Current Condition Assessment Report

For

the Sacramento Mountains Checkerspot Butterfly

(Euphydryas anicia cloudcrofti)

Prepared by the New Mexico Ecological Services Field Office
U.S. Fish and Wildlife Service Ecological Services, Albuquerque, New Mexico

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CHAPTER 1: INTRODUCTION

1.1 Regulatory Background

The Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*) (butterfly, checkerspot, Sacramento Mountains checkerspot) was petitioned for listing under the Endangered Species Act (Act) in January 1999 by the Southwest Center for Biological Diversity (now the Center for Biological Diversity (CBD)) (Southwest Center for Biological Diversity 1998, entire). The U.S. Fish and Wildlife Service (Service) concluded that listing may be warranted and proposed the species for listing as endangered with critical habitat (66 FR 46575: September 6, 2001). The Service placed the Sacramento Mountains checkerspot butterfly on the candidate list.

In 2005, the Service, U.S. Forest Service (Forest Service, FS), and private organizations agreed to a conservation plan containing habitat management information for the species. Later, the Service determined that threats to the butterfly no longer warranted protection of the Act. The Service withdrew the proposed rule, removing the butterfly's status as a candidate species (69 FR 76428; December 21, 2004).

The Service was again petitioned to list the Sacramento Mountains checkerspot butterfly under the Act in 2007 by Forest Guardians (now WildEarth Guardians) and CBD due to ongoing threats, such as cattle and feral horse grazing, noxious weeds, collection, and climate change, and an imminent plan to spray for insect pests (Forest Guardians and CBD 2007, entire). The Service concluded that listing might be warranted in December 2008 (73 FR 74123). In 2009, the Service assessed the Sacramento Mountains checkerspot butterfly's status, concluding that listing was not warranted because the species was not thought to be facing significant threats (74 FR 45396).

In July 2020, the Forest Service convened the Sacramento Mountains checkerspot butterfly working group to address the butterfly's rapid population decline. Since then, the Forest Service, Service, and private partners have been implementing actions to conserve the species. In March 2021, CBD petitioned the Service to list the Sacramento Mountains checkerspot butterfly (CBD 2021, entire).

CHAPTER 2: NATURAL HISTORY OF THE SACRAMENTO MOUNTAINS CHECKERSPOT BUTTERFLY

Just living is not enough, said the butterfly; one must have sunshine, freedom, and a little flower.
— Hans Christian Andersen

2.1 Taxonomy

Like other Lepidoptera, the Sacramento Mountains checkerspot butterfly undergoes complete metamorphosis, with distinct life cycle stages including egg, larval, pupal, and adult stages, which we discuss in more detail below (section 2.3 Life Cycle). The Sacramento Mountains checkerspot butterfly was first collected at Pines Meadow Campground near Cloudcroft, New Mexico, in 1964 (Forest Service 1999, p. 1). The subspecies was formally described in 1980 (Ferris and Holland 1980, pp. 3–9). Checkerspot butterflies are members of the brush-footed butterfly family (Nymphalidae) (Pohl *et al*. 2016, pp. 313–315). The Sacramento Mountains checkerspot butterfly is a subspecies of the Anicia checkerspot or variable checkerspot, a species native to mountainous regions in the western United States (Glassberg 2017, p. 207; Pohl *et al.* 2016, p. 315).

Checkerspot butterflies in the *Euphydryas* genus are similar but can be distinguished from one another by several subtle morphological traits. The Sacramento Mountains checkerspot butterfly has darker colors overall and wide, dark brown or black bands separating the checkered pattern of orange and cream. This subspecies is generally similar to its closest relative (*E. a. chuskae*), with darker lines and a blacker spotting pattern on the wing's dorsal (top) side. Dark black lines on both the top and bottom of the wing patterns separate certain spots; these spots are connected to related checkerspot subspecies (*E. a. capella*) (Ferris and Holland 1980, p. 5). Most butterfly taxa in the Sacramento Mountains are probably differentiated at the subspecies level (Cary and Holland 1992, p. 63).

Here we report those aspects of the life history of the Sacramento Mountains checkerspot butterfly that is important to our analysis. For further information on the Sacramento Mountains checkerspot butterfly, refer to Ferris and Holland 1980 (pp. 3–9) and Pittenger and Yori 2003 (entire).

2.2 Genetics

Preliminary genetic research shows that there has been a divergence between the Sacramento Mountains checkerspot butterfly and other closely related taxa. There might been significant diversion from *E. anicia* (Ryan 2007, p. 9). However, more information is needed to determine the level of differentiation between the Sacramento Mountains checkerspot butterfly and other closely related taxa. Future studies might shed more light on the biogeographic history of the species (Ryan 2007, p. 9).

2.3 Life Cycle

The Sacramento Mountains checkerspot butterfly is univoltine, meaning there is one generation per year (Figure 1). The butterfly's life cycle is synchronized with the development of host and nectar plants. The flight season lasts from mid-June to the end of August. The exact timing of adult flights can vary dramatically from one year to the next, depending on local weather conditions (Service *et al*. 2005, pp. 10–11). The adult butterflies stagger their emergence from pupation, with numbers peaking around the second week of the flight season. Each life stage has different microhabitat, resources, and seasonal specializations different from the other life stages. Resource uses of all life stages must be considered when determining suitable habitats for the subspecies (Lightfoot 2022, pers. comm.).

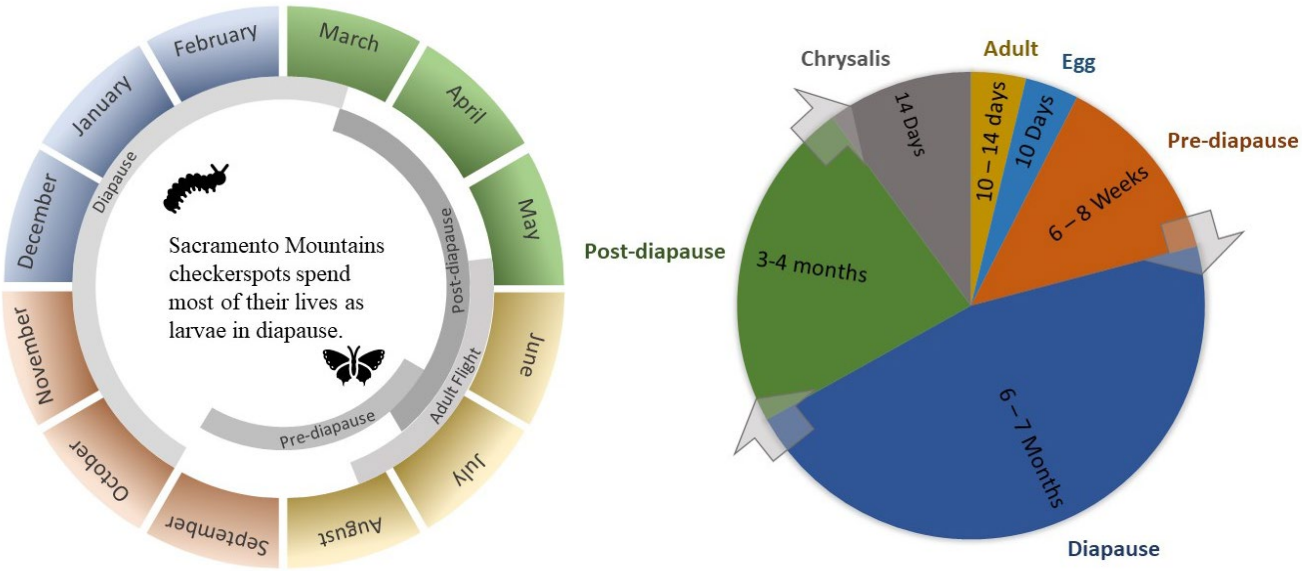

Figure 1. Life cycle and annual cycle of the Sacramento Mountains checkerspot butterfly

Females deposit a cluster of eggs on the underside of New Mexico beardtongue leaves. A female can lay two to three sets of eggs during her short lifetime (Ryan 2021a, pers. comm.). The eggs hatch within two weeks, and larvae collectively create a protective silken shelter, known as a tent, over the host plant feeding upon it until winter or the plant is defoliated (Pratt and Emmel 2010, p. 108). Pre-diapause caterpillars are relatively immobile and rely on host plant health and abundance to complete the first stages of their life cycle (Arriens *et al*. 2020, p. 2). Caterpillars can leave the plant and search for additional resources, but it is unknown how far they can travel in search of food (Pratt and Emmel 2010, p. 108; Service *et al.* 2005, p. 11).

After the third or fourth instar, the larvae enter a period of arrested metabolism known as diapause. Diapause occurs between late September and early October, depending on environmental conditions. The larvae remain in diapause until warm spring temperatures, moisture events, host plant growth, or a combination of these events prompts individuals to come out of their suspended state (Service *et al.* 2005, p. 11). There are aspects of diapause that are not well understood, as Sacramento Mountains checkerspot butterfly diapause has never been studied. Other species of checkerspot can re-enter or remain in diapause when environmental

conditions are not conducive to completing an entire life cycle, such as dry years when vegetation is limiting. These individuals can then come out of diapause the following year when conditions are suitable for growth (Pratt and Emmel 2010, p. 108). Therefore, it might be possible for caterpillars of the Sacramento Mountain checkerspot butterfly to re-enter or remain in diapause for more than one year if environmental conditions are not conducive for growth (Service *et al.* 2005, p. 11).

