San Bruno Elfin Butterfly (*Callophyrys mossii bayensis*)

Climate Change Vulnerability Assessment for the Golden Gate Biosphere Region

This document represents an evaluation of climate change vulnerability for San Bruno elfin butterfly in the Golden Gate Biosphere (GGB) region of California. The following information is based on stakeholder input provided during and following a winter 2022 vulnerability workshop as well as sources from the scientific literature.

Species Description

The San Bruno elfin butterfly (*Callophyrys mossii bayensis*) is a small, diurnally active, univoltine (one generation per year) butterfly (USFWS 1984). The butterfly's distribution closely follows the narrow distribution of its larval host plant, broadleaf stonecrop or sedum (*Sedum spathulifolium*), which is found on thin-soiled or rocky north-facing slopes within the coastal fog belt of central California (Weiss 1993; ICF 2017). Broadleaf stonecrop is found on varied substrates on dry rocky slopes, cliffs, marine bluffs, roadcuts, open forest, mossy riparian outcrops, and stone walls (Zika et al. 2022). It also can establish on roadcuts and quarry faces and in these locations can provide butterfly habitat if it is northeast-facing to receive direct morning light (Weiss 1993). Larvae emerge in the spring and feed on stonecrop leaves and, in later instars, flowerheads, until they enter pupation in June, which lasts until the following spring (Weiss 1993; NPS 2021). Adults emerge from late February to mid-April, with the peak of adult emergence occurring in the second half of March (USFWS 1984). Adults are highly sedentary, typically moving less than 100 meters (330 feet); the maximum recorded movement is 800 meters (0.5 miles; USFWS 2010; ICF 2017). The adults feed on the nectar of several flowering plants including common lomatium (*Lomatium utriculatum*; USFWS 1984). Oviposition occurs on stonecrop throughout March and early April, and larvae emerge and begin feeding within about a week.

The San Bruno elfin butterfly is currently found only within discrete local populations in the coastal mountains of San Mateo County (Figure 1; USFWS 2010; ICF 2017). Currently, populations exist at San Bruno Mountain, the area from Sweeney Ridge to Montara Mountain, and Milagra Ridge (ICF 2017; USFWS 2019, 2021; S. Simono, pers. comm., 2023).

