colors and markings of Tilden's blues can appear similar to Smith's blues, especially on faded or tattered individuals (Arnold 2002, p. 5).

We are not aware of any research conducted on the genetics of Smith's blue butterflies.

2.3 Historical Distribution

The Smith's blue butterfly was originally described from specimens collected at Burns Creek on the Big Sur coast, near California State Highway 1, in 1948 (Mattoni 1954, p. 158). At the time of listing in 1976, the Smith's blue was thought to inhabit only the coastal sand dunes that extend from the mouth of the Salinas River south to Del Rey Creek in northern Monterey County. This area is now considered the northern metapopulation (Figure 2). In the 1984 Recovery Plan, it was thought that the species may extend north into Santa Cruz and San Mateo Counties (Service 1984, p. 11). In 1986, a meeting of lepidopterists was convened and all available specimens of *Euphilotes* from Santa Cruz County and museum specimens were examined. The consensus was that the Santa Cruz specimens represented an intergrade between Smith's blue and Tilden's blue butterfly (*E. e. tildeni*) and were not part of the listed entity (Service 1986, p. 1–3). The 1984 Recovery Plan also noted that since the Smith's blue was listed, extensive surveys had located the butterfly in greater abundance and in more diverse habitats, including the Carmel Valley and the coastal Big Sur area to the south. This area is now considered the southern metapopulation (Figure 2). We consider these groupings to be metapopulations because the Smith's blues are spatially separated in scattered colonies but it is likely that a few individuals disperse during the flight season and facilitate an unknown degree of gene flow within each region.

Commented [TC3]: There should be a section on metapopulation dynamics in general, even if it is unknown for the blue specifically, in order to put down the importance of and expectations of colonization and extinction events as part of their typical population dynamics. Also the importance of connectivity for such dynamics. It is important to record this information for future surveying efforts, in that temporarily unoccupied habitat patches are expected to exists and yet are still important in the overall metapopulation viability and survival and recovery of the species.

Also include in the discussion if there is any knowledge about core populations vs satellite populations, although considering the lack of recent surveys this is probably unknown.

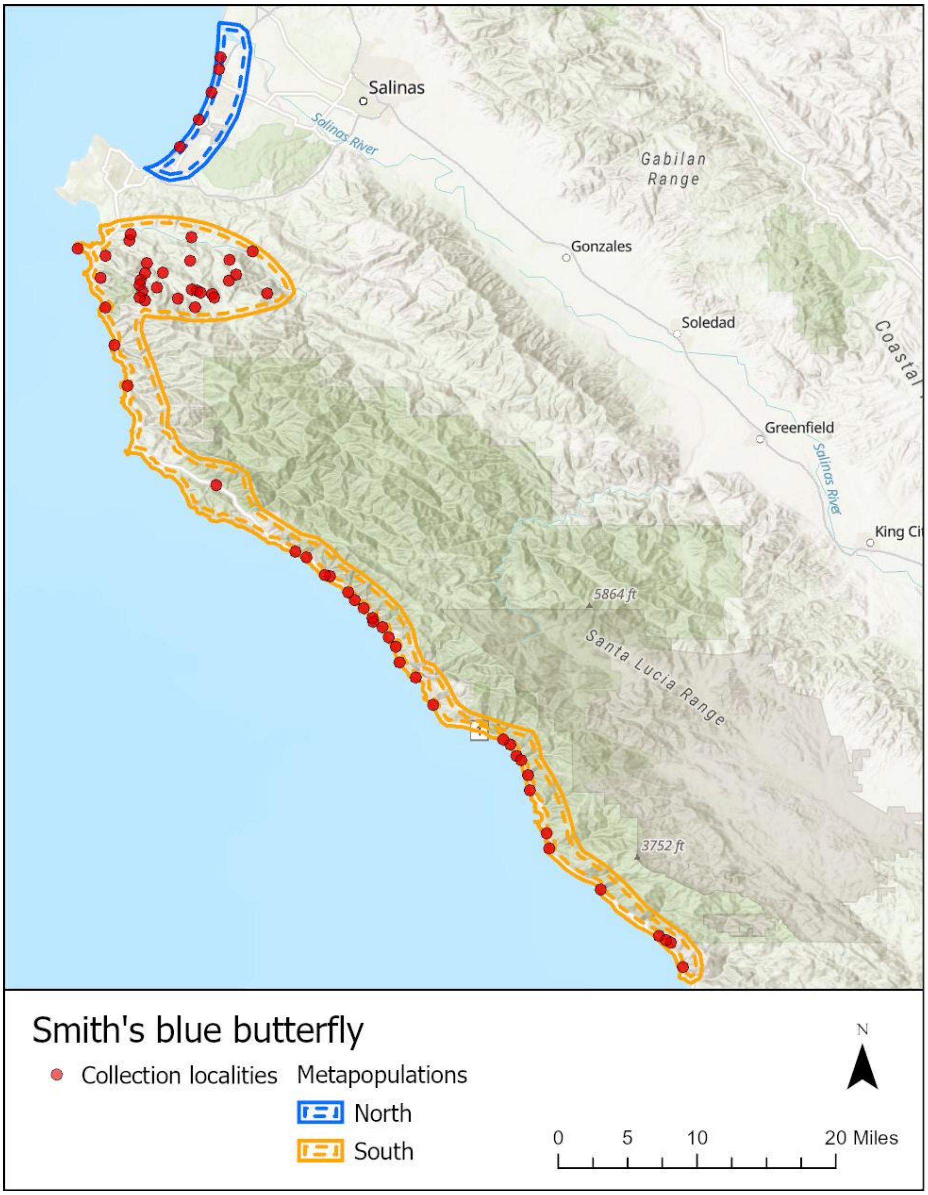

Figure 2. Distribution of the Smith's blue butterfly on the central coast of California. Collection localities are records for the subspecies from the California Natural Diversity Database (California Department of Fish and Wildlife [CDFW] 2019).

2.4 Life History

The Smith's blue is univoltine, which means one generation is produced per year (Figure 3). The life cycle of the butterfly and seasonal activity is synchronized with the blooming period of two buckwheat host species, coast buckwheat (*E. latifolium*) and seacliff buckwheat (*E. parvifolium*). A third species known as naked buckwheat (*E. nudum*) is used to a lesser extent by adults only for nectaring (Arnold 1991, p. 4). Each summer, adult Smith's blues are active for about four to ten weeks. The flight season extends from mid-June to early September, but the activity period and duration can vary dramatically from year to year and from one location to another (Figure 3; Arnold 2002, p. 15). Smith's blues in the northern metapopulation tend to be active from mid-June to early August, while those in the southern metapopulation are active later, between mid-July and early September (Arnold 1983b, p. 51).

Individual adult males and females live approximately one week, and both sexes spend the majority of their time on the buckwheat flowerheads. Adult Smith's blues use the flowerheads to perch, bask, forage for nectar, search for mates, and reproduce. Females lay single eggs on the buckwheat flowerheads, typically on sepals of the newly opened flowers or on the late bud stage (Arnold 1978, p. 52). Oviposition occurs after females probe flowers with their abdomens, repeatedly walking over the flowers and "dancing" on the flowerheads. In a fecundity study conducted in a lab (Arnold 1978, p. 52), Smith's females carried an average of 32 eggs (range: 5-67). Of eggs laid, an average of 86% hatched (range: 43-100%).

Larvae hatch four to eight days after oviposition and begin feeding. Young larvae feed on the pollen and developing flower parts, while older larvae feed on the seeds. Larvae grow and molt through five instars, maturing after approximately one month. They pupate between mid-August and September, and drop into the leaf litter and sand at the base of the buckwheat where they overwinter as pupae and emerge as adults the following summer.

Like many other lycaenid butterflies, Smith's blue larvae have a symbiotic relationship with ants. During the third through fifth instars, the larvae produce a sugary secretion on which the ants feed. In return, the ants are presumed to provide the larvae with protection from predation or parasitism. This relationship is well documented in other lycaenid butterflies (Pierce et al. 2002, p. 734), but the importance of ants for the Smith's blue is not well understood. For some species the relationship is obligate, meaning larvae depend on ants during at least some portion of the life cycle to survive, while the relationship may be less critical for other species (Pierce et al. 2002, p. 735). The loss of an obligate mutualistic relationship with an ant played a crucial role in the extinction of Britain's large blue butterfly (*Maculinea arion*) (Thomas 1980, p. 244). Hence, understanding this biological relationship may be important to managing and preserving the Smith's blue.

Movement data from capture-recapture studies indicate that most adults are quite sedentary, with most movements averaging 300 feet (ft; 90 meters [m]) (Arnold 1983b, p. 69; Arnold 1986, p. 10). However, a small percentage of adults move farther and exhibited movements greater than 400 ft (120 m), and one was observed flying 3770 ft (1150 m) from where it was originally captured (Arnold 1986, p. 10). In contrast to the adult butterflies, larvae are more stationary and will complete their development on a single plant if there is adequate food.

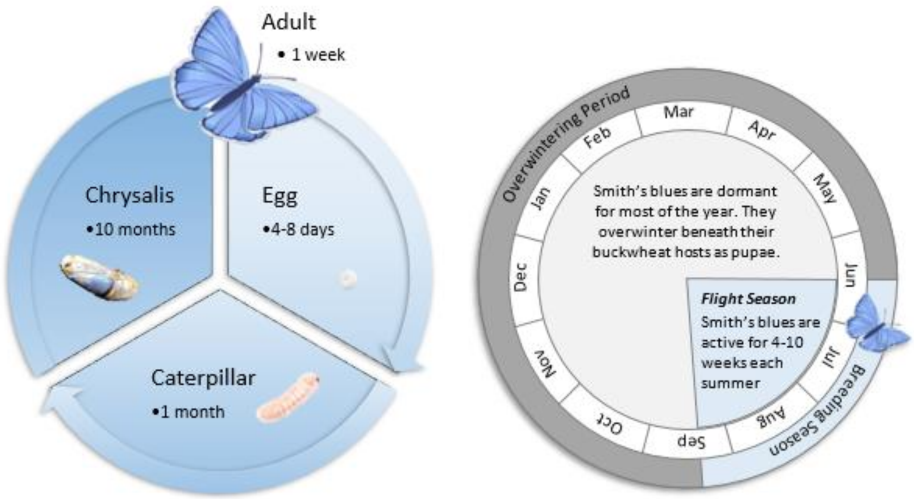

Figure 3. Life cycle and annual cycle of the Smith's blue.

2.5 Habitat

The Smith's blue utilizes inland and coastal sand dunes, serpentine grasslands, and cliffside chaparral communities along central California; however, the habitats of the northern and southern metapopulations of Smith's blue have significant differences. The northern metapopulation, which covers the coastal strip next to Monterey Bay, is distinguished by dune habitats occupied by both the coast and seacliff buckwheats. The portion of this metapopulation close to the Salinas River is dominated by the coast buckwheat, while the portion near Sand City is more of a mix of the two species. The southern metapopulation, which is defined as the Carmel Valley south into Big Sur, is distinguished by scrub, chaparral, and grassland plant communities. This area is rockier, with cliffs and more dramatic changes in elevation. The Smith's blues in the southern metapopulation utilize seacliff buckwheat, but adults have also been observed nectaring on the naked buckwheat, which grows in the more inland areas of the Carmel Valley (Arnold 1991, p. 9).

The plant communities that are present within the ranges of the two metapopulations are very dynamic. Seacliff buckwheat seedlings in scrub, chaparral, and grassland communities depend upon disturbances, such as fire and erosion (including landslides), for the development of site conditions favorable for germination and establishment (Service 2003, p. 7). Similarly, dune plants, including seacliff and coast buckwheat, are dependent on the deposition of windblown sand for germination (Arnold 1981, p. 88). The quality of habitat can change quickly due to natural successional processes and invasive, nonnative vegetation, which have the tendency to stabilize and dominate the dune systems (Arnold 1981, p. 88).

Commented [TC4]: Lack of such natural processes in conjunction with invasive grasses is probably one of the biggest threats

2.6 Species Needs

In order for individuals to complete their life cycle and populations to maintain viability, the Smith's blue requires healthy populations of their buckwheat host plants, coastal habitats with adequate levels of disturbance to support the buckwheat, and connectivity between occupied spaces to facilitate natural recolonization.

Buckwheat host plants

More than any other factor, the two species of host plants, coast and seacliff buckwheats, are essential to the Smith's blue life cycle (Figure 4). The butterfly is unique in that each stage of its life cycle relies upon the buckwheat, from egg to adult, and most rely on the flowerheads specifically. Because of the Smith blue's dependency on these plants, it is vulnerable to habitat degradation. Likewise, because its needs are relatively simple, conservation efforts to help the Smith's blue are more likely to be successful because restoration plans can consider augmenting just a few plant~~s~~ species.

Commented [TC5]: Considering others will need to be reduced or eliminated

It is known that butterflies in the Lycaenidae family that feed on *Eriogonum* flowers favor mature, robust individual plants~~s~~ because they produce more flowers, and it is believed the same is true for the Smith's blue (Arnold 1983a, p. 135 and 1983b, p. 50) Buckwheat plants that are too young to produce many flowers or that are older and senescent are less likely to contribute ~~less~~ to the resource base and thus viability of the Smith's blue.