In early spring (March–April), post-diapause larvae emerge and begin to feed again. In the spring, larvae are more mobile than in the fall, moving on average 2.6 meters (m) (8.5 feet (ft)) from their natal tents. They grow through three or four more instars before pupating (form a chrysalis). Precisely what triggers caterpillars to initiate pupation is not well understood but likely relies on various environmental cues (Ryan 2021a, pers. comm.). As many as 98 percent of individuals do not survive to the adult stage (Ryan 2021b, pers. comm.). Similar mortality rates are typical in other butterflies, as the caterpillars are vulnerable to predation, among other factors (Swengel 1997, p. 5). Currently, a reduced habitat suitability, due toa variety of factors (see Section 4.3) probably contribute to a low survival rate for the Sacramento Mountains checkerspot butterfly (Gisler 2022, pers. comm.).

Changes to the timing of precipitation, such as those caused by climate change, can result in a phenological mismatch and disrupt the butterfly's lifecycle. We discuss this more in section 3.2.2.3 below.

2.3.1 Adults

Figure 2. A dorsal view of the top wing surfaces (left) and lateral view of the bottom surfaces(right) showing colors and patterns of the Sacramento Mountains checkerspot butterfly.

The Sacramento Mountains checkerspot butterfly is small and checkered with dark brown, red, orange, cream, and black spots, punctuated with dark lines (Figure 2). The butterfly's antennae have yellow-orange clubs at the tip, and they have orange legs and eyes (Glassberg 2017, p. 207) (Figure 2).

The adult flight occurs from late June into early August, with peak adult densities occurring in early- to mid-July. Adult flight season can start as early as mid-May, depending on local conditions (Ryan 2022, pers. comm.). Adult checkerspots shelter beneath flowers or at the base

of plants during evening hours, thunderstorms, rain showers, and periods of high winds. Adults crawl up onto flowers or upper leaves of plants in the early morning and bask before becoming active. On sunny days with little wind, checkerspots have been observed chasing each other, basking, and nectaring during the afternoon hours. Mark and recapture studies recorded movement distances of adults ranging from about 460 m to 890 m. The adult lifespan seems to last between 14-20 days, and the oldest recorded adult survived for 23 days (Pittenger and Yori 2003, p. 44).

The Sacramento Mountains checkerspot butterfly has an extremely low dispersal rate (Pittenger and Yori 2003, pp. 16–17) found that none of the adult butterfly moved between canyon sites during their study. Additionally, 89 percent remained within their native meadow. These movement rates are common in checkerspots (Ehrlich *et al.* 1975, pp. 221–222). However, it is likely that due to currently low densities, that movement between meadows no longer takes place (See section 4.1 population structure).

2.3.2 Larval and pupal stage

During the summer and fall months (July to October), the Sacramento Mountains checkerspot butterfly's larvae are between 0.5 to 1.0 centimeters (cm) (0.2 to 0.4 inches (in)) in length. As the caterpillars shed their skins, they transition through growth phases known as instars. Over time, the larvae change from bare and brown to wooly and black with orange hairs (Figure 3) (Service *et al.* 2005, p. 7).

Figure 3. Larval and pupal stages of the Sacramento Mountains checkerspot butterfly. Pre-diapause (summer-fall) larvae (left), post-diapause (spring) larvae (center,) and the chrysalis (right) are shown (Pittenger and Yori 2003; Service 2005).

Once larvae emerge from diapause (now post-diapause), they are known to move considerable distances. Post-diapause larvae probably move away from the natal patch to seek better forage. Larvae seem to move toward thermally warmer areas, such as south-facing slopes and sunny areas (Pittenger and Yori 2003, p. 44). This behavior might aid in early spring growth for the larvae.

Pupae of the Sacramento Mountains checkerspot butterfly are challenging to locate in the wild. Pettinger and Yori studied the species' life history and could only locate one pupal case. The pupae they inspected were at an herbaceous plant's base, surrounded by fine webbing (Pittinger and Yori 2003, p. 45).

2.4 Range and Distribution

2.4.1 Biogeography

The Sacramento Mountains are an isolated mountain range in south-central New Mexico. The mountains rise from desert grasslands which encircle these mountains and stretch for miles. During previous glacial maximums over the past ~25,000 years, the climate of New Mexico was more similar to that of southern Oregon today (Dick-Peddie 1993, p. 16). Most of the state was covered by coniferous forest during glacial maximums. A number of major climatic changes took place between 17,000 and 600 years ago, and New Mexico became warmer and drier. Vegetative communities moved northward and into higher elevation areas. These are approximately the same vegetative communities seen throughout the state today (Dick-Peddie 1993, p. 17).

Currently, the habitats atop the Sacramento Mountains are colder and wetter than the surrounding area which provide an existing refugia for Pleistocene ecosystems (Dick-Peddie 1993, p. 17). Because of the isolation over the past 600 years, unique flora and fauna exist within these sky islands. Therefore, the forests atop these mountains are functionally isolated from similar ecosystems (Brown *et al.* 2001, p. 116). Due to this unique geography, the Sacramento Mountains checkerspot butterfly is a narrow-endemic glacial relict, having dispersed to the Sacramento Mountains when suitable habitat connected this region to similar habitats during the most recent ice age.

The ecoregion is 150 kilometers from comparable high-elevation habitats to the north and west (Cary and Holland 1992, pp. 61–62). Taxonomists believe the the Sacramento Mountains checkerspot's closests relative is *E. a. chuskae* (Chuska Mountains checkerspot), which is found in northwestern New Mexico. This butterfly also occurs in high-elevation mountain meadows and forest margins, but has likely been geographically isolated from *E.a. cloudcrofti* for thousands of years, and separated by seval hundred miles of desert habitat (Ferris and Holland 1988, p. 3).

2.4.2 Historical Range

The Sacramento Mountains checkerspot's historical range is unknown, and Forest Service completed the first range-wide surveys between 1996 and 1997. Forest Service found that the butterfly exists within a range of 82 square kilometers (32 square miles). However, the suitable habitat within this area is only around two square miles (Forest Service 2020a, entire). Therefore, the butterfly occupies an extremely narrow area of habitat (Figure 4).

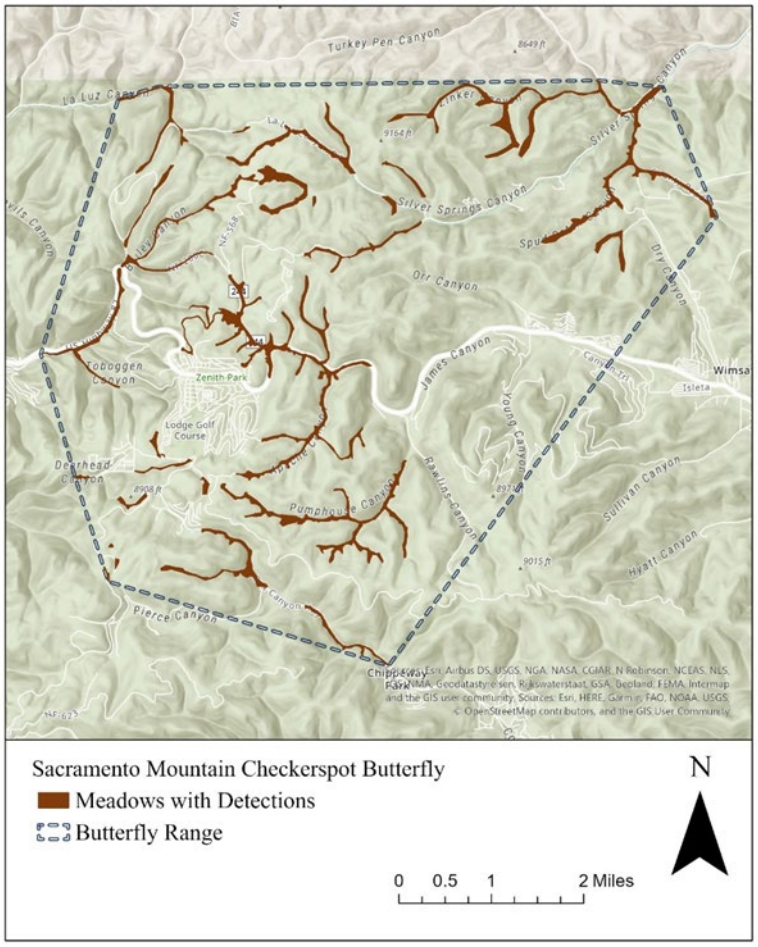

Figure 4. Distribution of the Sacramento Mountain checkerspot butterfly on the Lincoln National Forest in south-central New Mexico. Occupied meadow records for the subspecies were provided by the U.S. Forest Service, Sacramento Ranger District (Forest Service, 2020a).

2.5 Habitat Considerations

The capacity for Sacramento Mountains checkerspot butterfly sub-populations to grow is limited by the quantity and quality of suitable habitat, and connectivity among habitat patches. The minimum area and extent of habitat that is sufficient to support a local, healthy population is unknown. Remnant colonies currently exist in extremely small areas, less than a few acres in size. These sub-populations are probably not large enough to ensure viability. Therefore, habitat augmentation and expansion are probably needed to achieve species conservation.