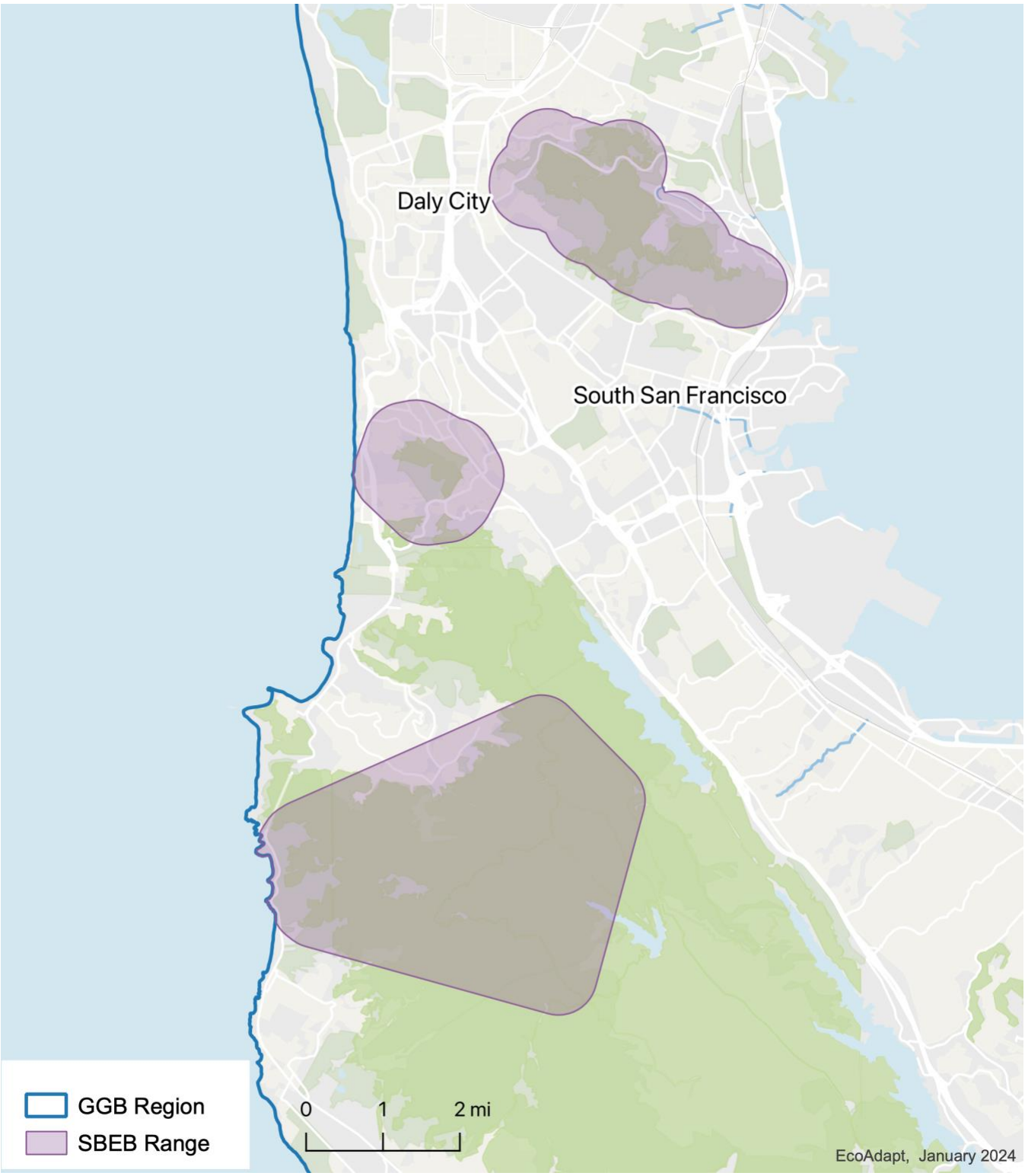

Figure 1. Range of San Bruno elfin butterfly (SBEB) within the GGB region, based on datasets published by the U.S. Fish and Wildlife Service Environmental Conservation Online System (ECOS).

Species Vulnerability → High *(moderate confidence)*

Vulnerability is evaluated by considering the species' sensitivity and exposure to various climate and non-climate stressors as well as the species' adaptive capacity (i.e., ability to cope with these stressors), and is given a ranking of low, moderate, or high. The confidence ranking represents confidence in the accuracy of the ranking based on available scientific knowledge, and is similarly ranked on a scale from low to high.

Summary of species vulnerability

The San Bruno elfin butterfly is highly susceptible to climate stressors and disturbances that affect the health and availability of the stonecrop species to which the butterfly's life cycle is closely tied, such as drought and wildfire. Increasing temperatures, precipitation variability, and storms are also likely to cause direct stress on the species as well as on its host plants. Host plants can be additionally impacted by fire exclusion, which allows encroachment by taller scrub vegetation that can shade and outcompete broadleaf stonecrop, and by competition from invasive plant species that displace it.

The San Bruno elfin butterfly is a federally endangered species that exists in small metapopulations in San Mateo County, and has limited capacity for dispersal due to its small size and limited flying capability. Dispersal is also challenged by high winds associated with coastal storms and by habitat fragmentation, including through type conversion of their habitat to vegetation communities that do not contain host plants (e.g., forested or tall scrub areas). Conservation efforts that prioritize restoring habitat, controlling invasive species, supporting the historical low-intensity fire regime, and potentially translocating individuals to enhance gene flow and connectivity will all be crucial for supporting the species' resilience to climate change. Additional information is also needed to better understand the population biology and genetics of this subspecies, and more information is needed about the distribution and abundance of its larval host plant. Although San Bruno elfin butterflies are federally protected, continued development pressure, disturbance, and fragmentation of the surrounding landscape are ongoing challenges both for maintaining integrity of intact habitat and for restoration of degraded lands.