Additionally, it is noteworthy that the flight season of the Smith's blue corresponds with the bloom time of its buckwheat hosts. A change in the timing of either the active period of adult butterflies or bloom time of the buckwheat flower could result in a phenological mismatch. Similar phenomena have been hypothesized for other lepidopterans (see Singer and Parmesan 2010, entire; and Renner and Zohner 2018, entire). To contribute to the viability of the Smith's blue, buckwheat flower~~s must~~ bloom must coincide with the timing of~~during the appropriate time of year to support~~ caterpillar development and ~~provide nectar for~~ adult foraging~~s~~.

Coastal habitats and disturbance

Figure 4. Coast buckwheat (left) and seacliff buckwheat (right) flowering during the Smith's blue's breeding season. Photos by Lara Drizd/Service.

In addition to the physical space itself, coast buckwheat and seacliff buckwheat each require habitat disturbance for the development of conditions favorable for germination and establishment (Service 2003, p. 7). Seacliff and coast buckwheat in ~~the~~ dunes are dependent on the deposition of windblown sand for site conditions favorable for germination (Arnold 1981, p. 88). In the scrub, chaparral, and grassland communities of the southern metapopulation, seacliff buckwheat seedlings depend upon disturbances such as low intensity wildfires, landslides, and other erosional features for the development of site conditions favorable for germination and establishment (Service 2003, pp. 7–8; Arnold 2006, pers. comm.). Landslides are common along the coast of Monterey County and provide the disturbances required by seacliff buckwheat. Conversely, these geologic activities can also temporarily destroy existing plant colonies ~~temporarily~~. The Smith's blue ~~may~~ benefit from ~~some human disturbance when these~~ anthropogenic disturbances that mimic natural processes (Cushman 2009, entire). When disturbances are rare, stands of seacliff buckwheat are likely to be displaced by larger native shrubs on all but the harshest sites.

Commented [TC6]: These are going to increasingly become important to maintain habitat for butterflies that require disturbed areas, which is nearly all listed species

The natural successional processes of the habitat in both metapopulations must be maintained in order to support the buckwheat plants utilized by the Smith's blue. In the southern metapopulation, invasive, nonnative vegetation (including kikuyu grass [*Pennisetum clandestinum*], pampas grass [*Cortaderia jubata*], Cape ivy [*Delaireria odorata*], and French broom [*Genista monspessulana*]) compete with and displace the seacliff buckwheat, especially in heavily? disturbed degraded locations (Service 2003, p. 8). Within the sandy dune habitats of the northern metapopulation, invasive, nonnative vegetation (especially iceplant [*Carpobrotus* spp.] and beach grass [*Ammophila arenaria*]) colonize and stabilize dune habitats, competing with coast and seacliff buckwheats and reducing the deposit of windblown sand that is needed for establishment of these and other native dune plants (Arnold 1981, p. 88). Landslides and erosional features are essential for clearing noxious weeds and regenerating the stands of buckwheat for the Smith's blue throughout the entire range.

Commented [TC7]: This is otherwise contradictory and needs explanations- perhaps the word degraded is better than disturbed here.

Habitat Connectivity

Because Smith's blue habitat is so dynamic, connectivity between areas with suitable habitat is required to facilitate dispersal and recolonization following disturbance events. Researchers have observed Smith's blues traveling no farther than 3770 ft (1150 m), less than three quarters of a mile (mi; 1.2 kilometers [km]) (Arnold 1986, p. 10). If sites are to become recolonized~~eoccupied~~ following disturbances, like those required to maintain the suitability of their habitat, they need to be ~~within geographic proximity of other~~connected enough to allow for dispersal from occupied areas. Recently, Smith's blues were discovered on the southern side of a hotel development where they had been previously extirpated, thus demonstrating that short distance re-colonization ~~such as this~~ is possible (Jake Martin, pers. comm. 2019). Having multiple occupied sites with a high degree of habitat connectivity can provide a source of redundancy that can benefit the viability of the Smith's blue. Without connectivity, similar circumstances have resulted in extirpations of other invertebrates, such as the Mitchells satyr butterfly (*Neonympha mitchellii mitchellii*) (Service 1998, p. 21).

Commented [TC8]: This is a key point and goes along with my comment above about expanding on metapopulation dynamics and the importance of unoccupied sites for recovery. This is essentially describing the rescue effect and is important here. This information is important so that temporarily unoccupied sites are not devalued or considered permanently unoccupied and surveyed for multiple years.

3.0 CURRENT CONDITION

3.1 Distribution

Currently, the Smith's blue occurs in scattered colonies along approximately 93 mi (150 km) of California's Central Coast from Monterey County to San Luis Obispo County. The range of the Smith's blue is larger than was known at the time of listing, primarily due to the discovery of additional occupied habitat along the coast of Monterey County south of the Monterey Peninsula and extending into northern San Luis Obispo County.

The current distribution includes two separate metapopulations separated by development around the City of Monterey (Figure 2). The majority of observation data comes from locations directly adjacent to roads from the California Natural Diversity Database (CDFW 2019). These points are the "collections localities" depicted in Figure 2. These points do not necessarily reflect all known localities for Smith's blue butterflies. For example, the Salinas River National Wildlife Refuge is one of the best surveyed areas for the species and no points on the Refuge are currently included in the California Natural Diversity Database.

We used satellite imagery to compare existing habitat to these known collection localities to estimate the maximum amount of potentially suitable habitat, which is depicted as the metapopulation polygons in Figure 2. The northern metapopulation occupies the dunes along Monterey Bay (~12 mi/19 km north to south) and the southern metapopulation occupies the scrub, chaparral, and grassland communities from the Carmel Valley south into Big Sur (~81 mi/130 km north to south) (Figure 2). The metapopulation polygons in Figure 2 are presumed to be occupied, but in many cases, surveys have not been conducted in decades if not longer.

Commented [TC9]: New surveys are desperately needed.

The lack of Smith's blue butterfly survey data makes it difficult to discuss trends in the subspecies' spatial distribution. There are no documented localities (historical or current) between the City of Monterey and Point Lobos State Reserve (approximately 6.5 mi (10.5 km)). Comparisons of historical accounts and current conditions of habitats in the intervening area, which includes the Monterey Peninsula, indicates that development, tree planting, and fire suppression may have reduced habitat suitability for Smith's blue butterflies (Service 2003, pp. 5 and 7). Smith's blue butterflies have not been detected recently between Sand City and Carmel Highlands (approximately 9 mi (14.5 km)) (Service 2003, p. 5; R. Arnold, pers. comm. 2006), including the Naval Postgraduate School, indicating that this gap in the range is expanding (Service 2006, p. 7). Those populations north of the City of Monterey are likely more isolated from southerly populations than they were historically.

3.2 Occupied Area Estimates

Smith's blue butterflies occupy many areas that are not possible to access and have therefore, never been surveyed. In addition, Smith's blues are known to occur in scattered colonies in dynamic environments where the availability of buckwheat host plants is variable. The numbers here are based on the metapopulation polygons in Figure 2 and are intended to provide a rough estimate of the habitat that could potentially be suitable given current land uses, but we do not expect the entire area to be occupied or suitable at any given time.

The northern metapopulation is approximately 23 square miles (mi^2; 60 square kilometers [km^2]). The southern metapopulation is estimated in two parts: the Carmel Valley, which includes the more inland habitat, is approximately 69 mi^2 (179 km^2), and the Big Sur coastal habitat is approximately 108 mi^2 (280 km^2).

3.3. Northern Metapopulation

The northern metapopulation contains the smallest area of Smith's blue habitat, but is the location where the most monitoring has taken~~s~~ place. It includes populations at the Salinas River National Wildlife Refuge, Marina Dunes Preserve, Fort Ord Dunes State Park, and dunes adjacent to the City of Marina and Sand City.

Of the northern metapopulation collection localities, approximately 20% are in private ownership, approximately 40% are part of California Department of Parks and Recreation and approximately 40% are in local government ownership.

Salinas River National Wildlife Refuge

The Salinas River National Wildlife Refuge was established in 1974, largely for migratory bird conservation. The area also provides habitat for several threatened and endangered species, including Smith's blue butterfly, western snowy plover, Monterey sand gilia, and the Monterey spineflower. Surveys for Smith's blues have been conducted at the Refuge for the past five years (Service 2019, p. 1). Detections of Smith's blue were on a downward trend for the first three years of surveys followed by a slight increase observed in 2018, and then a significant decrease to 395 in 2019 (Figure 5). Anecdotal evidence suggests that cool, cloudy, and windy weather conditions may account for a lower detection probability. The coast buckwheat utilized by the Smith's blues at this northernmost locality for the subspecies grows primarily in the "back dune" habitat of the Refuge, which is tucked behind the dunes and less exposed to winds coming off the Pacific Ocean (Figure 6).

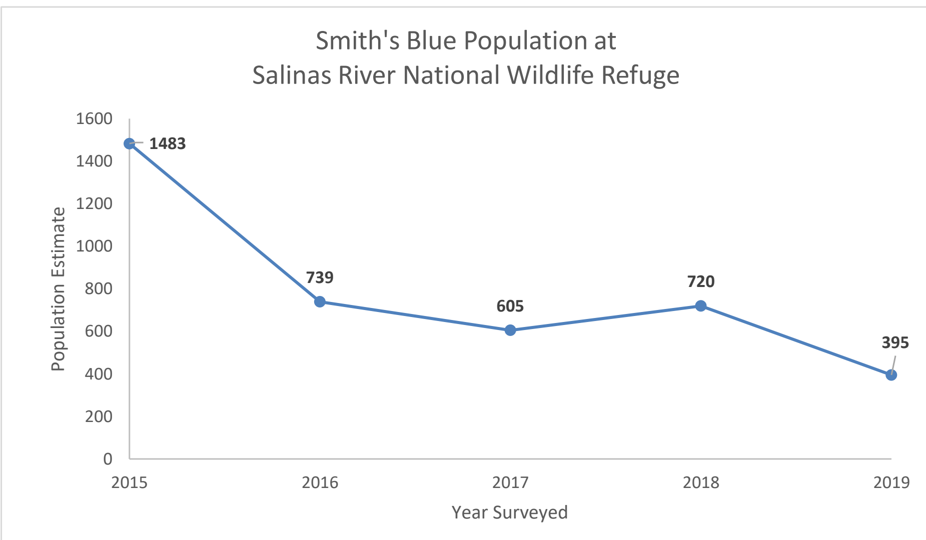

Figure 5. Population trend of the Salinas River National Wildlife Refuge population of Smith's blue, Monterey County, California. Data from US Fish and Wildlife Service survey report (Service 2019, p. 4).

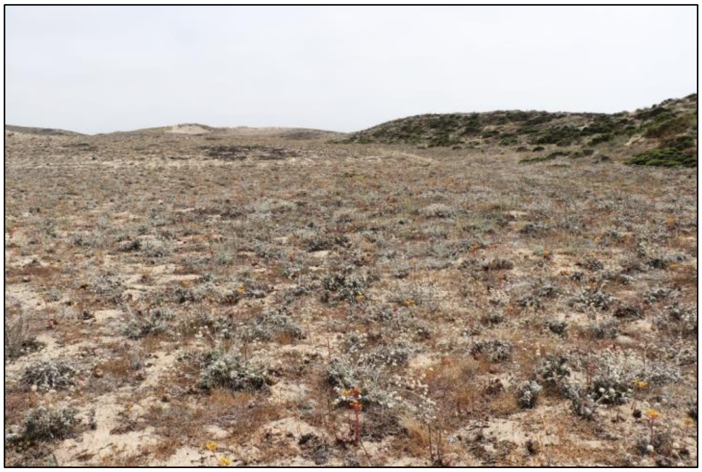

Figure 6. "Back dunes" buckwheat habitat at the Salinas River National Wildlife Refuge. Photo by Lara Drizd/Service taken July 30, 2019 during the butterfly's active flight season.

Fort Ord Dunes State Park and Marina State Beach

The coastal habitat formerly encompassed by the Fort Ord Army Base is now owned and managed by California State Parks (Fort Ord Dunes State Park). After undergoing restoration work, the area became a state park in 2009. Capture-recapture studies of Smith's blue populations were conducted at two sites (North Preserve and South Preserve) on Fort Ord (which was then an Army Base) in 1978, 1981, and 1983 and at a third site at Marina State Beach in 1986 (Arnold 1983b, p. 51; Thomas Reid Associates 1987, p. 1). The North Preserve site at Fort Ord included approximately 5.7 acres (ac) (2.3 hectares (ha)) of suitable habitat, with coast buckwheat as the host plant. The South Preserve site at Fort Ord included approximately 11.9 ac (4.8 ha) of suitable habitat, with seacliff buckwheat as the host plant. Over three years (1977–1979), population estimates ranged from 3,081–5,201 individuals at the North Preserve. Data were collected at the South Preserve only in 1978, which yielded a population estimate of 2,753 individuals. The Marina State Beach study site was larger, totaling 37.6 ac (15.2 ha), and included both coast and seacliff buckwheats, with coast buckwheat predominating. Data were collected at the Marina State Beach site only in 1986 and yielded a population estimate of 4,511 individuals.

City of Marina

Restoration of buckwheat habitat is being conducted at the sand plant in the City of Marina (Arnold 2019, p. 2). As part of restoration efforts, the flowerheads and seed of the coast buckwheat have been collected from the local area. Smith's blue has been observed on the property near the sand plant rather recently where expanses of the coast buckwheat habitat occur (California Coastal Commission 2017, Exhibit 6; p. 11). Restoration of the habitat in this area is expected to facilitate more breeding by the Smith's blues and it should act as a dispersal corridor to habitat in the north and south.