The butterfly inhabits high-altitude meadows in the upper-montane and subalpine zone at elevations between 2,380 and 2,750 m (7,800 and 9,000 ft) (Service *et al.* 2005, p. 9). The Sacramento Mountains checkerspot butterfly appears to have a stronger affinity for the highest elevation areas in its range, gentle or angled slopes, and south-eastern aspect orientations (McIntyre 2010, p. 30). Trees usually occur along the periphery of meadows including various

spruce (*Picea* spp.), fir (*Pseudotuga* spp. and *Abies* spp.) and pine (*Pinus* spp.) (Wahlberg et al. 2014, p. 69).

Suitable habitat for the Sacramento Mountains checkerspot butterfly occupied areas exist within specific parameters. The ecosystem is usually cool and wet, supporting diverse and robust plant life, including the butterfly's preferred host plant: New Mexico beardtongue (*Penstemon neomexicanus;* see section 3.1.1 below). Typically, these meadows have less than 10 percent tree canopy cover (Wahlberg *et al*. 2014, p. 69). The butterfly appears to prefer meadows and areas within meadows that have low canopy cover (McIntyre 2010, p. 24). Meadow habitats upon which the Sacramento Mountains checkerspot butterfly relies were probably spatially dynamic, driven by a historical fire regime (Brown *et al.* 2001, pp. 116–117).

Pre- and post-diapause larval suitable habitat characteristics shift throughout the year. Pre-diapause larval habitat have high vegetation cover (60%), with little bare ground (12%). By spring, post-diapause larvae are found with less vegetation (37%) and more bare ground litter (33% and 25%, respectively). New Mexico beardtongue cover remains relatively constant. These changes are due to plant growth characteristics between seasons (Pittenger and Yori 2003, p. 41).

2.5.1 Host Plant (Larval Food Source)

The larval host plant for the Sacramento Mountains checkerspot butterfly is the New Mexico beardtongue, also known as penstemon (Ferris and Holland 1980, p. 7). This plant is a member of the Plantaginaceae, or plantain family (Oxelman *et al.* 2005, p. 425; Gisler 2022, pers. comm.). These perennial plants prefer wooded slopes or open glades in ponderosa pine and spruce/fir forests at elevations between 1,830 and 2,750 m (6,000 and 9,000 ft) (New Mexico Rare Plant Technical Council 1999, entire). New Mexico beardtongue is native to the Sacramento Mountains within Lincoln and Otero Counties (Sivinski and Knight 1996, p. 289). The plant is perennial, has purple or violet-blue flowers, and grows to be 0.5 m (1.9 ft) tall.

New Mexico beardtongue appears to establish by seed in bare, disturbed soils. Vegetative reproduction from the rootstock appears to be quite vigorous under the right conditions. Under ideal conditions, the plant typically forms mats or mounds that can become extensive. New Mexico beardtongue is associated with areas where soils are disturbed by pocket gophers (Pittenger and Yori 2003, p. 41). Research has shown that New Mexico beardtongue plants grow taller and more densely within the butterfly's range (McIntyre 2010, p. 28). It is important to note that these patterns of growth and density are reliant on the local climate, and likely to be altered under various climate change scenarios.

Some plant species within the figwort family, including the New Mexico beardtongue, contain iridoid glycosides, a family of organic compounds that are bitter and emetic (vomit-inducing) for most birds and mammal species. The Sacramento Mountains checkerspot and other subspecies of *E. anicia* sequester the iridoid glycosides as caterpillars. It is believed that these compounds make the larvae and adult butterflies unpalatable to predators (Gardner and Stermitz 1987, pp. 2152–2167). It is possible that larvae can detect these compounds, which might stimulate feeding behavior (Lightfoot 2022, pers. comm.).

2.5.2 Adult Nectar Sources

The preferred adult nectar source for the Sacramento Mountains checkerspot butterfly is orange sneezeweed (*Helenium* (*Hymenoxys*) *hoopesii*), a native perennial forb (Service *et al.* 2005, p. 9). Forest Service personnel observed butterflies visiting orange composite flowers (family Asteraceae), including orange sneezeweed, as much as 90 percent of the time during surveys (Forest Service 2000, p. 4). Other surveys have shown that adult butterflies are closely associated with orange sneezeweed flowers (McIntyre 2010, p. 26). Although orange sneezeweed flowers are most frequently used, the butterfly has been observed collecting nectar from various other native nectar sources (Service *et al.* 2005, pp. 9–10). If orange sneezeweed is not blooming during the adult flight period (phenological mismatch), survival and fecundity could decrease for individuals.

Other known nectar sources for the Sacramento Mountains checkerspot butterfly include New Mexico elder (*Sambucus cerulea*); yellow salsify (*Tragopogon dubius*); spike verbena (*Verbena macdougalii*); dandelion (*Taraxacum officinale*); figwort (*Scrophularia montana*); short-rayed coneflower (*Ratibida tagetes*); cutleaf coneflower (*Rudbeckia laciniata*); and musk thistle (*Carduus nutans*) (Pittenger and Yori 2003, p. 40). These additional sources of nectar might be important for future species resilience.

2.5.3 Ground Cover and Soil Disturbance

New Mexico beardtongue appears to prefer well-drained sandy or rocky loam soils (Pittenger and Yori 2003, p. 12). Often, New Mexico beardtongue is situated on steep slopes near roads or drainages. In studies of caterpillars, the highest density of eggs and larvae were found on gopher (*Thomomys* spp.) mounds. Gophers might mix soil nutrients and make them more available to plants, resulting in healthier host plants preferred by adult butterflies (McIntyre 2010, p. 63). It is also possible that New Mexico beardtongue is a disturbance specialist that prefers reduced competition from other plants. Gopher mounds might reduce competition from other plant species (such as non-native grasses) and improve soil aeration, both of which might benefit the host plant (Gisler 2022, pers. comm.). Caterpillars of the Sacramento Mountains butterfly were also found in greater numbers on New Mexico beardtongues growing on gopher mounds (Pittenger and Yori 2003, p. 31).

Pocket gopher activity within meadows appears to be important for New Mexico beardtongue occupancy and succession, influencing the spatial pattern and density of this plant species over time, in turn creating and maintaining suitable habitat for the butterfly (Pittenger and Yori 2003, p. 41). In other ecosystems, gophers affect soil fertility, plant density, plant species diversity, and spatial variation in plant communities (Huntly and Inouye 1988, entire). Davis (1992, pp. 48–49) found that pocket gopher herbivory resulted in increased growth, survivorship, and reproductive output of other *Penstemon* species. Pocket gophers prefer forbs over grasses (Huntly and Inouye 1988, p. 787), so conversion of meadows to grass-dominant habitats with low forb density and diversity may reduce or eliminate pocket gophers from a meadow system and result in loss of butterfly habitat (See discussion on non-native invasive plants below).

2.5.4 Local Climate

The flora and fauna of the Sacramento Mountains are adapted to a historical cycle of summer precipitation known as the North American monsoons. Hail, strong winds, torrential rains, and flooding can result due to local monsoon events (Douglas *et al.* 1993, p. 1666). These rainstorms were once commonplace in the region of southern New Mexico. During this cycle, adult butterflies are active during mid-morning when the sunlight has warmed the air, but before rainstorms move into the area in the afternoon (Forest Service 1999, p. 3). On chilly, cloudy days when temperatures are around 60 °F, butterflies are inactive. Checkerspots start to become active on sunny days when temperatures remain near 70 °F (Forest Service 1999, p. 4). Adult butterflies seem to prefer to fly when temperatures between 73 and 80 °F (Ryan 2021a, pers. comm.). When temperatures regularly exceed 80 °F during the summer months, few adult butterflies were detected (Hughes 2021a, pers. comm.).

CHAPTER 3: POPULATION AND SPECIES NEEDS

For the subspecies to maintain viability, the Sacramento Mountains checkerspot butterfly requires healthy and abundant host plant populations, abundant nectar sources, open meadows, habitat connectivity between occupied meadows to facilitate natural re-colonization processes, and appropriate climatic conditions across the range. Throughout this document we will reference suitable habitat for the species. The habitat needs described in this section are synonymous with suitable habitat.

3.1 Individual Needs

3.1.1 Host Plant

The most crucial habitat factor for the Sacramento Mountains checkerspot butterfly is the New Mexico beardtongue's presence and abundance (McIntyre 2021, pers. comm.). Host plant populations must persist for the Sacramento Mountains checkerspot to maintain viability (Geisler 2022, pers. comm.). The Sacramento Mountains checkerspot butterfly's larvae rely nearly entirely upon the New Mexico beardtongue during pre-and post-diapause. McIntyre found during their study that the density of New Mexico beardtongue was higher in patches occupied by larvae and hypothesized that these densities are important for post diapause dispersal (McInctyre 2010, p. 31). Because of the Sacramento Mountains checkerspot butterfly's dependency on New Mexico beardtongue, it is vulnerable to any type of habitat degradation which reduces host plant health and abundance.

3.1.2 Nectar Source

Access to nectar sources is needed for adult Sacramento Mountains checkerspot butterflies to properly carry out their life cycle. Nectar plant populations must persist for the Sacramento Mountains checkerspot to maintain viability (Gisler 2022, pers. comm.). Female butterflies need abundant nectar resources available. Low nectar plant abundance reduces the number of eggs a female can produce, thus reducing adult recruitment (Murphy *et al.* 1983, p. 259). The primary adult food source is orange sneezeweed. To contribute to the species' viability, orange sneezeweed must bloom at a time that corresponds with the emergence of adult Sacramento Mountain checkerspot butterfly.