Sensitivity and Exposure → High *(moderate confidence)*

Sensitivity *is a measure of whether and how a species is likely to be affected by a given change in climate factors, climate-driven changes in disturbance regimes, and non-climate stressors. By contrast,* ***exposure*** *is a measure of how much change in these factors a species is likely to experience. Sensitivity and exposure are combined here into one score representing both components of vulnerability, with high scores corresponding to increased vulnerability and low scores suggesting a species is less vulnerable.*

Sensitivity and future exposure to climate factors → High *(high confidence)*

- **Rising air temperatures** and **heat waves** can impact San Bruno elfin butterflies, which are adapted to a cooler maritime climate. Hot spring conditions can shorten the duration of the adult flight season, reducing mating and oviposition opportunities (Vuln. Assessment Worksheets, pers. comm., 2022). Increasing temperatures may also drive declines in the vegetation types that support San Bruno elfin nectar resources. The sedum host plant, in particular, has a narrow ecological niche comprised of thin, rocky soils on steep, north-facing slopes in cool and seasonally dry climates of the San Francisco Peninsula fog belt (CNPS 2023), suggesting potential sensitivity of this species to increasing temperatures (Vuln. Assessment Worksheets, pers. comm., 2022).
- **Reduced soil moisture** and **increased drought** may negatively impact the host plants and nectar resources of San Bruno elfin butterflies (Vuln. Assessment Worksheets, pers. comm., 2022). Lower soil moisture may favor invasive annual plant species (Everard et al. 2010), which outcompete plants providing nectar resources and potentially the host plants. Stonecrops can resist drying and drought through physiological adaptations such as crassulacean acid metabolism (CAM), an alternative photosynthetic pathway that allows the plant to limit its stomatal openings to reduce water loss via evapotranspiration (Cushman 2001; Heyduk 2022). However, there is substantial uncertainty as to how plants using this pathway will fare under higher CO_2 and temperatures in the future (Heyduk 2022).
- **Changes in the amount and timing of precipitation**, including increases in precipitation variability, may impact the life cycle of the San Bruno elfin butterfly. Frequent spring rains and extreme precipitation events can delay or prevent flight of the adult butterflies (Weiss 1993). Climate change projections for California coastal grassland and low coastal scrub vegetation, in which nectar source plants and stonecrop are found, suggest that these communities are vulnerable to declines, particularly under wetter future scenarios (Thorne et al. 2016).

Sensitivity and future exposure to climate-driven changes in disturbances → Moderate *(moderate confidence)*

- **Storms** and **related impacts such as winds and flooding** can directly impact San Bruno elfin butterflies by delaying the onset of adult flights necessary for feeding and reproduction (Weiss 1993). The butterfly's populations were greatly reduced during and after near-record rainfalls in 1983 (Weiss 1993).
- **Climate-driven changes in wildfire regimes** may impact San Bruno elfin butterflies by altering their host plant and/or nectar source abundance. Although stonecrop can colonize disturbed sites like quarries and roadcuts (Weiss 1993), the historical fire regime and impacts of fire on this species and on the San Bruno elfin butterfly is relatively unknown. Given the relatively cool, moist fog-mitigated climate and predominance of the host plant on rocky outcrops, it is unclear what risk there is from a change in wildfire regimes in surrounding plant communities.