3.4 Southern Metapopulation

The southern metapopulation is the larger of the two and includes inland areas of the Carmel Valley and down the Big Sur coastline. It includes ranches and natural areas in the Carmel Valley south to the Carmel Highlands (including Vasquez Knob), and coastal bluffs of Big Sur and the Los Padres National Forest (including Big Creek Preserve [now Landels-Hill Big Creek Reserve], Partington Canyon, Dolan Creek, and Kirk Creek in Monterey County, and Hearst San Simeon State Park in San Luis Obispo County). None of these sites have monitoring data from which a population trend could be determined and most sites have not been surveyed in recent years.

Of the southern metapopulation collection localities, approximately 33% are in private ownership, 22% are in Federal (mostly U.S. Forest Service) ownership, 17% are in nonprofit conservancy and land trust ownership, 17% are in local government ownership, and 11% are part of California Department of Parks and Recreation and other State ownership. In 2003, the Service undertook a detailed review of the U.S. Forest Service lands within and adjacent to the Monterey Ranger District of the Los Padres National Forest, between Big Sur in Monterey County and San Carpoforo Creek in northern San Luis Obispo County (Service 2003, entire). We found that while a considerable amount of information on the distribution of Smith's blue habitat has been gained, population information gaps remained.

The nearly complete lack of data from population monitoring limits our ability to make assumptions or predictions regarding abundance. The majority of Smith's blue sightings are informal and do not allow for estimations of population size. Smith's blues in portions of the Carmel Valley were monitored as part of a research project conducted in 2007 in Palo Corona Regional Park (Cushman 2009, p. 30). Multiple populations are currently extant at sites within the park. Monitoring was also conducted as part of a Low-Effect Habitat Conservation Plan for the Smith's blue at the Point Sur Historic Park where suitable habitat was observed in 2015 (Arnold 2015, p. 4).

3.5 Factors Influencing Viability

Here we examine existing factors that are negatively and positively influencing the viability of Smith's blue butterflies (i.e., threats and existing voluntary or regulatory conservation efforts). We also identify factors not carried forward in our analysis because we determined that they are not likely to influence the risk of extinction. Threats are defined as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species (Service 2017, p. 1). This includes those actions or conditions that have a direct impact on individuals, and those that affect individuals through alteration of their habitat or required resources. Thus, threat is a general term that describes the source of an action or condition, or the action/condition itself, that may negatively affect the Smith's blue.

Each threat is considered in terms of its scale, intensity, and duration, as well as potential direct or indirect impacts it may have on a species or its habitat across its life history stages. Some threats may be affecting the species at all life stages or all individuals within a population, or possibly affecting all populations within the species range. Some threats, while present and acting on individuals of the species, may not rise to the level of affecting the population(s). Factors influencing current condition can include both negative and beneficial actions (Figure 7). Consideration and analysis areis also given to the cumulative effects of these factors on the

Commented [TC10]: This is arguable especially considering an endangered species. Threats that kill one individual, like some one stepping on it, of course could fall into this category but if that stems from a general recreation impact resulting in the death of a few individuals it could be a population-level threat. It is hard to separate the two. I think this statement should be deleted because of that fact.

species' overall viability. The overall current condition is expressed in terms of population resilience, and species redundancy and representation.

At the time of listing, habitat loss and degradation due to housing developments and highway construction, heavy foot and vehicular traffic on Fort Ord Army Base, and the spread of introduced iceplant were identified as the primary threats to the species (50 FR 48139). At the time of the last 5-year review, the decline of the Smith's blue butterfly across its range was attributed to degradation and loss of habitat as a result of urban development, recreational activities, sand mining, fire suppression, and encroachment of invasive, nonnative vegetation (Service 2006, p. 14).

3.5.1 Threats Considered with No Population-level Impact

Commented [TC11]: I'm not sure if this is a Service term that needs to be addressed in this SSA but if not and it is just used here, I suggest changing the term to something that depicts that this was a previous threat that is no longer a threat because the population-level vs non population-level does not provide the correct framing and doesn't make much sense in this case.

Military Activities

At the time of listing, the sand dunes at the Fort Ord Army Base were identified as having been heavily affected by military activities. Urbanization, off road vehicles, and the siting of shooting ranges had very negatively impacted the buckwheat habitat. The Army Base was closed in 1994 and much of the land changed ownership while only a very small portion was retained as an active military installment (77 FR 24579). The coastal area formerly encompassed by the Fort Ord Army Base is now owned and managed by California State Parks (Fort Ord Dunes State Park). In the 2002–2003 season, 6,100 buckwheat plants were installed, including 4,100 coast buckwheats and 2,000 seacliff buckwheats (California State Parks 2003, p. 9). Coastal dune restoration and revegetation using native plants is an ongoing effort at Fort Ord Dunes State Park and has occurred in most years since 2002–2003. Most recently, a completed restoration project of approximately 20-acres installed 55,000 native plants, which included 6,200 coast buckwheat plants (Palkovic 2019, pers comm.). Because military activities are not ongoing within the coastal dunes at Fort Ord and the habitat has been restored, military activities are no longer considered a threat to the Smith's blue and will not be discussed further in this analysis.

3.5.2 Threats Considered with Population-level Impact

Development

Loss of habitat for the Smith's blue butterfly in the coastal dunes within the northern metapopulation has been substantial. More than 50% of the dunes within the Seaside-Marina complex have been destroyed or significantly altered (Service 1984, p. 16). Development projects, including hotels, housing, and shopping centers, have occurred throughout this dune complex. California's Highway 1 also bisects the dune system and may present a dispersal barrier for Smith's blues. Sand mining has been conducted in the northern metapopulation since 1906 (Thornton et al. 2006, p. 45) and has caused substantial erosion of the shoreline and loss of habitat for the Smith's blue (California Coastal Commission 2017, Exhibit 23; p. 239). Only one mining operation continues today, which removes approximately 243,000 cubic yards of sand annually from a dredge pond on the beach in the City of Marina (California Coastal Commission 2017, Exhibit 5; p. 12). Due to impacts to sensitive habitats, the California Coastal Commission reached an agreement with the remaining sand plant to discontinue mining activities at the end of 2020 (California Coastal Commission 2017, Appendix A; p. 4).

Two-thirds of the habitat in the southern metapopulation is privately owned and could be proposed for development, especially in the vicinity of the Carmel Highlands. Recent and proposed development projects in this area include a small residential project that removed approximately 0.3 ac (0.12 ha) of good habitat (County of Monterey 2006, entire) and an expansion to an existing hotel complex that removed approximately 0.35 ac (0.14 ha) of scrub habitat containing seacliff buckwheat (Arnold et al. 2006, p. 2). The loss of habitat to development is considered irreversible in most cases and results in an overall loss of resiliency for the Smith's blue. The threat of development is considered on-going.

Overstabilization of Habitat/Competition with Invasive, Nonnative Vegetation

Commented [TC12]: In addition to nonnative vegetation, invasive Argentine ants or other ants might also be interfering with the symbiotic relationship between the Smith's blue larvae and ants. I know not much is known but it is worth mentioning as a potential threat.

Aggressive, disturbance-oriented invasive, nonnative vegetation, such as iceplant (*Carpobrotus* sp.), beach grass (*Ammophila* sp.), kikuyu grass (*Pennisetum clandestinum)*, pampas grass (*Cortaderia jubata)*, Cape ivy (*Delaireria odorata*), and French broom (*Genista monspessulana*) are found throughout the range of the Smith's blue and have replaced hundreds of acres of suitable habitat (Service 2003, p. 8). Nonnative annual grasses (e.g., ripgut brome [*Bromus diandrus*]) form dense ground covers that severely limit, and often prohibit, seedlings of native perennial plants, including seacliff buckwheat, from becoming established. Seedlings of native species often cannot compete for resources as well because the weedy annuals have faster growth rates.

Although landslides and other erosional features can provide disturbances that allow establishment of seacliff buckwheat, such disturbed locations are also vulnerable to invasion by noxious weeds, which colonize faster than native species and reduce the regeneration of the buckwheat stands (Service 2003, p. 8). Even conditions that would have benefitted the buckwheat in the past, such as landslides, are instead now facilitating the increase in the invasive, nonnative vegetation. This phenomenon is contributing to the degradation and fragmentation of habitat for the Smith's blue.

Commented [TC13]: I see now what the point above about disturbance – it should still be made clearer about beneficial disturbance levels vs those that facilitate non-native species. Disturbance should have its own section as a positive conservation mechanism where the nuance and balance can be discussed.

The establishment of invasive, nonnative vegetation has resulted in a gradual reduction in the abundance of host plants and continues to threaten habitat for the Smith's blue. The spread of invasive, nonnative vegetation is especially evident along the California Highway 1 corridor. Several locations of coastal bluffs that were previously documented as being occupied by seacliff buckwheat and the Smith's blue have been overtaken by invasive, nonnative vegetation, particularly kikuyu grass, pampas grass, and French broom (D. Pratt, personal observation as cited in Service 2003). In the northern metapopulation, invasive iceplant and beach grass have covered hundreds of acres of habitat that was previously suitable for the Smith's blue. In the southern metapopulation, the U.S. Forest Service has identified invasion by pampas grass as especially problematic on their lands on the coast of Monterey County (USDA 1999, p. 82). In addition, Monterey pines (*Pinus radiata*) and nonnative eucalyptus (*Eucalyptus* sp.) trees planted by private landowners are adversely affecting habitat through crowding and shading (Edell 2011, pers. comm.). The threat of habitat loss caused by invasive, nonnative vegetation is considered to be one of the most significant because it has the potential to destroy and degrade habitat that is considered protected.

Some restoration activities have been conducted with the purpose of controlling invasive, nonnative vegetation, which require long-term implementation for effectiveness. In the northern metapopulation, Marina State Beach and Fort Ord Dunes State Park have over a 1,000 ac (405 ha) in various stages of restoration (Dorrell-Canepa 2005, p. 5). Over 60 acres on the Salinas River National Wildlife Refuge have been treated for invasive, nonnative vegetation and over 110 acres have been treated on the adjacent Martin Dunes, owned by the Big Sur Land Trust (Milar 2019 pers comm.). The Martin Dunes property has long-term stewardship strategies to restore the natural dune habitat and has identified the removal of nonnative, invasive vegetation as a priority since 2009 (Big Sur Land Trust 2019, website). In the southern metapopulation, California Department of Transportation (Caltrans) actively restores portions of habitat along the Big Sur Coast associated with highway repairs (Caltrans 2004, p. 81; M. Fowler 2019, pers. comm.). These projects have allowed native plants to thrive and could benefit the Smith's blue if they become recolonized by the butterflies.

Commented [TC14]: Another threat that exacerbates this is nitrogen deposition- this has been recognized as a significant threat to Bay Area butterflies, such as the Bay checkerspot, in that exhaust from vehicles emits nitrogen that then acts as a fertilizer in serpentine grasslands and facilitates that non-native plants, many of which are similar or the same to these plants. This could be a phenomenon happening here, especially along Hwy 1 as mentioned above.

Wildfires

Wildfire suppression increases the risk of large-scale, high-intensity wildfires and reduces the frequency of smaller fires. Smaller fires create disturbances that favor establishment of seacliff buckwheat, while large, high-intensity fires are more likely to damage soils and destroy seed banks to the detriment of native plant communities. As a recent example, the 2008 Basin Complex fire burned over 160,000 ac (64,750 ha) in the vicinity of Big Sur, including a large area (approximately 19,424 ac [7,861 ha]) of potential Smith's blue habitat. Fire intensity was variable, but the large size of the area burned creates concern about the ability of Smith's blue to recolonize the area. Due to a lack of monitoring data, details of the effects of this fire on the species are unavailable, but a large area of potential habitat was burned and mortality of the species and removal (at least temporarily) of its habitat almost surely resulted. The increasing size and intensity of wildfires with climate change is also a concern (discussed further below).

Road and Trail Maintenance and Use

Maintenance of existing roads and trails throughout the range of the Smith's blue requires the cutting or removal of vegetation, which causes loss of seacliff buckwheat and can cause direct loss of Smith's blue individuals. Recreational use of trails, roads, and other areas is also an ongoing threat to the Smith's blue butterfly because pedestrians, equestrians, and bicyclists trample plants, cause erosion, and facilitate the establishment of invasive, nonnative vegetation (Service 2003, p. 9). Maintenance and vegetation control along California Highway 1 results in ongoing removal of Smith's blue host plants. Caltrans has taken steps to replace these plants through revegetation projects (Service 2008, entire), but some mortality of Smith's blue individuals is likely and there is a temporal loss of habitat. When mature host plants are removed and seed or seedling replacements are planted, it takes several years before the replacement buckwheats are able to grow large enough to provide an equivalent number of flowerheads.

Grazing

Commented [TC15]: While this is another threat, it may be important to consider pesticide use, particularly neonicotinoids as they have been found to negatively impact butterflies. I know that Smith's blue is not necessarily in agricultural areas, but neonicotinoids are also commonly found in household and landscaping plants and they can seep into the soil and water where they remain for years. They are systemic and so will be readily taken up by plants into tissue and nectar, thus could be taken up by buckwheat and other nectar plants.