3.2 Population Needs

3.2.1 Abundance and Density

To successfully reproduce and increase their fecundity and abundance, butterflies need access to mates. The Sacramento Mountains checkerspot does not fly long distances and probably relies on local abundance and population density to successfully find mates and reproduce. In order to ensure viability, it is likely that the butterfly will benefit from a diversity of flowering plants in the area (Gisler 2022, pers. comm.). Higher densities and more abundant individuals of both orange sneezeweed and other native flora will result in more successful mating attempts and ensure species viability.

3.2.2 Habitat Connectivity

Before human intervention, the habitat of the Sacramento Mountains checkerspot was dynamic over time, with meadows forming and reconnecting due to natural wildfire regimes (Hughes 2021a, pers. comm.). These patterns would have facilitated natural dispersal and re-colonization of meadow habitats following disturbance events, especially when there was high population density in adjacent meadows.

Disturbances to habitat, such as wildfire suppression, and habitat fragmentation, have reduced the ability of the butterfly to move across the landscape. Preliminary genetic research suggested no gene flow across the species' range or between meadows surveyed (Ryan 2021a, pers. comm.), likely due to reduced habitat. If new sites are to become colonized or recolonized by the butterfly, meadow areas will need to be sufficiently connected to ensure dispersal from occupied areas. Habitat connectivity is needed for genetically healthy populations across the species' range to persist into the future.

3.3 Species Needs

The Sacramento Mountains checkerspot needs to have sufficient quality and quantity of habitat for resilient populations, numerous populations to create redundancy through to survive catastrophic events, and enough genetic diversity to allow for adaptations to changing environmental conditions (representation) to achieve viability. The genetic interchange between separate colonies survive colonies within the metapopulations is needed for the species to maintain and maximize the existing genetic diversity, increase adaptive capacity, and adequately respond to environmental changes. We summarize species needs according to resiliency, redundancy, and representation, collectively known as the "three Rs," in Table 1 below.

Table 1. Species needs for the Sacramento Mountains checkerspot butterfly as related to resiliency, redundancy, and representation. These are the ideal conditions needed for the subspecies have viability.

The three Rs	Requisites of Viability	Description
Resiliency (ability to withstand stochastic events)	There are healthy, diverse, abundant host plants and nectar sources available within meadows.	Plant growth is driven by precipitation cycles. Plants need moisture throughout the growing season to flower and produce vegetation for larval food.

	Microclimate conditions that create a moist environment might be needed for larval development.	Moisture from snowmelt, rain, or fog might prevent larvae in diapause from desiccating.
	High metapopulation density and abundance.	Larger, more dense populations are more likely to facilitate colonization events and increase genetic exchange.
	Multiple areas within capable flight distance with host plants and nectar sources are available to populations within each meadow.	Provide energy to adults for mating, egg-laying, and dispersal between and within meadows.
Redundancy (withstand catastrophic events)	Populations or metapopulations are scattered across the range to prevent the loss of the species during catastrophic events.	Multiple metapopulations spread across he species historical range to reduce the risk of extirpation reduce risk from catastrophic events (such as wildfires).
Representation (adaptive capacity)	Populations are genetically diverse.	Genetic diversity provides adaptive advantages, promotes population health and resilience, while maximizing adaptive potential.
	Habitat connectivity between metapopulations.	Habitat connectivity facilitates gene flow across the range and expands access to host plant and nectar resources.

CHAPTER 4: CURRENT CONDITION

4.1 Population Structure

Within western landscapes, many *Euphydryas* populations exist in spatial patterns known as metapopulations (Ehrlich *et al.* 1975, p. 221). Over time, metapopulations are maintained by dynamic processes are characterized by occasional extirpation of local colonies or populations and occasional re-colonization of unoccupied habitat patches. Previous studies show that metapopulation-level processes have been critical to the long-term persistence of the Sacramento Mountains checkerspot in the historical past. The range of the Sacramento Mountains checkerspot butterfly has always been discontinuous and fragmented (Figure 4). Widespread and pervasive spruce-fir forests circumscribe suitable butterfly habitat, comprised of mountain meadows, creating intrinsic barriers to butterfly dispersal and effectively isolating populations from one another (Pittenger and Yori 2003, p. 1). Since human habitation in the area, the movement rate of individuals between meadows within the butterfly range is probably low (Ryan 2021a, pers. comm.).

Currently, the Sacramento mountains checkerspot butterfly population structure no longer exists as a metapopulation. The extant locations are separated by a matrix (unsuitable) habitat of dense conifer forest. It is unlikely that the butterfly will disperse through such habitat. Additionally, population densities are extremely low, reducing the likelihood of colonization events between populations. Therefore, we assume that the Sacramento Mountains checkerspot butterfly currently has small populations, which are distinct from one another, and will refer to populations throughout this document. It should be the goal of restoration efforts to reconnect habitat and reestablish metapopulation dynamics for the butterfly to maintain species viability.

4.2 Abundance

Currently, the Sacramento Mountains checkerspot butterfly is extremely rare. Over the past two decades, the species has declined, both in abundance and in the area occupied (Forest Service 2020b, p. 2) (Figure 5). Across the range, there has been a drastic decline in both areas occupied, and the number of observed individuals (Ryan 2022, pers. comm.). The butterfly is currently found in only two meadows on the Lincoln National Forest (Forest Service 2020b, p. 1).

When the Forest Service began surveying for the species in 1998, ten meadow systems were identified as part of the range (Forest Service 1999, p. 2). Since then, Forest Service and species experts have surveyed these meadows with relative regularity. Forest Service biologists conducted adult butterfly and larval surveys were conducted annually between 1999 and 2010. Larval surveys were conducted again on an annual basis between 2013 and 2015, and again in 2017 (Forest Service 2017, p. 5). We will refer to these as the legacy survey sites or meadow units. Through this survey work, Forest Service has recorded a steep decline in abundance, density, and number of subpopulations (Figure 5) (Forest Service 2020b, pp. 2–4). Forest Service only detected a few adult butterflies in 2020 (Forest Service 2020b, p. 3), and no larval tents were found (Forest Service 2020b, pp. 1–3; Hughes 2020, pers. comm.). Please note that the trendline plotted from these data indicates that species went extinct in 2019; however, 2020 and 2021 adult surveys detected the species in two meadows (Hughes 2021a, pers. comm.).

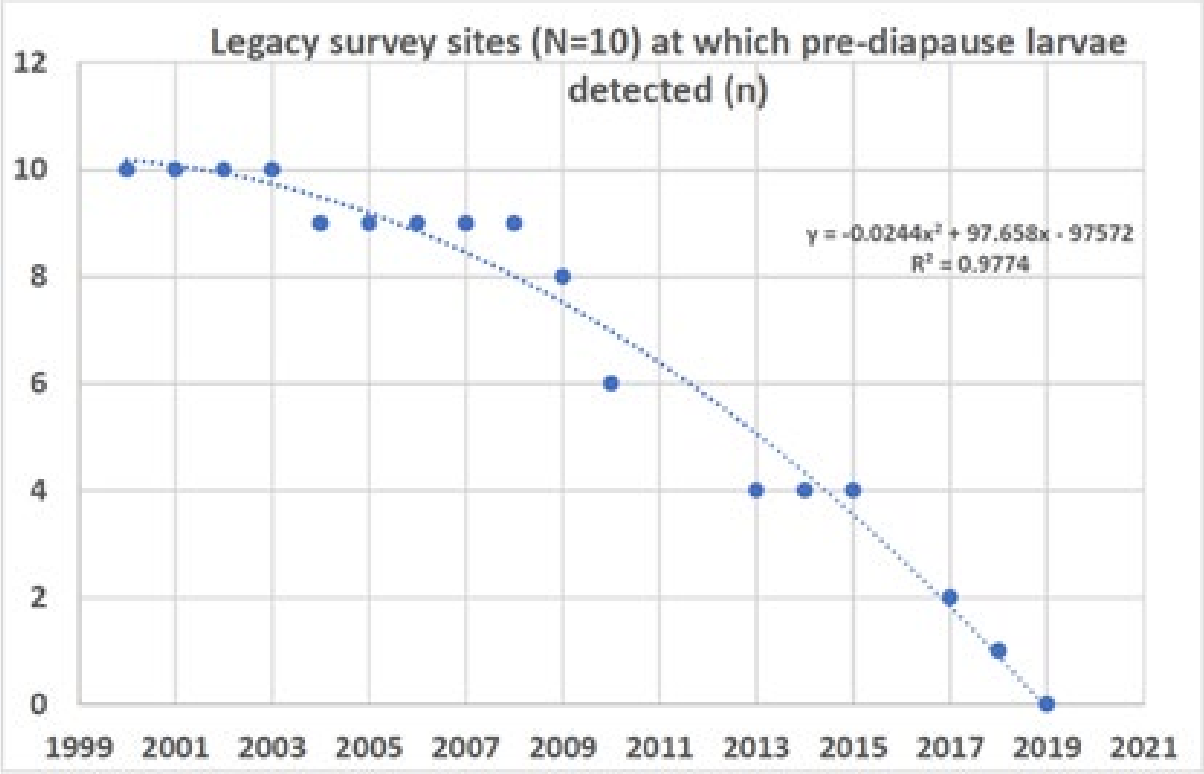

Figure 5. Populations/colonies of the Sacramento Mountains checkerspot butterfly have declined over the past two decades (Forest Service 2020b). Please note that while trends from 2019 projected the extinction of the species, data from 2020 and 2021 show that the species did not perish.