Dependency on habitat and/or other species → High *(high confidence)*

San Bruno elfin butterflies are highly dependent on rocky outcrops and low scrub vegetation that includes their host plant broadleaf stonecrop, which is adapted to the maritime-influenced weather of the coastal mountains (CNPS 2023). Increased variability in these climate conditions may prove challenging to a relatively low-disturbance plant like stonecrop (Vuln. Assessment Worksheets, pers. comm., 2022). Courtship, mating, oviposition, and larval development all take place in the immediate vicinity of this larval host plant (ICF 2017), although some larvae have been found on other surfaces and plants than stonecrop (USFWS 2021). Adults can make use of a wider range of nectar flowers, but a limited number of species are in bloom during their flight season (Vuln. Assessment Worksheets, pers. comm., 2022).

San Bruno elfin butterfly larvae are facultative myrmecophiles, meaning that they can have (but do not require) mutualistic relationships with multiple species of ants which tend the larvae for honeydew production and presumably protect the larval butterflies from parasitoids and predators (USFWS 1984; Weiss 1993; Vuln. Assessment Worksheets, pers. comm., 2022). They have relatively high rates of parasitism, which has the potential to be exacerbated by decline or loss of the ant species that tend them (Weiss 1993; USFWS 2010).

Sensitivity and current exposure to non-climate stressors → High *(high confidence)*

Non-climate stressors can exacerbate ecosystem sensitivity to changes in climate factors and disturbance regimes, and/or can be exacerbated by these changes.

- **Woody invasive plant species** can compete with and shade out the butterflies host and nectar plants (Kobernus 2008; USFWS 2010; ICF 2017). **Invasive Argentine ants** (*Linepithema humile*) may also be facilitating increased parasitism in San Bruno elfin larvae in a similar manner as has been observed for endangered mission blue butterflies (*Icaricia icariodes missionensis*), by interrupting the protective function of native ants that care for these larvae (USFWS 2010).
- **Pesticide use** impacts native plants used by the San Bruno elfin butterfly, although managers are generally careful about herbicide use in areas that are publicly managed for rare butterflies (Kobernus 2008). However, drift of herbicides and insecticides from proximate areas remains a potential threat (USFWS 2019).
- **Roads, highways, and trails** can eliminate habitat and create barriers to butterfly movement, which is particularly problematic for a species that does not travel long distances (Weiss 1993; USFWS 2019; Vuln. Assessment Worksheets, pers. comm., 2022). Although road cuts can create surfaces on which stonecrop can colonize, severely angled cuts can lead to extensive shading that limits stonecrop viability, and these deeply shaded areas are rarely occupied by the butterfly (Weiss 1993).

- **Off-trail recreational activity**, and even monitoring activities that require monitors to move through off-trail habitat, can lead to disturbance of butterflies and trampling of their habitat (USFWS 2019; NPS 2023).
- **Residential and commercial development** has likely led to significant historic loss of San Bruno elfin butterfly habitat (USFWS 1984; Weiss 1993). With the federal listing of the species and the ensuing protection and management of several remaining populations of the species and its habitat, development pressure has been decreased and is seen as less of a threat to the species (USFWS 2010, 2019).

Adaptive Capacity → Low *(high confidence)*

Adaptive capacity *is the ability of a species to respond to or cope with climate change impacts with minimal disruption. High adaptive capacity corresponds to lower overall climate change vulnerability, while low adaptive capacity means that the species will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the species.*

Species extent, status, connectivity, and dispersal ability → Low (high confidence)

The San Bruno elfin butterfly is extremely restricted in its range, as it is only found in a few areas in northern San Mateo County (USFWS 2019). Populations have been impacted by habitat loss and fragmentation, illegal poaching, and host plant declines as a result of invasive species and alterations to natural disturbance regimes (Kobernus 2011; USFWS 2021). Species distribution has remained consistent since federal listing, but variability in survey protocols across sites and years prevent an accurate understanding of population trends (USFWS 2021).