Grazing occurs primarily in the southern metapopulation. Both the Carmel Valley and areas of the Big Sur coastline support livestock. Grazing can result in the loss of Smith's blue butterflies and their host plants because livestock may trample buckwheat plants. Trampling and physical destruction of buckwheat is considered more likely with cattle grazing (Cushman 2009, p. 11). However, grazing by cattle may also serve to maintain habitat for the Smith's blue by reducing competition with exotic grasses and maintaining areas in grassland and scrub habitats that might otherwise be colonized by woody shrubs. In a study conducted in the coastal grasslands in the southern metapopulation at Palo Corona Regional Park, Cushman (2009, pp. 37–40) found that grazing had both positive and negative effects on the Smith's blue. Grazing was observed to have no effect of the abundance of female Smith's blues and had a negative effect on the abundance of male Smith's blues (Cushman 2009, p. 37). Evidence of trampling was apparent, with the number of broken branches of buckwheat increasing with grazing, and live branch length and diameter decreasing with grazing (Cushman 2009, p. 37). However, the number of larvae detected between grazed and ungrazed plots was not significantly different. The number of larvae detected decreased between 2008 and 2009 in both grazed and ungrazed plots (Cushman 2009, p. 63).

Changing Climate Conditions

Changes in weather patterns have been observed in recent years and are predicted to continue in California (Frankson et al. 2017, p. 1). These changes can include extreme events such as higher temperatures, multi-year droughts, heavy rain events, global and local sea level rise, and wildfires that are larger and more intense (Frankson et al. 2017, pp. 2–5; Langridge et al. 2018, p. 6–7). All of these have the potential to remove, reduce, and degrade the Smith's blue's habitat as well as impact their buckwheat host plants, reducing germination and survival rates.

The Smith's blue is vulnerable to drought conditions because of its reliance on buckwheat host plants. It is also possible that individual plants that may have been exposed to enough rain to germinate could experience desiccation during dry periods in the growing season, and that drought conditions could reduce survival rates, though this has not been studied. Drought could also cause a reduction in flowerheads available as food for adults and larvae in both the northern and southern metapopulations.

Coastal dune systems are vulnerable to erosion from rising seas and storm surges. An increase in the volume of the world's oceans can lead to localized changes in sea level depending on many contributing factors (Griggs et al. 2017, p. 11); this is discussed further under potential future conditions (Section 4.0). Between 1897 and 2006, the observed sea level rise has been approximately 0.08 in (2 millimeters [mm]) per year, or a total of 8 inches (203 mm) over that period (Herberger et al. 2009, pp. 5–6).

Currently, there is no evidence that factors related to climate change are influencing the butterfly (erosion on the coastline in the northern metapopulation is attributed to the sand mining discussed above), and it is unknown how changes in sea levels or drought may have affected the species in the past. To combat the potential future impacts of climate change, an area within Fort Ord Dunes State Park was recently revegetated with native plants for the purpose of preventing erosion of the shoreline. As the plants mature, it could become occupied by the Smith's blue, contributing to the subspecies' resiliency and redundancy.

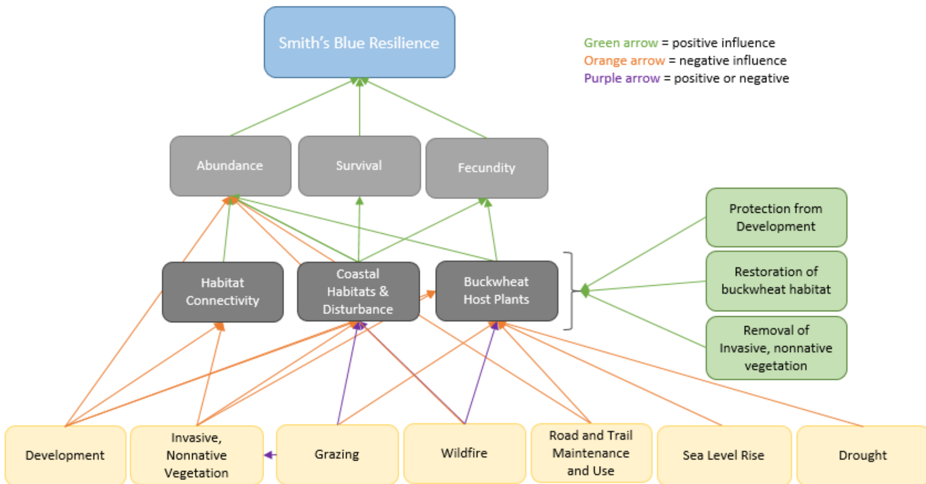

Figure 7. Influence diagram for the Smith's blue.

3.6 Threats Summary

In summary, the primary threats currently impacting the Smith's blue are habitat loss and degradation due to (1) development (including sand mining) and (2) invasion by invasive, nonnative vegetation and overstabilization of the habitat, as well as (although to most likely a lesser degree) (3) wildfires, (4) road and trail maintenance and use, and (5) grazing. Loss of habitat for the Smith's blue butterfly in the coastal dunes north of the Monterey Peninsula has been significant. Development projects including hotels, housing, and shopping centers have occurred throughout this dune complex. The species is notably absent from the Monterey Peninsula; historical accounts suggest that buckwheat was more widely distributed and locally abundant (Service 2003, p. 5). Much of the habitat for the Smith's blue butterfly south of the Monterey Peninsula is privately owned and could be proposed for development in the future, especially in the vicinity of the Carmel Highlands. The threat of habitat loss caused by invasive, nonnative vegetation has the potential to destroy and degrade habitat, including that which is considered protected. Without management of invasive, nonnative vegetation, Smith's blue habitat can be overtaken and rendered unsuitable for the butterflies. The increasing size and intensity of wildfires has the potential for large-scale habitat loss. Maintenance of existing roads and trails throughout the range of the Smith's blue requires the cutting or removal of vegetation, which causes loss of seacliff buckwheat and can cause direct loss of Smith's blue individuals. Grazing can damage Smith blue's habitat by trampling buckwheat plants, however, grazing may also improve habitat by helping to manage invasive, nonnative vegetation. Factors related to climate change are not currently impacting the species but may worsen into the future.

Commented [TC16]: Has this been adequately researched? I'm thinking specifically about CA droughts and more severe El Nino events which are the result of climate change. I think this needs to be backed up and/or changed to discuss current impacts.

3.7 Current Condition - Three Rs: Resiliency, Redundancy, and Representation

We do not have data to determine the resiliency of Smith's blue populations. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. We would need information on abundance, growth rate, or an acceptable proxy to determine resiliency and currently no such data are available to us. The one project at the Salinas River National Wildlife Refuge tracking the size of the Smith's blue population indicated a decline in the past year (Service 2019, pp. 2 and 4). We are unable to determine if the decrease in abundancy was a localized occurrence or a range-wide trend. We do know that the Smith's blues in the northern metapopulation occupy a very small area totaling less than 23 mi^2 (60 km^2). More than 50% of the dunes within the Seaside-Marina complex have been destroyed or significantly altered from historic conditions, resulting in habitat loss and fragmentation (Service 1984, p. 16). Currently, approximately 40% of the collection localities recorded in this metapopulation are part of California Department of Parks Recreation. The best-surveyed population is on the Salinas River National Wildlife Refuge. However, the threat of habitat loss caused by invasive, nonnative vegetation is considered one of the most significant threats because it has the potential to destroy and degrade even protected habitat. Ongoing, active management is required to maintain the dynamic environments in which buckwheat host plants thrive. Buckwheat host plants, coastal habitats and disturbance, and habitat connectivity are all under threat, likely reducing the abundance, survival, and fecundity of the species and impacting resiliency in the northern metapopulation.

Commented [TC17]: Again this needs to be defined above and then referred to here as you define it- the beneficial disturbances

The southern metapopulation is estimated in two parts: the Carmel Valley, which includes the more inland habitat, is approximately 69 mi^2 (179 km^2), and the Big Sur coastal habitat is approximately 108 mi^2 (280 km^2). Due to the lack of survey and monitoring data for the southern metapopulation, very little is known about the presence of Smith's blue and it would be difficult to determine if sites are occupied or unoccupied. While the threat of development is not as great as in the northern metapopulation, habitat has been lost to development and 67% of the suitable habitat in the southern metapopulation is in private ownership. All other threats are ongoing in this metapopulation at a similar or greater intensity than the northern metapopulation, including invasive, nonnative vegetation and resultant habitat overstabilization, grazing, wildfire, and road and trail maintenance and use. Active management is required to maintain the dynamic environments in which buckwheat host plants thrive. Buckwheat host plants, coastal habitats and disturbance, and habitat connectivity are all under threat, likely reducing the abundance, survival, and fecundity of the species and impacting resiliency in the southern metapopulation.

Commented [TC18]: This is an example of what I mean about defining disturbance that is required by the buckwheat/butterfly- what does it mean to be dynamic in this system? It is needed so that we know what types of disturbances are needed and can be restored or used as a management technique.

Redundancy will always be limited for local, endemic species with a naturally limited range. The subspecies is comprised of two metapopulations and the northern metapopulation is particularly small and restricted. Range contraction appears to have occurred due to habitat loss at the center of the range in the area of the Monterey Peninsula. However, the size of the Smith's blue's range is considerably larger than it was at the time of listing due to the discovery of numerous new occupied sites found throughout the southern metapopulation. Currently, there are thought to be multiple populations throughout much of the known range of the subspecies, which inhabit a reasonably wide range of habitats (from sand dunes to cliffside chaparral). Two metapopulations and two habitat types provides some level of redundancy in the face of potential catastrophic events, such as wildfire or catastrophic drought.

Commented [TC19]: Assuming they could survive in similar environments, see comment above about the potential for the two being too different to necessarily be used to reintroduce to a different ecosystem. My above comment:

"There is a risk that the two habitat types house two genetically differentiated populations, maybe not enough to consider them different subspecies but perhaps enough to not consider them necessarily redundant. For instance, could a coastal individual survive if placed in the inland habitat? This seems unknown. "

The two metapopulations encompass the north-south and east-west gradients within the limited distribution of the subspecies and both ecological settings, likely encompassing the breadth of genetic and ecological diversity within and among populations. Though Smith's blues are able to utilize two species of buckwheat as host plants (both of which were historically very common in the environment) in a reasonably wide range of habitats (from sand dunes to cliffside chaparral), the subspecies is unable to adapt to conversion of the habitat to nonnative, invasive vegetation due to its niche specificity. Because of its reliance on buckwheat, the nonnative, invasive vegetation must be managed in order for the Smith's blues to have sufficient habitat. Given the host-plant specificity, the subspecies has always had some level of limitation on its adaptive capacity. Habitat loss and degradation has reduced the potential for already limited adaptive capacity, which comprises representation for the subspecies.

3.7.2 Uncertainties

Commented [TC20]: This could probably be added to with my comments above- invasive ants, pesticides, etc.

- Population numbers or trends, particularly for the southern metapopulation.
- Correlations between habitat quality/quantity with occupancy by the Smith's blue that would allow for more accurate estimates and locations of suitable habitat.
- Limitations to dispersal by Smith's blues, geographical and/or physical.
- Genetic diversity within Smith's blues, and the frequency of hybridization with Tilden's blues.
- The importance of ants to survival of the Smith's blue larvae.
- Fire and burn regime that would be optimal for the buckwheat and Smith's blue.
- Optimal disturbance regime to help influence the most beneficial management considerations for recovery actions.

Commented [TC21]: This is another example of how beneficial disturbance can be defined prior to this

4.0 POTENTIAL FUTURE CONDITIONS

As an annual species, the Smith's blue is sensitive to changes in habitat and climatic conditions and populations can fluctuate from year to year, which make future population trends difficult to predict. The future viability assessment is therefore, focused on habitat availability and suitability of conditions as they relate to species needs.

4.1 Factors Influencing Viability

Development

Removal of Smith's blue's habitat along coastal California due to development is a threat; however, the risk has changed since the subspecies was listed. First, occupied habitat within the Fort Ord Army Base has been converted from a military installment to a State Park with plans for habitat restoration and limited recreational development. Second, sand mining activities that have been commonplace for the last hundred years will be discontinued at the end of 2020. Commercial development pressures are ongoing, especially in the Sand City area, and could be exacerbated by impacts related to rising sea levels (see *Changing Climate Conditions, Sea-Level Rise*). Third, because of its proximity to the coast, much of this habitat is subject to restrictions mandated by local coastal programs, the California Coastal Act, and the California Environmental Quality Act. Much of the habitat in the southern metapopulation is privately owned and could be proposed for development, especially in the vicinity of the Carmel Highlands. However, approximately 28% of the southern metapopulation is in State or local government ownership, and approximately 22% is in Federal (mostly U.S. Forest Service) ownership, which effectively protects these areas from major development. Overall, development remains a threat to the subspecies, but is likely to proceed at a slower rate into the future than rates of development in the past.