During the 2020 survey season, Forest Service biologists detected only eight butterflies were detected within those two meadows, causing concern among conservationists (Forest Service 2020, p. 8). A report from an amateur naturalist suggested were as many as two dozen checkerspot in lower Bailey Canyon in the summer of 2020, and they were a common site in that location (Banker 2022, pers. comm.). In the summer of 2021, 23 adult Sacramento mountains checkerspot butterflies were detected buy Forest Service biologists (Hughes 2021c, pers. comm.). Nectar resources in 2021 appeared to be limited, which might have impacted butterfly behavior (Ryan 2022, pers. comm.). No tents were collected in 2020. However, two tents were found in 2021, and placed into a captive rearing program. Below we have charted the results of

both adult and larval surveys over time (Figure 6 and Figure 7). Note that trendlines for each project the recent extinction for the species, based on the numbers observed. This serves to illustrate that while numbers have increased marginally, the species has extremely low viability based on survey data.

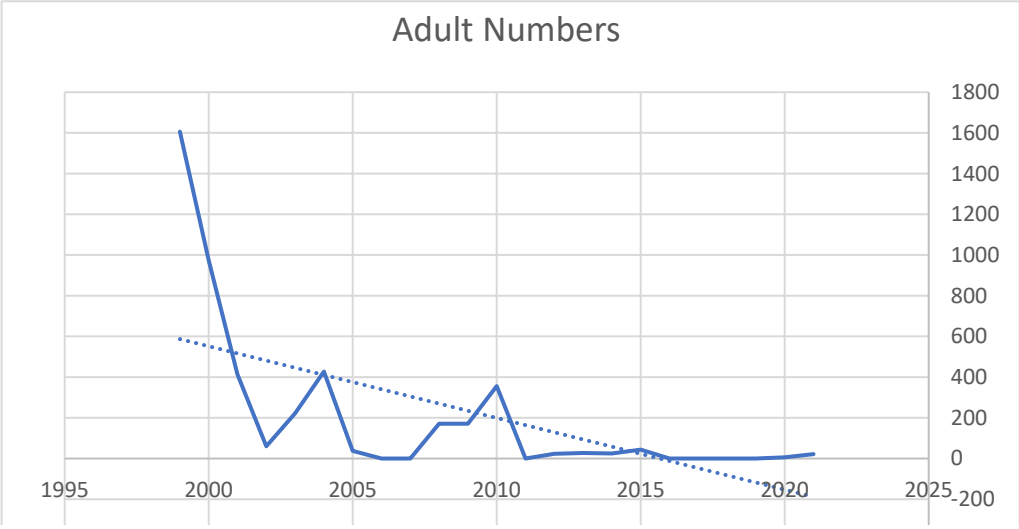

Figure 6. Adult numbers for the Sacramento Mountains checkerspot butterfly showing survey results over time based on Forest Service survey data. Note that the overall trendline (dashed blue line) suggests that the species recently went extinct. While this has not happened, it does show that the Sacramento Mountains checkerspot butterfly future viability is extremely low.

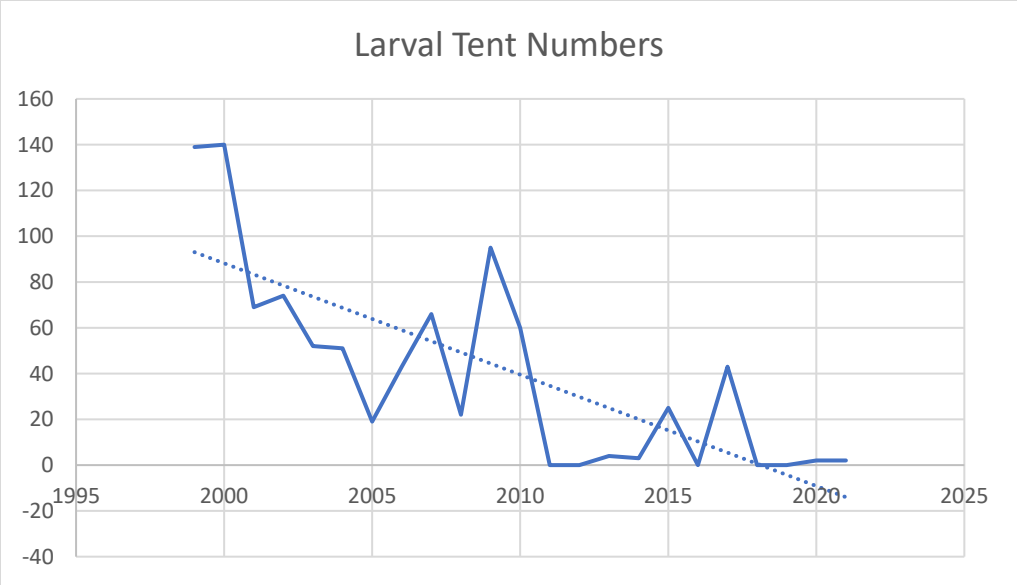

Figure 7. Larval numbers for the Sacramento Mountains checkerspot butterfly showing survey results over time based on Forest Service survey data. Note that the overall trendline (dashed blue line) suggests that the species recently went extinct. While this has not happened, this model does show that the Sacramento Mountains checkerspot butterfly future viability is extremely low.

4.3 Factors Influencing Species Viability

Here we consider the anthropogenic and natural environmental factors influencing the Sacramento Mountains checkerspot butterfly's resiliency, which contributes to the species' overall viability. Climate change, incompatible domestic livestock grazing (domestic, feral, and wild), human recreation, collection, non-native vegetation, habitat management, parasites, and insecticides are factors that influence or could influence species viability for the Sacramento Mountains checkerspot. We divided these factors into minor, major, and beneficial categories. At times, we use the term "threat" to refer to actions or conditions known to negatively affect individuals of a species.

4.3.1 Secondary Factors

We define secondary factors as those which currently have a small impact on overall species viability; these are factors that are no longer affecting the species, have a small chance of occurring, or do not affect the species throughout a large portion of the range. It is important to note that all factors affecting the viability of a species are additive, and when affecting the species concurrently with one another, can further decrease viability. Please note that secondary factors can become primary factors should they begin to occur again, increase in intensity, or begin to occur range wide.

4.3.1.1 Collection

Butterflies in the *Euphydryas* genus are widely collected by private insect collectors due to their bright colors (Murphy and Weiss 1988, p. 183). We know of a handful of people who have collected an unknown number of Sacramento Mountains checkerspot butterflies (66 FR 46575).

Listing has increased public interested in rare species within the genus and might increase the value and demand among collectors for this species (Ehrlich and Murphy 1987, p. 129). However, few people have collected the Sacramento Mountains checkerspot butterfly, and we do not believe collectors have contributed to the recent decline of the butterfly. Based on this information, we believe that collection is a minor, negative factor impacting the butterfly's viability.

4.3.1.2 Disease

There are no known diseases that affect the Sacramento Mountains checkerspot butterfly. However, viruses, bacteria, fungi, and other pathogens cause mortality in other butterfly species, and it is possible these could be transmitted to the checkerspot, especially under climate change conditions (Scott 1986, pp. 70, 71; Lightfoot 2022, pers. comm.). It is possible, especially with high levels of human recreation within the Lincoln National Forest (see section 4.3.2.2 below) that new pathogens could be introduced into the area and could cause increased butterfly mortality. However, we currently have no data to suggest that disease is a factor influencing the species' viability.

It is important to note that diseases can become a primary, negative factor as climate change affects the health of the species and creates environmental conditions more suitable for pathogen transfer. This phenomenon has been documented for other insect species (Lightfoot 2022, pers. comm.).

4.3.1.3 Parasites and Predation

Spiders, pocket gophers, ants, and some birds have been documented predators of butterflies in the *Euphydryas* genus (66 FR 46575). The Sacramento Mountains checkerspot butterfly adults have been seen with ripped or torn wings, indicating that birds pursue butterflies as prey (McIntyre 2021, pers. comm.). One biologist observed deer and elk eating caterpillar tents; it is unknown if cervids seek out tents to consume or if it is a random act during grazing (Ryan 2021c, pers. comm).

Biologists have also found parasitoids on Sacramento Mountain checkerspot caterpillars (Ryan and Milligan 2009, p. 66). There are no indications that parasites or predators significantly affect the viability of the species. However, due to low population numbers, parasites and predators can impact the species.

4.3.1.4 Insecticides

Between 2005 and 2006, the Sacramento Mountains on the Lincoln National Forest experienced an outbreak of a looper moth species, *Nepytia janetae*. Also called inchworms, these moths are native to the Sacramento Mountains and feed on subalpine fir tree needles and cause mass defoliation (Forest Service 2007a, p. 2). The defoliation of conifers by inchworms is not unprecedented; there have been at least five outbreaks of looper moths on the Sacramento Ranger District since 1924. However, concern about defoliation from the outbreak led Otero County officials and the Forest Service to seek actions to control the looper outbreak (Forest Service 2007b, p. 3). Officials decided to treat the affected areas around Cloudcroft using an aerial application of the insecticide, *Bacillus thuringiensis* var. *kurstaki* (Btk) (Forest Service

2007c, p. 1). The bacteria Btk produces a toxin that, when consumed by moths and butterfly larvae, is deadly to all individuals which come in contact with the bacterium.