Historically, the San Bruno elfin butterfly was probably more abundant prior to development and disturbance of its habitat, but the distribution of this subspecies has likely never been very widespread due to its specialized host plant requirements (Weiss 1993; USFWS 2010). Appropriate habitat in the GGB region has declined significantly due to widespread land-use conversion and fragmentation resulting from urban and suburban development (Weiss 1993; USFWS 2010). The federal listing of the species and the protection and management of public lands on which the species is currently found (USFWS 1984) has reduced the direct threat of development to this species' current habitat (USFWS 2021). However, San Bruno elfin butterflies continue to be threatened by invasive plants and other factors that degrade their habitat (Kobernus 2011; USFWS 2019, 2021).

As San Bruno elfin butterflies are relatively sedentary, are closely associated with their larval host plant, and have limited dispersal ability (no more than several hundred meters; Weiss 1993; ICF 2017; Vuln. Assessment Worksheets, pers. comm., 2022), they likely cannot navigate discontinuous vegetation types or habitat fragmented by human development (USFWS 2019). As a result, populations are mostly isolated from each other (USFWS 2010).

Intraspecific/life history diversity → Low (moderate confidence)

San Bruno elfin butterfly life history is closely tied to its reliance on stonecrop and a more diverse group of flowering plants used for nectar by adults (USFWS 1984; Weiss 1993). There is limited evidence that the larvae have been found on other plants, which suggests the potential for some flexibility with respect to host plant alliances (USFWS 2021).

The isolated populations and limited numbers of San Bruno elfin butterflies suggests low genetic diversity in this species, particularly within populations, but the genetics of this species has not been studied (USFWS 2019; Vuln. Assessment Worksheets, pers. comm., 2022).

Resistance and recovery → Low (low confidence)

San Bruno elfin butterflies are found in several small populations, and it is uncertain whether the species could recover without assisted reintroduction in the event of extirpation of one or more populations (USFWS 2010; ICF 2017). The butterfly's recovery from perturbations such as inclement weather and storms seems to be slow (Weiss 1993; ICF 2017). Their host plants are not particularly disturbance-associated, and very low rates of disturbance can lead to vegetative transitions that result in the loss of stonecrop and nectar sources. Changes in natural disturbance regimes that pose threats to the butterfly's habitat include the suppression and exclusion of wildfire from these habitats and climate change that may facilitate invasive plants and woody vegetation encroachment (Cohen 2010; Kobernus 2011; Thorne et al. 2016; Vuln. Assessment Worksheets, pers. comm., 2022). The butterflies may be helped by recent efforts to plant stonecrop with the goal of increasing the abundance and distribution of this important larval host plant (USFWS 2021).

Management potential → Low (high confidence)

The San Bruno elfin butterfly is afforded significant regulatory protection and resources due to its status as a federally-endangered species (USFWS 1984). Over the more than forty years since its listing, significant efforts have been made to protect the known habitats of San Bruno elfin butterflies and conduct extensive monitoring (USFWS 2019, 2021; NPS 2021). However, this subspecies is small and subtle in coloration, so it is not widely recognized by the public and there is not high awareness of its importance as a species (Vuln. Assessment Worksheets, pers. comm., 2022). The butterfly's population biology is not well understood, and increased standardization of monitoring protocols and coordination between agencies that are managing populations of this butterfly are needed to enhance its protection (USFWS 2021). Although there have been some recent efforts to increase plantings of stonecrop to support the butterfly, more work needs to be done mapping and surveying the extant distribution of stonecrop habitat to better understand host plant status and availability (ICF 2017; USFWS 2021). The U.S. Fish and Wildlife Service has specifically identified that additional research into the intersection of climate change, sedum ecology, and the butterfly is needed to better understand this subspecies' climate change vulnerability and capacity for adaptation (USFWS 2021).

Recommended Citation

EcoAdapt. 2024. San Bruno elfin butterfly (*Incisalia mossii bayensis*): Climate change vulnerability assessment summary for the Golden Gate Biosphere region. EcoAdapt, Bainbridge Island, WA.

Further information on the Golden Gate Biosphere Region Climate Adaptation Project is available on the project page (www.ecoadapt.org/goto/GGBRClimateProject).

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