Overstabilization of Habitat/Competition with Invasive, Nonnative Vegetation

The Smith's blue has evolved in habitats where disturbance is so common that its buckwheat host species require it for germination and establishment (Service 2003, p. 7). Its need for habitat with periodic disturbance is directly linked to the risk posed by overstabilization of the habitat and competition with nonnative, invasive vegetation. Future predictions are that increasing temperatures will favor trait states that tend to be possessed by exotic species, increasing the dominance of exotic species in California (Sandel and Dangremond 2012, pp. 282–283). This prediction is corroborated by the current distribution of exotic species richness relative to native richness in California; warmer areas contain higher proportions of exotic species (Sandel and Dangremond 2012, pp. 282–283). Few areas across the subspecies' range have been restored or have plans for future restoration. With exception for a couple of Low-Effect Habitat Conservation Plans, most of these projects have taken place in the northern metapopulation. Across the entire range of the Smith's blue, there are few existing management activities and no management plans to improve existing habitat conditions in the future. If invasive, nonnative vegetation continues to spread and fill habitat that should otherwise be occupied by buckwheat undergoing natural dynamics, then the butterfly's ability to persist into the future will be negatively affected by reducing the abundance and availability of their host plants (i.e., the health of the species as a whole will be reduced from current conditions).

Commented [TC22]: What kinds?

Commented [TC23]: This could also be a current impact of climate change, not just future

Commented [TC24]: Ah, exactly. So it would appear that it is already impacting the species and so the statement above about it being only a future threat should be changed.

Changing Climate Conditions

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) projects many changes in climate by the end of the 21st century, relative to the 1986 to 2005 averages (IPCC 2014, pp. 8–12). Changes in weather patterns attributed to changes in climate have been observed in recent years and are predicted to continue in California (Frankson et al. 2017, p. 1). This can include extreme events such as higher temperatures, multi-year droughts, heavy rain events, global and local sea level rise, and wildfires that are larger and more intense (Frankson et al. 2017, pp. 2–5; Langridge et al. 2018, p. 6–7). All of these have the potential to remove, reduce, and degrade the Smith's blue's habitat as well as impact their buckwheat host plants, reducing germination and survival rates.

Commented [TC25]:

<u>Sea-Level Rise</u>

The biology of the Smith's blue makes it especially susceptible to climate change related threats into the future. Glick et al. (2011, entire) developed guidelines for assessing the vulnerability of species to climate change. They determined that species living in low-lying coastal areas, such as the northern metapopulation of Smith's blues, are particularly vulnerable to climate impacts due to the sensitivity of their habitat. They also determined that habitat specialists are more vulnerable than habitat generalists. Because the Smith's blue requires specific buckwheat host plants, it is among those most vulnerable. Rising sea levels can lead to removal or reduction of habitat, and the removal of individual plants, seedbanks, and whole populations. Given that the northern metapopulation of Smith's blues only occupies coastal dune systems, sea level rise has the potential to have a significant impact on the species range-wide by causing shoreline erosion, increased overwashing, and inundation.

Glick et al. (2011, p. 49) also determined that species like the Smith's blue that have limited dispersal capabilities are vulnerable due to their restricted ability to follow shifting habitat. This threat is amplified by the already fragmented nature of the Smith's blue's habitat which is naturally patchy and has been fragmented by development and invasive, nonnative vegetation. McLaughlin et al. (2002, entire) observed extinction of two well-studied populations of the Bay checkerspot butterfly (*Euphydryas editha bayensis*) and their results implicated the interaction of climate change, habitat fragmentation, and limited dispersal capabilities.

Commented [TC26]: This seems like a substantial issue and fragmentation is not discussed thoroughly as a threat, which limits gene flow and can result in inbreeding depression. Fragmentation should be added as a threat above either as part of the development section or its own, perhaps its own because as you write here, it is also a result of the lack of disturbance or overstabilization of sand habitats.

Especially with respect to sea level rise and the northern metapopulation, there is a lack of connectivity between north and south. Also of importance to the redundancy issue, you could discuss connectivity restoration between the two metapopulation, which would drastically increase the potential for redundancy.

Older estimates projected that sea level rise along the California Coast would reach 0.7–2 ft (0.2–0.6 m) by 2100 (IPCC 2007, pp. 20–21). Recent observations and models indicate that those projections were conservative and ignored some critical factors, such as melting of the Greenland Ice Sheet and Antarctica (Herberger et al. 2009, p. 1). Herberger et al. (2009, p.1) have updated the sea level rise projections for California to 3.3–4.6 ft (1.0–1.4 m) by 2100, while Vermeer and Rahmstorf (2009, p. 21530) calculated sea level rise globally at 2.4–6.2 ft (0.75–1.9 m). In both cases, their estimates were more than twice the original projections. Modeling indicates that as mean sea level rises, there will also be an increase in the number and duration of extreme high sea level events, which occur during high tides, often in conjunction with winter storms (Cayan et al. 2009, entire). The intensity of storm surges has already increased relative to 1970 (Field et al. 1999, p. 49). This increase in number, intensity, and duration of extreme high sea level events implies an increase in coastal erosion (Cayan et al. 2009, p. 30). Waves would reach further inland during these extreme events with great impact on natural systems (Cayan et al. 2009, p. 40).

In a report prepared for the Monterey Bay Sanctuary Foundation (ESA PWA 2014, pp. 4–5), researchers incorporated multiple coastal hazards assessments to determine the effects of sea level rise on the Monterey Bay, where the northern metapopulation of Smith's blues is located. They created three scenarios for dune erosion: 1) continuation of existing wave climate and management, which assumes the wave climate through 2100 remains constant with the last 17 year record; 2) increased intensity of extreme storm and wave events; and 3) cessation of sand mining (ESA PWA 2014, p. 20). Based on these scenarios, we have calculated the potential habitat loss for the years 2030, 2060, and 2100 (Table 1). Because mining operations are now scheduled to be discontinued in 2020, we believe the third scenario is more likely than the first one. A map showing the projected dune erosion hazard zone, which represents the inland retreat of the dune crest, for the year 2060 overlaps with a substantial portion of Smith's blue habitat and potentially suitable habitat in the northern metapopulation (Figure 8).

We expect that increased coastal erosion and wave run-up will remove low-lying Smith's blue habitat, primarily in the northern metapopulation where that habitat is already less abundant and more fragmented by development. The potential habitat lost could be 14–25% of the current range of the northern metapopulation by the year 2060, and 17–35% by the year 2100 (Table 1). In addition to the direct effects of sea level rise, we expect that there will be increased development pressure in Smith's blue habitat as people seek to harden the coastline by installing sea walls and other armor to protect private property where storm surges and erosion pose a risk (Hanak and Moreno 2012, pp. 53–54). The combination of these factors could result in a significant loss of important habitat.

Table 1. Projected percentage of habitat lost from the northern metapopulation of the Smith's blue given scenarios modeled in ESA PWA 2014.

		Dune Erosion Scenarios (% habitat impacted)		
Year	**Magnitude of Sea Level Rise**	**No Change**	**Stormier**	**Mining Stops**
2030	Low	13%	17%	11%
	Medium	13%	18%	11%
	High	14%	18%	12%
2060	Low	19%	23%	14%
	Medium	19%	23%	14%
	High	21%	25%	16%
2100	Low	26%	30%	17%
	Medium	28%	32%	19%
	High	31%	35%	23%

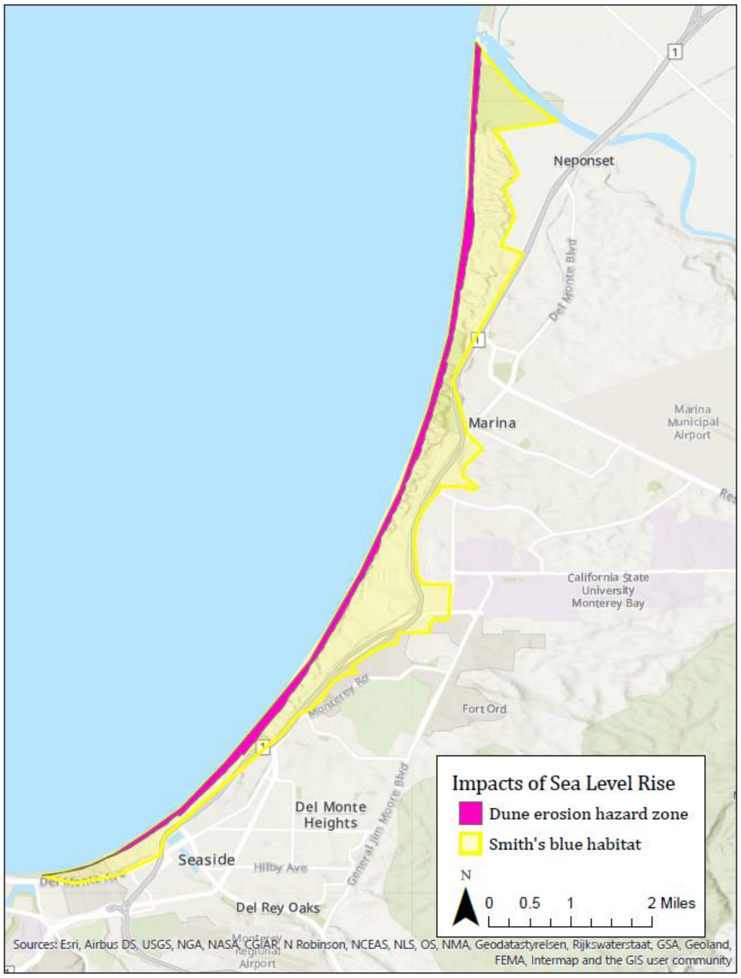

Figure 8. Dune erosion hazard zone for the year 2060 within the maximum potential habitat area for the northern metapopulation of Smith's blue. The zone shown here is the area affected considering medium sea level rise and discontinued mining operations as modeled in ESA PWA 2014.

Drought

Projections of changes in precipitation in California are more nuanced than projected changes in temperature and have less separation between Representative Concentration Pathway (RCP) scenarios 4.5 and 8.5 (Pierce et al. 2018, p. 20). Overall, there is a projected increase of year-to-year variability with wetter days during periods of precipitation, but with fewer total days with precipitation (Langridge et al. 2018, p. 16). Average annual precipitation under RCP 8.5 shows significant increases by 2100 for the state overall as well as for California's Central Coast region. When combined with higher temperatures, these changes will create significant challenges for the state's water supplies, potentially creating more serious flooding events as well as drier conditions (Langridge et al. 2018, p. 16). For Monterey County, average annual precipitation is 19.3 in (49 cm). In California's 4th Climate Change Assessment, the projections for 2040–2069 range from 21.1 in (53.6 cm) under RCP 4.5 to 21.4 in (54 cm) under RCP 8.5 (Langridge et al. 2018, p. 16).

While average precipitation is expected to increase by a relatively small amount, the annual variability increases substantially by the end of the century. Across the region, projections show that the wettest day of the year will become wetter relative to historical conditions. In California's 4th Climate Change Assessment, maximum and minimum temperatures are projected to continue to increase through the next century, with greater increases in the inland region (Langridge et al. 2018, p. 17). By 2040–2069, average annual maximum temperatures in Monterey County are expected to increase between 3.7 degrees Fahrenheit (°F; 2.1 degrees Celsius [°C]) (RCP 4.5) and 4.9°F (2.7°C) (RCP 8.5). Climate projections also show an increase in extreme dry events and that drought conditions will increase (Langridge et al. 2018, p. 23).

Commented [TC27]: Should there be a range here?

Drought conditions are expected to lead to an increase in the intensity and size of wildfires, especially in grasslands and shrublands of California's coast and foothills (PRBO Conservation Science 2011, p. 38). As discussed above, fire can have positive and negative effects on Smith's blue butterfly habitat. However, larger and more intense fires are more likely to cause long-term damage to habitat and directly kill Smith's blues over larger areas. The southern metapopulation is more vulnerable to this threat.

Warmer and dryer conditions and increased wildfire are also expected to lead to an increase in grassland habitat and a reduction in shrub dominated habitats in the California Coast Ranges, including the scrub and chaparral habitats of the Smith's blue (PRBO Conservation Science 2011, p. 38). Although Smith's blue butterflies can occur in grasslands if their buckwheat host plants are present, conversion of shrub dominated habitat to grassland would likely result in a loss of buckwheat host plants, because seacliff buckwheat is dominant in some scrub habitats, while nonnative grasses dominate almost all California grasslands. Climate change is also likely to favor increased spread of invasive, nonnative vegetation (Lenihan et al. 2008, Service 2010, p. 10), which could further reduce the quality, quantity, and connectivity of Smith's blue habitat.

4.1 Future Scenarios

Commented [TC28]: This could also include an element of increased connectivity if steppingstone patches are created or restored which would increase the three R's.

Based on the best available information about future projections of factors influencing Smith's blue viability, we developed three future scenarios that capture the range of possible effects to the species from predicted change in factors influencing viability over a 40 year period (Table 2). We chose 40 years because this encompasses projections for each factor influencing viability, where available. Scenario 1 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and effects of Representative Concentration Pathway (RCP) 4.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018). Scenario 2 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 8.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018). Scenario 3 assumes a continuation of current trends in development, an increase in conservation-related actions for invasive, nonnative vegetation, and RCP 4.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018).

Table 2. Future scenarios for Smith's blue butterflies predicted out 40 years. Scenario 1 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 4.5 projections for climate change in the California Central Coast region. Scenario 2 assumes a continuation of current trends in development, invasive, nonnative vegetation proliferation, and RCP 8.5 projections for climate change in the California Central Coast region. Scenario 3 assumes a continuation of current trends in development, an increase in conservation-related actions for invasive, nonnative vegetation, and RCP 4.5 projections for climate change in the California Central Coast region.