If Btk comes in contact with individual Sacramento Mountain checkerspot butterflies it is lethal (Forest Service 2007a, p. 4). To minimize risk to the butterfly, Forest Service chose to apply Btk during months outside of the active period for the Sacramento Mountains checkerspot, when larvae were in diapause (Forest Service 2007a, p. 3). Otero County officials ordered the spraying of Btk in mid-October of 2007. The exact date that spraying occurred is unclear. While efforts were made to avoid active Sacramento Mountains checkerspot butterflies, we do not know exactly where the Btk was sprayed and if it negatively impacted the butterfly in 2007 (Otero County, unpaginated). Sacramento Mountains checkerspots might have been affected by Btk if the insecticide was sprayed on private lands where the species was present.

If the aerial spraying of Btk did affect the Sacramento mountains checkerspot butterfly, the outcome is not known. In terrestrial environments, the half-life of Btk is 1-3 days. UV light is also known to degrade the bacterium (Surgeoner and Farkas 1990, p. iii). Within the known range of the checkerspot, UV radiation is considered high, which would decrease the persistence of Btk on the environment, likely rendering it inert after less than a week.

Based on the half-life of Btk, and observations from conservationists, it seems interagency cooperation seem to have been successful at reducing impacts to the Sacramento Mountains checkerspot from the use of Btk (Hein 2007, unpaginated; McIntyre 2008, unpaginated). From 2007 until the present, there have been no future looper moth outbreaks, and the immediate impacts due to insecticide use has abated. However, if another looper moth outbreak develops then insecticide use could become a primary factor, with the potential to drastically reduce the future viability of the species. Currently, no Sacramento Mountains checkerspot butterfly populations are at risk from insecticide use. However, care should be used if future insect outbreaks occur with the range of the species.

4.3.1.5 Human Development

Since the discovery of this subspecies, human development has resulted in habitat loss for the Sacramento Mountains checkerspot butterfly on the Yardplot Meadow unit, which the Forest Service sold in 2009 (Forest Service 2017, p. 2). The Village of Cloudcroft later developed this area and it no longer contains butterfly habitat. There could be future, small-scale habitat impacts to all meadow units that have roads, powerlines, and other Forest Service infrastructure and maintenance (74 FR 66937). Because the range of the species is small and fractured, each development project has the potential to negatively impact the species by removing suitable habitat. While we do not currently know of development projects that are planned within the range of the species, private development has a significant impact (74 FR 66937), care needs to be taken to protect the species' remaining habitat.

4.3.1.6 Wild Ungulate Grazing

Rocky Mountain elk (*Cervus canadensis nelsoni*) have been introduced to the Sacramento Mountains, filling the same ecological niche as Merriam's elk did before (NMDGF 2009, unpaginated). Therefore, all species endemic to the Sacramento Mountains evolved to coexist

with some level of elk grazing. Grazing might even have a beneficial impact on meadow ecosystems within the Sacramento Mountains, which might ultimately benefit the Sacramento Mountains checkerspot butterfly (see section 4.3.3.2)

However, studies have shown that at the microhabitat scale, elk grazing might have a negative impact on the larvae of Sacramento Mountains checkerspot butterflies. Data show that the same New Mexico beardtongue plants selected by females for oviposition were also preferentially selected by elk for grazing. It is even possible that larvae were consumed while elk were grazing New Mexico beardtongue (McIntyre 2010, p. 71).

It is likely that the negative impacts of elk grazing on any remaining populations of Sacramento Mountains checkerspot butterflies are additive with other factoring influencing the species viability. At extremely low abundance, inadvertent consumption by elk, or a grazing of host plants can further reduce the species viability. While elk might have an overall benefit to mountain meadow ecosystems which sustain the butterfly, there is a possibility that elk could reduce populations at the microhabitat scale.

4.3.2 Primary Factors

We define primary factors as those which have a significant impact on the overall species viability; these are factors that currently affect the species, have a high chance of occurring, and have impacted the species throughout a large portion of the range. It is important to note that all factors affecting the viability of a species are additive, and when affecting the species concurrently with one another, can further decrease viability. Please note that secondary factors can become primary factors should they begin to occur again, increase in intensity, or begin to occur range wide. We list these factors in alphabetical order, for ease of reference; we do not attempt to order these factors with regard to significance in how they impact the species.

4.3.2.5 Altered Wildfire Regime

Historically, fire has played an important role in shaping the vegetation structure, composition, and succession. Prior to European settlers, most fires were started by lightning, but American Indians would also light wildfires. Increased European settlement brought changes to the fire regime, altering the temporal and spatial extent of wildfire disturbance within the Sacramento Mountains (Forest Service 2018, p. 15).

Fire suppression, large-scale logging, and even-aged timber management have altered vegetation structure within the Lincoln National Forest, contributing to and increasing fire severity and frequency (Forest Service 2018, p. 15), while reducing habitat suitability and connectivity for the butterfly. Fire suppression has been ongoing in the Sacramento Mountains since 1907 and resulting dense tree growth has increased fuel loads (Forest Service 1998, pp. 3, 63). Additionally, suppression of fires has increased ponderosa and mixed conifer forest growth (Forest Service 2018, p. 146), which now surrounded meadow habitats for the butterfly, decreasing the likelihood of dispersal by the species.

The Sacramento Mountains checkerspot butterfly has a small range with low redundancy, making it vulnerable to catastrophic wildfire. The entire species could be eliminated in the event of a high severity fire. However, wildfires were a natural part of the Sacramento Mountains

ecosystem and historically maintained many important ecosystem processes within the butterfly's range (Forest Service 1998, p. 20). Low-intensity fires could benefit the species by managing forest density and augment meadow habitats (Service *et al.* 2005, p. 21).

No significant wildfires have occurred in butterfly habitat since 1916 (Service *et al.* 2005, p. 21). Before active fire suppression, fire in the Sacramento Mountains occurred at intervals between three and ten years (Forest Service 1998, p. 63). A large fire can occur within the range of the species; there have been at least nine large, severe wildfires (over 90,000 ac (34,000 ha)) in the Sacramento Mountains during the past fifty years (Forest Service 1998, p. 63). Trees and other woody vegetation have begun encroaching into suitable meadow habitats for the butterfly. Current forest conditions make the chances of a high-severity fire within the range of the butterfly increasingly likely (Service *et al.* 2005, p. 21). Wildfires have caused the extirpation of other *Euphydryas* populations (Murphy and Weiss 1988, p. 186). Natural, interannual population perturbations combined with severe wildfires could easily result in the extinction of a rare butterfly (Siemann *et al.* 1997, p. 359).

4.3.2.3 Climate Change

Climate change is impacting natural ecosystems in the southwestern United States (IPCC 2014, p. 240). Temperature and moisture conditions are critical to the life history of the Sacramento Mountains checkerspot butterfly. The species relies on a unique ecosystem and is extremely sensitive even to small changes in temperature and precipitation. Such changes to the environment, which are hallmarks of a warming climate, can significantly alter temperature, the amount of precipitation, and the timing of precipitation events (Ganey *et al.* 2020, p. 238). These changes can alter the physiology and phenology of butterflies (Lightfoot 2022, pers. comm.). Moreover, as ecosystem processes change, there is more opportunity for non-native plant species to encroach into meadows, which we discuss in the next section (Giejsztowt *et al.* 2020, p. 6) (see 4.3.2.4 below).

The Sacramento mountains checkerspot butterfly is sensitive to both changes in temperature, and precipitation regime to carry out all aspects of its life cycle (see section 2.3 above). Even slight changes to these natural cycles can reduce the viability of the species. New Mexico has been in a drought for the past several years, many of which have been the warmest on record (Franklin *et al.* 2016, entire). Recently, the drought has reached historic levels. Roughly 54 percent of the state is experiencing an "exceptional drought," including the Sacramento Mountains. Droughts of this severity push wildlife to the limit, while vegetation in habitats becomes extremely degraded (McMahan *et al.* 2021, entire).

Over the past several years, annual precipitation levels have decreased throughout the butterfly's range. Snowfall and corresponding snowpack have remained well below normal levels (McMahan *et al.* 2021, entire). Some alpine butterflies need high levels of snowpack levels during diapause to shelter from wind and cold temperatures (Roland *et al.* 2020, p. 335). Experts have suggested that the same might be true for the Sacramento Mountains checkerspot butterfly, as the species likely evolved with higher levels of winter snowpack than are common over the past decade (Hughes 2021a, pers. comm.). However, Sacramento Mountain checkerspot butterfly diapause is not well understood. While snowpack might be an important factor, we do not have enough evidence to analyze the effects of low snow years on the butterfly.

We know that the Sacramento Mountains checkerspot butterfly needs adequate vegetation growth in host plants and nectar sources during the summer months. Vegetation growth within the butterfly's range appears to rely heavily on summer rains to survive (Forest Service 2015, p. 2). Large rainfall events typically form during the mid-summer months in the Sacramento Mountains, marking the beginning of the monsoon season (Ganey *et al.* 2020, p. 331). These midday showers occur almost daily for several months, giving rise to a lush environment (Douglas *et al.* 1993, pp. 1667–1668). It appears that the monsoons stimulate much of the vegetation to grow and proliferate during the midsummer season. New Mexico beardtongue growth increases in response to the monsoons (Forzieri *et al.* 2011, pp. 1769–1770). It is thought that winter moisture might also encourage the butterflies to emerge from diapause in spring as well (Ryan 2021b, pers. comm.).

Climate change will likely impact the frequency, severity, and timing of monsoon events throughout the southwest (Colorado-Ruiz *et al.* 2018, pp. 5706–5707). New Mexico beardtongue and other plant species in sub-alpine meadows are adapted to the pulse of moisture from monsoons (New Mexico Rare Plant Technical Council, 1999, online; Douglas *et al.* 1993, pp. 1667–1668). Without monsoon rains, the butterfly is at risk, as the species relies on vegetation growth, which relies on the timing of precipitation.

In the Southwestern US, wildfire frequency, and season length have increased substantially since 1985, under climate change conditions. This pattern is linked to earlier spring snowmelt and increased summer temperatures. As summer temperatures increase, precipitation decreases, and overall drought conditions become more common, fire frequency and severity can be further exacerbated on the Lincoln National Forest (Forest Service 2017, p. 29).

Climate change increases the likelihood of larger, more frequent wildfires. Wildfires have caused the extirpation of other *Euphydryas* populations (Murphy and Weiss 1988, p. 186). Natural, interannual population perturbations combined with severe wildfires could easily result in the extinction of a rare butterfly (Siemann *et al.* 1997, p. 359). On the other hand, some level of fire activity might help to maintain and augment natural ecosystem processes and create or maintain open meadow habitats the species needs for connectivity (Service *et al.* 2005, pp. 21–23). Careful wildfire management is needed to reduce the threat of catastrophic wildfire and maintain natural ecosystem processes to ensure the persistence of the Sacramento Mountains checkerspot butterfly.

The 2020 monsoon season within the Sacramento mountains was an exceptionally weak one, with far less precipitation falling than does in an average summer (McMahan *et al.* 2021, entire). As a result, the New Mexico beardtongue growth was also weak; few plants grew larger than small rosettes on the ground. Even fewer plants survived to produce flowers. Some experts believe that the dry conditions, compounded with increased browse pressure from large ungulates, have contributed to the deterioration of habitat throughout the Sacramento Mountains checkerspot butterfly's range (Ryan *et al.* 2021, pers. comm.).

4.3.2.1 Incompatible Grazing

Domestic Livestock- Domestic livestock grazing, primarily by cattle, has historically been practiced throughout the meadows inhabited by the Sacramento Mountains checkerspot butterfly

(Service *et al.* 2005, p. 29). Based on the currently available information, the exact relationship between the Sacramento Mountains checkerspot butterfly population abundance and cattle grazing are not well understood (Service *et al.* 2005, p. 30). It is likely the effect of cattle grazing on butterfly abundance varies, depending on the current habitat and climatic conditions. Here, we provide an overview of available information concerning cattle grazing and butterfly abundance for the checkerspot, as well as other butterfly species.

There are two main ways cattle might impact butterflies: direct mortality or impacts on habitat. Mortality can occur either by trampling eggs and larva or by consuming host plants (White 1986, p. 56). Impacts on the species' habitat due to cattle might include:

1. Changing the abundance and distribution of vegetation (host and nectar plants);
2. Reducing vegetative cover (overgrazing of habitat);
3. Altering vegetive communities;
4. Compaction and erosion of soil; and
5. Reducing natural disturbance processes, such as gopher activity (Service *et al*. 2005 p. 29).

In some cases, cattle can increase host plant abundance by grazing on competing plant species (Weiss 1999, entire). However, New Mexico beardtongue is consumed by cattle as well, and grazing might reduce available plants may impact the species' presence and survival (McIntyre 2010, pp. 94–104).

Research on population abundance in response to grazing for other butterfly species has shown that results vary depending on the species and system studied (Service et al. 2005, p. 30). One study showed the number of butterflies per species, including 4 threatened species rose with light grazing and no grazing (WallisDeVries and Raemakers 2001, pp. 185–186). In contrast, the Northern Californian Bay Checkerspot (*E. e. bayensis*) saw a population decrease when land managers removed cattle from the landscape; some subpopulations became extinct due to non-native grasses (Weiss 1999, pp. 1479–1480).

Forest Service surveys did not show a strong correlation between grazing and butterfly abundance. Pre-diapause larval tent counts of the butterfly using the plot method were tallied from 1998 to 2003 (Forest Service 2004, p. 7). The results are summarized in Table 2 below:

Table 2. Results of the Sacramento Mountains checkerspot butterfly population trends and how they responded to grazing over five years. Data are based on Forest Service larval surveys between 1998 and 2003.

Site	Grazing Status	Population response
Horse pasture	Grazed	Declined
Cox Canyon	Grazed	Declined
Pumphouse Canyon	Grazed	Increased
Bailey Canyon	Ungrazed	Declined
Pines Campground	Ungrazed	Declined
Silver Springs Canyon	Ungrazed	Declined
Spud Patch Canyon	Ungrazed	Declined

Yarplot	Ungrazed	Increased
Deerhead Canyon	Ungrazed	Increased

Similarly, adult surveys in the early 2000s indicated population decreases at ungrazed sites and increases at the two sites where grazing occurred (Service *et al*. 2005, p. 30). These data suggest that grazing was not a significant predictor of population declines under the environmental conditions present at the time of the surveys.

Impacts of livestock grazing on native wildlife in Southwestern montane ecosystems vary depending on the timing, duration, and intensity of grazing (Service *et al*. 2005, p 32). Grazing intensities and durations that exceed the ability of herbaceous plants to recover or survive are detrimental to the Sacramento Mountains checkerspot butterfly (Service *et al*. 2005, p. 31). Drought and increased temperatures can exacerbate this trend. Overgrazing by stock animals has led to the extinction of some butterfly populations in the United States, including butterflies in the genus *Euphydryas* (Murphy and Weiss 1988, entire; Ehrlich 1989, entire; Weiss *et al.* 1991, entire).

The Forest Service permits livestock grazing in select allotments on the Lincoln National Forest in the Sacramento Mountains. The butterfly range occurs within about 17 ac (7.2 ha) of the Russia Canyon Allotment (Forest Service 2004, entire), which has two grazing permittees. The Pumphouse Allotment also contains suitable butterfly habitats open to livestock grazing (Forest Service 2005, p. 1; Forest Service 2009, p. 1). Most of the butterfly's range is encompassed by the James Allotment. Currently, the James Allotment is vacant (Forest Service 2009, p. 2). At this time, the National Environmental Policy Act analysis has not yet been finalized, and the James Allotment remains ungrazed.

The areas where grazing allotments overlap the species range do not current contain extant populations of the Sacramento Mountains checkerspot butterfly (See Section 4.4). Extant populations are currently within the ungrazed, James Canyon allotment. Therefore, butterfly individuals are not currently in direct competition with domestic livestock for habitat resources. However, there has been significant impacts from grazing in the past (Lightfoot 2022, pers. comm.). Previous grazing activity, acting synergistically with current drought conditions in New Mexico (See Section 4.3.2.1), might have contributed to the decline of the species.

Due to current habitat conditions, it is likely that in the areas of the butterfly's range where grazing does occur, that livestock grazing continues to degrade habitat for the species. Outside of drought conditions, it might be possible to collect data on the effects of cattle grazing on the Sacramento Mountains checkerspot butterfly habitat and establish an adaptive management plan for grazing within butterfly habitat. However, current conditions of butterfly habitat are not compatible with cattle grazing (See section 4.5 on current condition).

Feral horses – Feral horses have become established on the Lincoln National Forest. Feral horses damage natural systems through trampling vegetation, compacting soil, and overgrazing. They graze vegetation very short, close to the soil surface, which damages many plants (including New Mexico beardtongue) to the extent that re-growth is precluded. Feral horse impacted areas have lower plant diversity, less plant cover, and more exotic plant species than un-impacted areas. Grazing impacts to the environment are exacerbated, and competition with

native grazers and livestock is intensified where feral horses are present (Forest Service 2017, p. 25). The population of feral horses on the Lincoln National Forest continues to grow annually within the range of the butterfly (Hughes 2021a, pers. comm.). Where they are found in concentrations, they cause vegetation loss and soil compaction (Forest Service 2017, p. 25). These impacts to habitat reduce suitable habitat for the butterfly's host plant, and subsequently the subspecies.

During drought conditions, as vegetation becomes scarce, both horses and elk will browse New Mexico beardtongue (McIntyre 2021, pers. comm.). when there is significant browse pressure from large herbivores New Mexico beardtongue will remain small rosettes, less than an inch tall, and do not flower (Hughes 2020, pers. comm.). New Mexico beardtongue might also have phenological plasticity for flowing. If grazing happens at a particular time each year, penstemon, as well as nectar species, may adapt to grazing and shift their flowering to a later time to escape the loss of valuable, expensive reproductive structures (flowering stalks). Overtime, plants with later flowering genes or shorter stalks (less visible/attractive to ungulates) may be favored resulting in populations with shorter plants with later flowering (Gisler 2022, pers. comm.). These small, stunted plants are not large enough to support tent colonies of caterpillars; any larvae will starve after hatching. The result will be less available food resources for the Sacramento Mountains checkerspot butterfly larvae.