Factor influencing viability	Scenario 1	Scenario 2	Scenario 3
Development	Decrease from historic trends	Decrease from historic trends	Decrease from historic trends
Overstabilization of Habitat/Competition with Invasive, Nonnative Vegetation (Sandel and Dangremond 2012, entire)	Current trajectory of increasing invasive, nonnative vegetation	Steeper than current trajectory of increasing invasive, nonnative vegetation due to changing climate conditions	Decrease from current trajectory of increasing invasive, nonnative vegetation due to increased management
Sea-level rise (ESA PWA 2014, entire)	14-16% of habitat in the northern metapopulation area impacted	23-25% of habitat in the northern metapopulation area impacted	14-16% of habitat in the northern metapopulation area impacted
Drought (Langridge et al. 2018, p. 13)	Average annual maximum temperatures expected to increase 3.7°F (2.1°C)	Average annual maximum temperatures expected to increase 4.9°F (2.7°C)	Average annual maximum temperatures expected to increase 3.7°F (2.1°C)

4.1.1 Future Scenario 1

Scenario 1 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 4.5 projections for climate change in the California Central Coast region over the next 40 years (Table 2). Overall, development remains a threat to the subspecies, but is likely to proceed at a slower rate into the future than rates of development in the past within Smith's blue habitat. Invasive, nonnative vegetation is predicted to increase in the future as temperatures increase (Sandel and Dangremond 2012, pp. 282–283). For sea level rise, under the "cessation of sand mining" scenario (ESA PWA 2014, p. 20), the potential habitat loss by 2060 is 14–16% in the northern metapopulation. Under RCP 4.5, while average precipitation is expected to increase by a relatively small amount, but over fewer precipitation days, average annual maximum temperatures in Monterey County are expected to increase by 3.7°F (2.1°C) by 2040–2069 (Langridge et al. 2018, p. 17).

Development and invasive, nonnative vegetation have reduced the abundance of the Smith's blue more than any other threat. The increase in invasive, nonnative vegetation over the next 40 years is likely to have significant negative impacts to populations across the range of the subspecies by reducing and degrading the buckwheat on the landscape and limiting habitat connectivity. Drought is likely to exacerbate these threats, by potentially degrading buckwheat habitat further and promoting spread of invasive, nonnative vegetation. This is likely to significantly influence multiple populations throughout the range of the subspecies, resulting in reduced population size and growth rate. These stressors, in combination with a 14–16% habitat loss due to sea level rise in the northern metapopulation, suggest the potential for population-level effects from threats under Scenario 1. There will likely be extirpations, at least in the northern metapopulation.

4.1.2 Future Scenario 2

Scenario 2 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 8.5 projections for climate change (Langridge 2018, pp.12–23) for the next 40 years (Table 2). Overall, development remains a threat to the subspecies, but is likely to proceed at a slower rate into the future than rates of development in the past within Smith's blue habitat. Invasive, nonnative vegetation is predicted to increase in the future as temperatures increase (Sandel and Dangremond 2012, pp. 282–283). Under this scenario, with increasing potential for negative effects of climate change under RCP 8.5, we predict that invasive, nonnative vegetation will proliferate in Smith's blue habitat at a faster rate than under Scenario 1. For sea level rise, under the "increased intensity of extreme storm and wave events" scenario (ESA PWA 2014, p. 20), 23–25% of the habitat in the northern metapopulation is predicted to be lost. While average precipitation is expected to increase by a relatively small amount, average annual maximum temperatures in Monterey County are expected to increase by 4.9°F (2.7°C) by 2040–2069 under RCP 8.5 conditions (Langridge et al. 2018, p. 17).

The greater increase in invasive, nonnative vegetation in the next 40 years is likely to have significant negative impacts to populations across the range of the subspecies by reducing and degrading the buckwheat on the landscape and limiting habitat connectivity. Increased drought is likely to exacerbate this, by degrading buckwheat habitat and promoting spread of invasive, nonnative vegetation. This is likely to significantly influence multiple populations throughout the range of the Smith's blue, resulting in reduced population size and growth rate and population-level effects. Sea-level rise is predicted to affect 23–25% of the habitat in the northern metapopulation. The eastern edge of the habitat in this metapopulation is completely developed, halting potential inland migration by buckwheat, so the 25% will be a complete loss. Therefore, it is possible that more than a quarter of the northern metapopulation will be lost and the rest will be heavily degraded, which will result in extirpations. The southern metapopulation will also be heavily degraded from invasive, nonnative vegetation and drought, and will also likely experience extirpations.

4.1.3 Future Scenario 3

Scenario 3 assumes a continuation of current trends in development, an increase in conservation-related actions for invasive, nonnative vegetation, and RCP 4.5 projections for climate change in the California Central Coast region over the next 40 years (Table 2). Overall, development remains a threat to the subspecies, but is likely to proceed at a slower rate into the future than rates of development in the past within Smith's blue habitat. Under this scenario, we predict that invasive, nonnative vegetation will decrease from the current trajectory due to increased management. In the northern metapopulation area, 40% of the habitat is within State/Federal ownership. In the southern metapopulation area, 33% of the habitat is within State/Federal ownership. If invasive, nonnative vegetation management actions were funded and implemented across these areas, the trajectory for invasive, nonnative vegetation spread could be slowed and area infested would be reduced. For sea level rise, under the "cessation of sand mining" scenario (ESA PWA 2014, p. 20), the potential habitat loss by 2060 is 14–16% in the northern metapopulation. While average precipitation is expected to increase by a relatively small amount, average annual maximum temperatures in Monterey County are expected to increase by 3.7°F (2.1°C) by 2040–2069 under the RCP 4.5 projections (Langridge et al. 2018, p. 17).

With increased management on public lands for invasive, nonnative vegetation in the next 40 years, we predict that habitat quality could improve for Smith's blue butterflies. Areas with extensive available habitat that are not degraded by nonnative, invasive vegetation and/or are receiving ongoing invasive, nonnative vegetation management are more likely to continue to support resilient populations into the future. Drought is likely to be a continual challenge, but without the influx of invasive, nonnative vegetation, we predict that these stressors may affect the subspecies on the individual-level, but we do not expect population-level effects. Given this, there may be extirpations due to the loss of 14–16% of suitable habitat in the northern metapopulation due to rising seas, but this will not be compounded by additional population losses due to other stressors.

4.2 Future Condition - Three Rs: Resiliency, Redundancy, and Representation

We do not have data to determine the resiliency of Smith's blue populations. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. We would need information on abundance, growth rate, or an acceptable proxy to determine resiliency and currently no data are available to us. However, we can forecast that the resiliency for Smith's blue butterfly populations will likely change under each future scenario. Under future scenarios 1 and 2, invasive, nonnative vegetation, drought, and sea level rise are predicted to increase in Smith's blue habitat, more so in Scenario 2 than Scenario 1. The butterfly's ability to persist into the future will be negatively affected by increased overstabilization by nonnative, invasive vegetation, habitat degradation due to drought, and loss of habitat due to sea-level rise, which will reduce the abundance and availability of their buckwheat host plants, and coastal habitats with appropriate disturbance and habitat connectivity (i.e., the resiliency of populations will be reduced from current conditions). Under future scenario 3, we forecast increased management for invasive, nonnative vegetation, but increased drought and sea-level rise. The butterfly's ability to persist into the future will be negatively affected by habitat degradation due to drought and loss of habitat due to sea-level rise, but will be positively affected by management for invasive, nonnative vegetation. The abundance and availability of their buckwheat host plants, coastal habitats with appropriate disturbance and habitat connectivity may be only somewhat reduced from current conditions under this scenario.

Redundancy will always be limited for local, endemic species with a naturally limited range. The Smith's blue is comprised of two metapopulations and the northern metapopulation is particularly small and restricted. All 3 future scenarios forecast a loss of habitat in the northern metapopulation. Scenarios 1 and 2 forecast that the resiliency of populations will be reduced from current conditions. If habitat loss and reduced resiliency predicted under scenarios 1 and 2 leads to population extirpations, redundancy for the subspecies will be reduced, increasing extinction risk from catastrophic events, such as wildfire or catastrophic drought.

The two metapopulations encompass the north-south and east-west gradients within the limited distribution of the subspecies and both ecological settings, likely encompassing the breadth of genetic and environmental diversity within and among populations. Though Smith's blues are able to utilize two species of buckwheat as host plants (both of which were historically very common in the environment) in a reasonably wide range of habitats (from sand dunes to cliffside chaparral), it is unable to adapt to conversion of the habitat to nonnative, invasive vegetation due to its niche specificity. Because of its reliance on buckwheat, nonnative, invasive vegetation will need to be managed for the Smith's blues to have sufficient habitat. Given the host-plant specificity, the subspecies has always had some level of limited adaptive capacity. In future scenarios 1 and 2, habitat degradation is predicted to reduce the potential for already limited adaptive capacity, which comprises representation for the subspecies. In future scenario 3, in which invasive, nonnative vegetation management actions are funded and implemented, the trajectory for invasive, nonnative vegetation spread could be slowed and areas infested would be reduced. Increased habitat quality would maintain the subspecies' ability to withstand catastrophic events and facilitate the potential for adaptive capacity by increasing habitat extent and quality.

3.7.2 Uncertainties

- Likelihood of individual future scenarios
- Future development scenarios for coastal Monterey County
- Likelihood of metapopulation-level future catastrophic events
- Effect on abundance, growth rate, or an acceptable proxy of future habitat loss and degradation.
- Adaptive capacity of Smith's blue butterflies

5.0 RECOVERY CRITERIA EVALUATION

5.1 Downlisting & Delisting Criteria

The recovery plan for the Smith's blue was signed in 1984 (Service 1984, entire). Instead of recovery criteria, the plan includes a list of objectives, which are similar to the recovery criteria in more recent recovery plans. The objectives state that the Smith's blue would be considered eligible for delisting when either of the following two conditions has been met:

1. The Smith's blue colonies at all 18 sites identified in the recovery plan have been made secure. Colonies are considered secure when viable, self-sustaining populations have been maintained for a period of ten consecutive years and no foreseeable threats to the future survival of the colonies exist. If, after 10 consecutive years, these sites appear to be permanently protected and the butterfly colonies that occupy these sites no longer appear to be threatened, then the Smith' s blue butterfly would qualify for delisting.
2. An equivalent number of Smith's blue colonies have been made secure at comparable alternative sites to insure the continued existence of the subspecies. The determination that a colony is secure and is comparable to sites listed in the recovery plan is to be based on the following criteria:

a. Status surveys are conducted that indicate the alternative colony is comparable in size and distribution to the colony listed;

b. Status surveys are conducted that indicate the alternative colony has, relative to one of the colonies listed, comparable opportunities for genetic exchange with other Smith's blues;

c. Genetic studies are performed that indicate there are no taxonomic differences between the alternative colony and the colony listed ; and

d. Status surveys are conducted to document that a viable, self-sustaining population has been maintained at the alternative site for a period of 10 consecutive years and no foreseeable threats to the future survival of the colony exist.

The plan states that downlisting of the Smith's blue's status to threatened would be considered when 10 of the 18 colonies mentioned in item #1 above have been made secure or when 10 colonies comparable to those sites have been secured, as described in item #2.

5.2 Evaluation

The recovery objectives in the 1984 plan focus on protection of known (as of 1984) localities. However, due to changes in our knowledge of the butterfly's range and the threats that it faces, the objectives are no longer applicable to the whole range of the listed entity. The range is larger and shifted to the south relative to what was known in 1984, and several of the locations identified for protection in the recovery plan no longer have suitable habitat or are outside the currently accepted range (Service 2003, pp. 9 and 13). Of the 18 locations identified for protection in the recovery plan (Service 1984, pp. 28–29), 3 are north of the current range (Lone Star Olympia Quarry, Santa Cruz Aggregates, and Crystal Springs Reservoir) and 1 was likely misidentified (Cone Peak), as it is at a higher elevation than any other occupied location and has no suitable habitat (Service 2003, p. 20).

The intent of the delisting criteria seems to be that viable, self-sustaining populations across the range are maintained overtime and that no threats to the future survival of these populations exist. The intent of the downlisting criteria seems to be some proportion of the necessary populations for delisting are viable and self-sustaining overtime and no threats to the future survival of the populations.

In 2006, we completed a 5-year review for the Smith's blue butterfly in 2006 (Service 2006, entire) and at that time, found sufficient evidence to recommend downlisting based on the following:

(1) The occupied range of the Smith's blue butterfly is larger than was known at the time the subspecies was listed and numerous new occupied sites have been found throughout the southern part of its range.

(2) Since its listing in 1976, some locations occupied by the Smith's blue butterfly have been secured from residential or commercial development threats through public or non-profit conservation ownership and additional occupied locations have been located in the southern portion of the subspecies' range.

(3) We did not recommend delisting Smith's blue because it still continues to require protection under the Act as a threatened species because of ongoing threats, primarily

related to habitat loss due to development (which is more prevalent in the northern portion of the subspecies' range) and invasion by non-native plants throughout the range.

Currently, the occupied range of the Smith's blue is significantly larger than was known at the time the subspecies was listed, and numerous new occupied sites had been found throughout the southern part of its range. However, most occupied sites were surveyed only once, and we have no substantial information on the persistence or resiliency of such occurrences. In terms of distribution, the lack of Smith's blue survey data makes it difficult to discuss trends in the subspecies' spatial distribution. There are no documented localities (historical or current) between the City of Monterey and Point Lobos State Reserve (approximately 6.5 mi (10.5 km)). Smith's blue butterflies have not been detected recently between Sand City and Carmel Highlands (approximately 9 mi (14.5 km)) (Service 2003, p. 5; R. Arnold, pers. comm. 2006), including the Naval Postgraduate School, indicating that this gap in the range is expanding (Service 2006, p. 7). Those populations north of the City of Monterey are likely more isolated from southerly populations than they were historically. In terms of population numbers, the nearly complete lack of data from population monitoring limits our ability to make assumptions or predictions regarding abundance. The majority of Smith's blue sightings are informal and do not allow for estimations of population size.

Commented [TC29]: This is definitely the elephant in the document! I hope there are plans to survey for the species.

Overall, the primary threats currently impacting the Smith's blue are habitat loss and degradation due to development, invasion by invasive, nonnative vegetation and overstabilization of the habitat, and factors related to climate change, as well as (although to most likely a lesser degree) wildfires, road and trail maintenance and use, and grazing. Loss of habitat for the Smith's blue butterfly in the coastal dunes north of the Monterey Peninsula has been significant. Development projects including hotels, housing, and shopping centers have occurred throughout this dune complex. However, since its listing in 1976, some locations occupied by the Smith's blue butterfly have been secured from residential or commercial development threats through public or non-profit conservation ownership. In particular, the coastal area formerly encompassed by the Fort Ord Army Base is now owned and managed by California State Parks (Fort Ord Dunes State Park). Much of the habitat for the Smith's blue butterfly south of the Monterey Peninsula is privately owned and could be proposed for development in the future, especially in the vicinity of the Carmel Highlands.

The threat of habitat loss caused by invasive, nonnative vegetation has the potential to degrade habitat, including that which is considered protected. Without management of invasive, nonnative vegetation, Smith's blue habitat can be overtaken and rendered unsuitable for the butterflies. In the future, the risk posed by overstabilization of the habitat and competition with nonnative, invasive vegetation is expected to increase. Future predictions are that increasing temperatures will favor trait states that tend to be possessed by exotic species, increasing the dominance of exotic species in California (Sandel and Dangremond 2012, pp. 282–283). Few areas across the subspecies' range have been restored or have plans for future restoration. If invasive, nonnative vegetation continues to spread and fill habitat that should otherwise be occupied by buckwheat undergoing natural dynamics, then the butterfly's ability to persist into the future will be negatively affected by reducing the abundance and availability of their host plants.

Habitat loss and degradation from factors related to climate change, such as sea-level rise and drought, are also expected to worsen into the future. Changes in weather patterns attributed to changes in climate have been observed in recent years and are predicted to continue in California

(Frankson et al. 2017, p. 1). This can include extreme events such as higher temperatures, multi-year droughts, heavy rain events, global and local sea level rise, and wildfires that are larger and more intense (Frankson et al. 2017, pp. 2–5; Langridge et al. 2018, p. 6–7). All of these have the potential to remove, reduce, and degrade the Smith’s blue’s habitat as well as impact their buckwheat host plants, reducing germination and survival rates.

In summary, the occupied range of the Smith’s blue is significantly larger than was known at the time the subspecies was listed, and numerous new occupied sites have been found throughout the southern part of its range, but we do not know if populations are resilient and self-sustaining overtime. We forecast that threats to the future survival of the populations will likely increase without increased management.

6.0 OVERALL SYNTHESIS

At the time of listing, habitat loss and degradation due to housing developments and highway construction, heavy foot and vehicular traffic on Fort Ord Army Base, and the spread of introduced iceplant were identified as the primary threats to the species (50 FR 48139). Since then, we have learned that the range of the subspecies includes a larger area and this has changed our understanding of the threats. At the time of the last 5-year review, the decline of the Smith's blue butterfly across its range was attributed to degradation and loss of habitat as a result of urban development, recreational activities, sand mining, fire suppression, and encroachment of invasive, nonnative vegetation (Service 2006, p. 14). We now consider the impacts of grazing and factors related to climate change, especially sea level rise and drought, to be threats to the species. Some of the currently occupied habitat is owned by Federal, State, and local agencies with at least some management direction to conserve Smith’s blue habitat across its range; however, much of the potential habitat for the Smith’s blue is privately owned and at risk of development. Because of its proximity to the coast, much of this habitat is subject to restrictions mandated by local coastal programs, the California Coastal Act, and the California Environmental Quality Act. Some conservation efforts to remove invasive, nonnative vegetation and restore the habitat have been completed, but large areas remain infested. Additionally, no mechanism has yet been implemented to ensure that monitoring and restoration efforts will be completed in the future, nor has a permanent and dedicated source of funding been allocated for that purpose. Only the population at the Salinas River National Wildlife Refuge has been consistently monitored in recent years (Service 2019, p. 1). Smith’s blue’s buckwheat habitat remains vulnerable to the persistent encroachment of nonnative, invasive vegetation and overstabilization of its habitat throughout its range. Restoration, monitoring, and adaptive management is necessary to reduce the Smith’s blue’s risk from invasive, nonnative vegetation and overstabilization into the future.

Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Currently, we do not have data to determine the resiliency of Smith’s blue populations. Buckwheat host plants, coastal habitats and disturbance, and habitat connectivity are threatened by habitat loss and degradation, likely reducing the abundance, survival, and fecundity of the species. Redundancy will always be very limited for local, endemic species with a naturally limited range. However, two metapopulations composed of several to many populations and two habitat types provides some level of redundancy in the face of potential catastrophic events, such as wildfire or catastrophic drought. Finally, because of its reliance on buckwheat, invasive, nonnative vegetation must be managed in order for the Smith's blues to have sufficient habitat. Given the host-plant specificity, the subspecies has always had some level of limited adaptive capacity. Habitat degradation has reduced the potential for already limited adaptive capacity, which comprises representation for the subspecies.

Looking into the future, we developed three scenarios that capture the range of plausible effects to the species from predicted change over 40 years. We chose 40 years because this encompassed projections for each factor influencing viability, where available. Scenario 1 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and effects of Representative Concentration Pathway (RCP) 4.5 scenario for climate change in the California Central Coast region based on California's 4^{th} Climate Change Assessment (Langridge et al. 2018). Scenario 2 assumes a continuation of current trends in development and invasive, nonnative vegetation proliferation, and RCP 8.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018). Scenario 3 assumes a continuation of current trends in development, an increase in conservation-related actions for invasive, nonnative vegetation, and RCP 4.5 scenario for climate change in the California Central Coast region based on Langridge et al. (2018).

While we do not have data to determine the resiliency of Smith's blue populations, we can forecast that the resiliency for Smith's blue butterfly populations will likely change under each future scenario. Under future scenarios 1 and 2, invasive, nonnative vegetation, drought, and sea level rise are predicted to increase in Smith's blue habitat, more so in Scenario 2 than Scenario 1. The butterfly's ability to persist into the future will be negatively affected by increased overstabilization of its habitat by nonnative, invasive vegetation, habitat degradation due to drought, and loss of habitat due to sea-level rise, all of which will reduce the abundance and availability of their buckwheat host plants, coastal habitats with appropriate disturbance and habitat connectivity (i.e., the resiliency of populations will be reduced from current conditions). Under future scenario 3, we forecast increased management for invasive, nonnative vegetation, but increased drought and sea-level rise. The butterfly's ability to persist into the future will be negatively affected by habitat degradation due to drought and loss of habitat due to sea-level rise, but will be positively affected by management for invasive, nonnative vegetation. The abundance and availability of buckwheat host plants, coastal habitats with appropriate disturbance, and habitat connectivity may be only somewhat reduced from current conditions under this scenario. If habitat loss and reduced resiliency predicted under Scenarios 1 and 2 lead to population extirpations, redundancy for the subspecies will be reduced, increasing extinction risk from catastrophic events, such as wildfire or catastrophic drought. In future scenarios 1 and 2, habitat degradation is predicted to reduce the potential for already limited adaptive capacity, which comprises representation for the subspecies. In future scenarios 3, in which invasive, nonnative vegetation management actions are funded and implemented, the trajectory for invasive, nonnative vegetation spread could be slowed and the area infested would be reduced. Increased habitat extent and quality would maintain the subspecies' ability to withstand catastrophic events and facilitate the potential for adaptive capacity and long-term viability of the species.

7.0 REFERENCES CITED

Arnold, R.A. 1978. Status of six endangered California butterflies. Report to California Department of Fish and Game, Nongame Wildlife Investigations, Endangered Species Program, Sacramento.

Arnold, R.A. 1981. A review of endangered species legislation in the U.S.A. and preliminary research on 6 endangered California butterflies (Lepidoptera-Lycaeindae). In: Biotop- und Artenschutz bei Schmetterlingen. G. Schmid (ed.) Beih. Verhoff. Naturschutz Landschaftspflege Bad. Wurtt. Karlsuhe. 21:79–96.

Arnold, R.A. 1983a. Conservation and management of the endangered Smith's blue butterfly. Journal of Research on the Lepidoptera 22:135–153.

Arnold, R.A. 1983b. Ecological studies of six endangered butterflies (Lepidoptera, Lycanaenidae): Island biogeography, patch dynamics, and the design of habitat preserves. University of California Publications in Entomology 99. 161 pp.

Arnold, R.A. 1986. Ecological studies of the endangered Smith's blue butterfly at Marina State Beach in 1986. Final Report for an Interagency Agreement between the California Department of Parks and Recreation and the University of California's University Research Expeditions Program. Entomological Consulting Services, Inc., Pleasant Hill, California. 24 pp. and figures.

Arnold, R.A. 1991. Status surveys and habitat assessment for the endangered Smith's blue butterfly at the Garland Ranch Regional Park in Carmel Valley, California. Pleasant Hill, California. 28 pp. and map.

Arnold, R.A. 2002. Survey protocol for presence-absence surveys of the endangered Smith's blue butterfly in the Los Padres National Forest in Monterey and northern San Luis Obispo Counties, California. Prepared for the U.S. Forest Service. Entomological Consulting Services, Inc., Pleasant Hill, California. 30 pp. and figures.

Arnold, R.A., J.A. Gilchrist, M. Allaback, and J. Norman. 2006. Low-Effect Habitat Conservation Plan for the Smith's blue butterfly and California red-legged frog, at the Post Ranch Inn (APN 419-311-034) in Big Sur, Monterey County, California. Prepared for Post Ranch L.P. 112 pp.

Arnold, R.A. 2015. Low-Effect Habitat Conservation Plan for the endangered Smith's blue butterfly for repair of five bridges that provide access to the Light Station and Lighthouse at Point Sur State Historic Park in Monterey County, CA. Prepared for the State of California Department for Parks and Recreation, Monterey District. 67 pp.

Arnold, R.A. 2019. 2018 Annual Report for Permit #TE-797233. Letter to the U.S. Fish and Wildlife Service Regional Recovery Permit Coordinator. 5 pp.

Big Sur Land Trust. 2019. Martin Dunes /Marina. Website accessed on November 8, 2019. https://bigsurlandtrust.org/martin-dunes-marina/

California Coastal Commission. 2017. Th22 CCC-17-CD-02 (Cemex) July 31, 2017 exhibits. 307 pp. plus appendices.

California State Parks. 2003. Habitat restoration and monitoring at former Fort Ord, Site 3. California State Parks, Monterey District annual report AR-BW-2279. 24 pp.

[Caltrans] California Department of Transportation. 2004. Big Sur Coast highway management plan. 141 pp.

Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. Climate change scenarios and sea level rise estimates for California, 2008 climate change scenarios assessment. California Climate Change Center. CEC-500-2009-014-F.

[CDFW] California Department of Fish and Wildlife. 2019. Smith's blue butterfly. California Natural Diversity Database. Retrieved September 2, 2019 from https://www.wildlife.ca.gov/Data/BIOS

County of Monterey. 2006. Initial study, Keig (Sarment parcel). Report of the Monterey County Planning and Building Inspection Department. 41 pp.

Cushman, J.H. 2009. Impact of cattle grazing on the Smith's blue butterfly, its host plant, and the surrounding plant community. Final report prepared for The Nature Conservancy and other managing partners of Palo Corona Regional Park – Monterey Peninsula Regional Park District and Big Sur Land Trust. 66 pp.

Dorrell-Canepa, J. 2005. Dune restoration plan Marina Dunes Preserve. Marina, CA. Report prepared for Monterey Peninsula Regional Parks District. 41 pp.

ESA PWA. 2014. Monterey Bay sea level rise vulnerability study: technical methods report. Prepares for the Monterey Bay Sanctuary Foundation. Website: https://maps.coastalresilience.org/california/ [accessed 25 September 2019]

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. Confronting Climate Change in California: Ecological Impacts on the Golden State. Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Flint, L. E., A.L. Flint, J.H. Thorne, and R. Boynton. 2013. Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model. Dataset available via California Climate Commons http://climate.calcommons.org/bcm. Accessed September 24, 2019.

Frankson, R., L. Stevens, K. Kunkel, S. Champion, D. Easterling, and W. Sweet. 2017. California State Summary. NOAA Technical Report NESDIS 149-CA, 4 pp.

Glick, P., B.A. Stein, and N.A. Edelson, eds. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C.

Griggs, G., J. Árvai, D. Cayan, R. DeConto, J. Fox, H.A. Fricker, R.E. Kopp, C. Tebaldi, E.A. Whiteman (California Ocean Protection Council Science Advisory Team Working Group). 2017. Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017. 43 pp. plus appendices.

Hanak, E., and G. Moreno. 2012. California coastal management with a changing climate. Climatic Change 111:45–73.

Herberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. The impacts of sea level rise on the California Coast. California Climate Change Center. CEC-500-2009-024-F. 115 pp.

[IPCC] Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland. 104 pp.

[IPCC] Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland. 151 pp.

Langridge, R. 2018. Central Coast Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-006.

Lenihan, J.M., D. Bachelet, R.P. Neilson and D. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change 87(Suppl 1):S215-S230.

Mattoni, R.H.T. 1954. Notes on the genus Philotes: I. Descriptions of three new subspecies and a synoptic list. Bulletin of the Southern California Academy of Science 53:157-165.

Mattoni, R.H.T. 1977. The Scolitantidini. Part 1. Two new genera and generic rearrangement (Lycaenidae). Journal of Research on the Lepidoptera 16:223–242.

McLaughlin, J.F., J.L. Hellmann, C.L. Boggs, and P.R. Ehrlich. 2002. Climate change hastens population extinctions. Proceedings of the National Academy of Sciences 99(9):6070–6074.

Pierce, N.E., M.F. Braby, A. Heath, D.J. Lohman, J. Mathew, D.B. Rand, and M.A. Travassos. 2002. The ecology and evolution of ant association in the Lycaenidae (Lepidoptera). Annual Review of Entomology 47:733–71.

Pierce, D.W., J.F. Kalansky, and D.R. Cayan (Scripps Institution of Oceanography). 2018.

Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CNRA-CEC-2018-006.

Pratt, G.F., and J.F. Emmel. 1998. Revision of the *Euphilotes enoptes* and *E. battoides* complexes (Lepidoptera: Lycaenidae). In: Systematics of Western North American Butterflies. Mariposa Press. Gainesville, Florida. PRBO Conservation Science. 2011. Projected effects of climate change in California: ecoregional summaries emphasizing consequences for wildlife, version 1.0. http://data.prbo.org/apps/ bssc/climatechange [accessed 20 September 2019]

Renner, S.S., and C.M. Zohner. 2018. Climate change and phenological mismatch in trophic interactions among plants, insects, and vertebrates. Annual Review of Ecology, Evolution, and Systematics. 49:165–182.

Sandel, B. and Dangremond, E. M. 2012. Climate change and the invasion of California by grasses. Global Change Biology 18: 277–289.

[Service] U.S. Fish and Wildlife Service. 1976. Determination that six species of butterflies are Endangered Species. 41 FR 22041. 4 pp.[Service] U.S. Fish and Wildlife Service. 1984. Smith's blue butterfly recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon. 87 pp

[Service] U.S. Fish and Wildlife Service. 1986. Letter to Kris Schenk, Santa Cruz County Planning Department. 5 pp.

[Service] U.S. Fish and Wildlife Service. 1998. Recovery plan for Mitchell's satyr butterfly. U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota. 71 pp.

[Service] U.S. Fish and Wildlife Service. 2003. Status review for the Smith's blue butterfly (*Euphilotes enoptes smithi*), Los Padres National Forest, Monterey Ranger District. Report to the U.S. Forest Service under cooperative agreement number 03-IA-11050700-024. 42 pp. plus appendices.

[Service] U.S. Fish and Wildlife Service. 2006. Smith's blue butterfly (*Euphilotes enoptes smithi*) 5-year review: Summary and evaluation.

[Service] U.S. Fish and Wildlife Service. 2008. Programmatic Biological Opinion for Highway 1 Management Activities that Affect the Smith's Blue Butterfly, Monterey and San Luis Obispo Counties, California (1-8-07-F-68). 18 pp.

[Service] U.S. Fish and Wildlife Service. 2010. Rising to the urgent challenge. Strategic plan for responding to accelerating climate change. 32 pp.

[Service] U.S. Fish and Wildlife Service. 2016. USFWS Species Status Assessment Framework: an integrated analytical framework for conservation. Version 3.4 dated August 2016.

[Service] U.S. Fish and Wildlife Service. 2017. Guidance Regarding "Threats" Terminology in Status Assessments. November 27, 2017.

[Service] U.S. Fish and Wildlife Service. 2019. 2018 activities involving the Smith's blue butterfly at Salinas River NWR. February 20, 2019 report.

Shields, O. 1975. Studies on North America *Philotes*. IV. Taxonomic and biological notes, and new subspecies. Bulletin of the Allyn Museum. 28:1–31.

Singer, M. and C. Parmesan. 2010. Phenological asynchrony between herbivorous insects and their hosts: signal of climate change or pre-existing adaptive strategy? Philosophical Transactions of the Royal Society B. Volume 365:Issue 1555:3161–3176.

Smith, D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, and H.M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9: 302–320.

Thomas, J. 1980. Why did the large blue become extinct in Britain? Oryx 15(3): 243-247.

Thomas Reid Associates. 1987. Marina Dunes Smith's blue survey. Final report prepared for the Marina Dunes Task Force, City of Marina. 19 pp.

Thomas Reid Associates. 1999. Marina Dunes plan species management guidelines. 67 pp.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, & J. Bjorkman. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. California Department of Fish and Wildlife, Sacramento, California.

Thornton, E., A. Sallenger, J. Conforto Sesto, L. Engley, T. McGee, and R. Parsons. 2006. Sand mining impacts on long-term dune erosion in southern Monterey Bay Marine Geology 229: 45–58.

[USDA] U.S. Department of Agriculture Forest Service. 1999. Southern California mountains and foothills assessment. General Technical Report PSW-GTR-172. Albany, California. 424 pp.

Vermeer, M. and S. Rahmstorf. 2009. Global sea level linked to global temperature. Proceedings of the National Academy of Science of the USA, 106, 21527–21532.

In Litt.

White, R. R. 2000. Letter to Colleen Scully, U.S. Fish and Wildlife Service.

Personal Communications

Arnold, R.A., Entomological Consulting Services, Limited. Telephone conversation with Jacob Martin, U.S. Fish and Wildlife Service. April 10, 2006.

Fowler, M., Caltrans. Telephone conversation with Lara Drizd, U.S. Fish and Wildlife Service. September 25, 2019.

Martin, Jacob. U.S. Fish and Wildlife Service. Draft SBB review. 2019

Palkovic, A., California State Parks, Environmental Scientist. Electronic mail message to Robert McMorran, U.S. Fish and Wildlife Service. October 28, 2019.

Fw: [EXTERNAL] RE: Peer Review Request from USFWS - Smith's blue butterfly

Darst, Cat <cat_darst@fws.gov>

Tue 3/24/2020 2:55 PM

To: McMorran, Robert <robert_mcmorran@fws.gov>

2 attachments (2 MB)

Arnold's Peer Reviewer Comment Matrix for Smith's Blue SSA.xlsx; Arnold-SBB COI form peerreview.pdf;

From: bugdctr@comcast.net <bugdctr@comcast.net>
Sent: Tuesday, March 24, 2020 2:46 PM
To: Powelson, Katherine W <katherine_powelson@fws.gov>
Cc: Darst, Cat <cat_darst@fws.gov>
Subject: [EXTERNAL] RE: Peer Review Request from USFWS - Smith's blue butterfly

Hi Kat:

I apologize for missing your deadline for peer review by a day. My 96-year old mother passed away recently. There has been much to deal with since her passing and I am behind on everything else.

I did read through the Smith's Blue SSA document. Comments related to specific paragraphs in the text are itemized in the attached Excel Comment Matrix.

With regard to the three over-riding questions you asked below:

1. Overall, I believe USFWS has considered the best available scientific info; however, see my comment about Gordon Pratt's genetic studies that were part of his PhD dissertation, if I remember correctly.
2. Information on the butterfly's occurrences, abundance, and other population parameters seems accurate to me. Note my caveat about interpreting maximum dispersal distances too literally and the occurrence of the butterfly at Monterey State Beach (not sure if this is considered Monterey or Seaside).
3. Scientific conclusions based on the aforementioned info seem reasonable. The conclusions of the potential future conditions and 3 scenarios are not unreasonable, but because one or more assumptions may not be entirely correctly, the estimated positive or negative effects on the butterfly and/or its habitat may be more uncertain than presented.

Dick (Richard A.) Arnold
104 Mountain View Court
Pleasant Hill, CA 94523
925-825-3784 h, 925-586-6981 m

From: Powelson, Katherine W <katherine_powelson@fws.gov>
Sent: Wednesday, February 19, 2020 4:10 PM
To: bugdctr@comcast.net
Cc: Darst, Cat <cat_darst@fws.gov>
Subject: Peer Review Request from USFWS - Smith's blue butterfly

Dick Arnold,

The U.S. Fish and Wildlife Service is soliciting independent scientific reviews of the information contained in our Species Status Assessment for the Smith's blue butterfly. You were identified by our office as a potential peer reviewer based on your area of expertise.

This request is provided in accordance with our July 1, 1994, peer review policy (USFWS 1994, p. 34270) and our current internal guidance. This request also satisfies the peer review requirements of the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review." The purpose of seeking independent peer review of this document is to ensure the use of the best scientific and commercial information available; to ensure and maximize the quality, objectivity, utility, and integrity of the information upon which we base our actions; and to ensure that reviews by recognized experts are incorporated into our final rulemaking processes. Please let us know if you would like us to provide any of the referenced materials to help facilitate your review.

Please note that we are not seeking advice on policy or recommendations on the legal status of the species. Rather, we request that peer reviewers focus their review on identifying and characterizing scientific uncertainties, and on ensuring the accuracy of the information in this report. Specifically, we ask peer reviewers to focus their comments on the following:

(1) Have we assembled and considered the best available scientific and commercial information relevant to this species?

(2) Is our analysis of this information correct?

(3) Are our scientific conclusions reasonable in light of this information?

Our updated peer review guidelines also require that all peer reviewers fill out a conflict of interest form (**see attached**). We will carefully assess any potential conflict of interest or bias using applicable standards issued by the Office of Government Ethics. Divulging a conflict does not invalidate the comments of the reviewer; however, it will allow for transparency to the public regarding the reviewer's possible biases or associations. If we receive comments from a reviewer that we deem to have a substantial conflict of interest, we will evaluate the comments in light of those conflicts, and may choose not to give weight to those comments if the conflict is viewed as problematic. You may return the completed conflict of interest form either prior to or with your peer review.

So that we may fully consider any input and coordinate other peer review comments, we are requesting peer review comments by **March 23th, 2020**. If you are willing to peer review but are unable to complete your assessment during this time period, please let me know when we may anticipate receiving your comments. We value your input and understand that your time is valuable and limited.

You can provide your comments in any format you are most comfortable using. However if possible please use the Comment Matrix provided. Please use track changes if you choose to make changes or comments in the document. Please be aware that your completed review of the species report, including your name and affiliation, will be included in the administrative record for this evaluation and will be available to interested parties upon request.

Kat Powelson
Science Support Coordinator
(916) 278-9448 office
(916) 915-2692 cell

Reviewer Name	Chapter	Page	Paragraph #	Line #
R.A. Arnold	Exec Summary	iii	1	
	2.2	10	3	
	2.2	10	5	
	2.4	13	4	
	2.4	13	5	
	2.5	14	1	
	3.1	17	3	
	3.6	25	1	
	3.6	25		1

4.1.3		34	1
	5.2	38	1

Comment
larvae may burrow into the soil to pupate
Arnold 1983b referred to the use of two buckwheats as potential incipient stages of speciation; with better genetic techniques available these days, some genetic divergence might possibly be detectable
Pratt did some preliminary genetic work as part of his PhD thesis or post-doc studies. If I recall correctly, he analyzed individuals of populations feeding on Eriogonum latifolium and/or E. parvifolium
The relationship between larvae of Smith's Blue and ants can be referred to as facultative myrmecophily. Ants do not remain continuously with the larvae as is more typical of blues and ants that have an obligate mutualistic relationship.
A limitation of determining maximum movements or dispersal is that the size of the study site limits the maximum distance that might be detected during capture-recapture studies. My study sites in 1977-79 were smaller because I worked as a single sampler, while my study site in 1986 was larger because I had field assistants. Because we did the 1986 study in a larger study site, we detected longer movements by adult butterflies. I suspect that still longer movements are possible for this butterfly, but because sampling did not occur outside of the boundaries of these study sites and they probably occur less frequently, they were not detected. Related butterflies, such as the endangered El Segundo Blue, have moved greater distances to colonize restoration sites.
Smith's Blues do not occur in serpentine grasslands. This idea is a holdover of the butterfly's (erroneously) reported occurrence in serpentine grasslands in San Mateo County many years ago.
Smith's Blues inhabit Monterey State Beach in the City of Monterey or Seaside (I am not sure which municipality).
No mention of coastal erosion? This process has been on-going for ages.
I suggest rewording the last sentence to say "don't appear to be.." since there really is no evidence to substantiate a conclusion of "are not currently impacting..."

The assumption that there will be an increase in conservation-related actions for invasive, non-native vegetation seems unlikely to me. My experience is that resource agencies are under-funded and under-staffed, so while efforts to control non-natives happen periodically and locally, they are rarely done in a longterm, consistent manner over a large area. An exception is bio-control, but these efforts usually target a single non-native, whereas there are numerous non-natives that degrade habitat conditions for the Smith's Blue.

See my earlier comment about Smith's Blue at Monterey State Beach.