Horses are not native to the Sacramento Mountains and the native vegetation and soils did not evolve with feral, European horses present on the landscape (Lightfoot 2022, pers. comm.). The presences of feral horses add significant browse pressure to meadow units. Larger than elk, horses need to consume large quantities of vegetation to survive. Heavy browse, and increasing drought, result in reduced habitat suitability, and has likely already caused declines in occupied habitat units (See section 4.4 below). Increasing numbers of feral horses is already negatively impacting the habitat within the butterfly's range, reducing the species' viability.

4.3.2.4 Invasive Plants

Non-native plants have begun to encroach into meadow areas within the Lincoln National Forest (Kennedy 2020, pers. comm.). Non-native grasses can affect butterfly host plants, behavior, and fitness. Other species of butterfly had become scarcer when invasive plants appeared in suitable butterfly habitats (Gallien *et al.* 2017, p. 191). During the drought, Kentucky bluegrass (*Poa pratensis*) has proliferated within meadow areas in the Sacramento Mountains. This aggressive, turf-building, non-native plant can outcompete native wildflowers, such as New Mexico beardtongue. As invasive plants begin to expand their influence, native plants, including New Mexico beardtongue and orange sneezeweed, are likely to become scarcer (Kennedy 2020, pers. comm.). The Forest Service (2013, entire) has compiled a comprehensive list of invasive plants which impact National Forests. Without careful management, native plants can become imperiled within the meadow habitats. Without the native plant species on which they rely, abundance of the Sacramento Mountain checkerspot butterfly will also diminish.

4.3.2.2 Recreation

Over the past ten years, human recreation has increased in the Lincoln National Forest (Hughes 2021b, pers. comm.). The original listing rule (66 FR 46575) suggested that off-road vehicle

(OHV) use on Forest Service trails posed some threat to meadow units, which continues to this day, and has likely increased in popularity. Additionally, large recreational vehicles (RV) and camping trailer use has also increased. Meadows within the range of the Sacramento Mountains checkerspot are popular with RV users because they are open, flat, and easily accessible by road. Forest Service does not require permits for parking vehicles within the Lincoln National Forest. Other forms of incompatible recreation might include horseback riding, mountain biking, and camping (Lightfoot 2022, pers. comm.).

Recreation can negatively affect the butterfly in several ways. Trampling and crushing the habitat can physically kill both butterflies and larvae, crush host and nectar plants, and reduce habitat suitability for New Mexico beardtongue. While adults can fly away, these butterflies are slow, especially on cold mornings. During times of drought, these plants are especially vulnerable and unlikely to survive repeated damage.

New Mexico beardtongue is often associated with gopher burrows and seems to prefer areas where the soil has been disturbed (Pittenger and Yori 2003, pp. 32–33). RVs compact soil where large vehicles are parked. Repeated trampling by humans around the vehicles, caused by normal camping activities, will further compact soils, making it less likely for New Mexico beardtongue to recover or re-establish in former campsites (Hughes 2021b, pers. comm.).

Recreation can directly kill the Sacramento Mountains checkerspot butterflies and their larvae by crushing individuals. This factor can also directly affect the habitat of the species by tramping plants and compacting soils. All meadow units within the range are experiencing some level of impact from this factor.

4.3.3 Beneficial Factors

4.3.3.1 Habitat Management

Several habitat management actions can benefit the viability of the Sacramento Mountains checkerspot butterfly. The Lincoln National Forest has erected exclosures, consisting of corral fencing, to protect butterfly habitats from large ungulate browsers. These efforts are currently focused within Bailey and Pines Meadow Campground units, where adult butterflies were most recently found. Botanists involved with the Sacramento Mountains checkerspot butterfly working group are currently growing plants for habitat restoration. Biologists will soon plant nectar sources, including orange sneezeweed and New Mexico beardtongue, within exclosures to ensure the individual needs of caterpillars and adult butterflies are met.

Forest Service has proposed that fire management aimed at reducing tree stocking within forested areas surrounding meadows might also help restore suitable habitat and connectivity throughout the range of the butterfly. Maintaining edge habitat and connectivity could greatly improve the butterfly's viability in the long term.

4.3.3.2 Wild Ungulate Grazing

The Sacramento Mountains checkerspot butterfly and its corresponding habitat evolved to coexist with some level of grazing pressure from large ungulates (McIntyre 2010, p. 71). Historically, Merriam's elk (*Cervus canadensis merriami*), an extinct subspecies, grazed

meadows within the Sacramento Mountains (NMDGF 2009, unpaginated). Under normal conditions, these species coexisted without endangering the existence of the butterfly. While at the microhabitat scale grazing can have negative impacts, it seems that cumulative moderate to low grazing levels by elk might be beneficial and sustainable (McIntyre 2010, p. 77). It is important to note that these interactions were studied outside of prolonged drought conditions and prior to substantial Sacramento Mountains checkerspot butterfly declines.

4.3.3.3 Wildland Fires

Some level of wildfire activity might help to maintain and augment natural ecosystem processes and create or maintain open meadow habitats the species needs for connectivity (Service *et al.* 2005, pp. 21–23). Beneficial wildland fire use generally allows for only mild to moderate severity burns, improving natural ecosystem conditions (Forest Service 2018, p. 16). While current wildland fire regimes are outside the historic range of variation for most ecosystems management in place since the late 1900s may help move wildland fire regimes toward historic conditions. Careful wildfire management is needed to reduce the threat of catastrophic wildfire and maintain natural ecosystem processes to ensure the persistence of the Sacramento Mountains checkerspot butterfly.

4.4 Factor Impacting Species Resiliency

We focused on major factors in this report while assessing the resiliency of the Sacramento Mountains checkerspot butterfly. We want to note that many factors reduce the species' resiliency even further when they occur together. For instance, climate change increases the threat of large ungulate grazing. Here, we illustrate how the factors impact species' resiliency. Figure 8 shows an influence diagram summarizing the pathways through which management actions and anthropogenic or environmental factors can influence Sacramento Mountains checkerspot butterfly resiliency through the factor effects on habitat needs or demographic parameters.

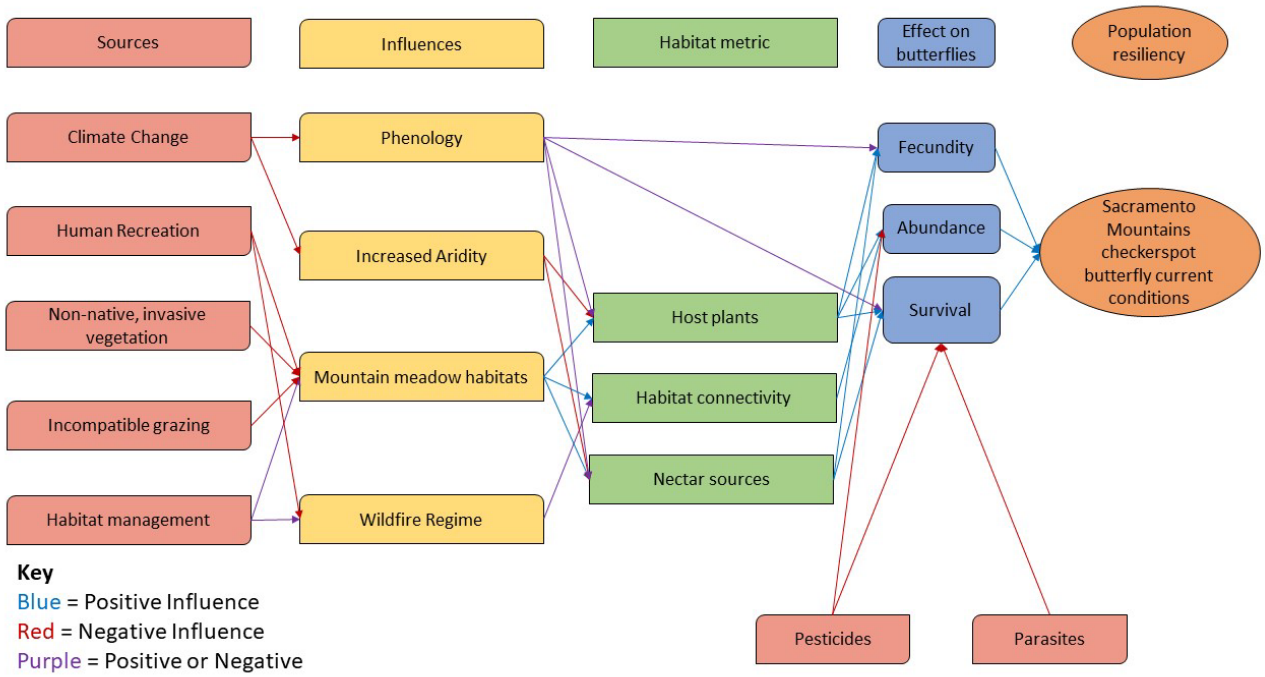

Figure 8. An influence diagram shows pathways through which various anthropogenic and environmental factors can affect the Sacramento Mountains checkerspot butterfly's habitat needs and demographic parameters. Red arrows represent negative influences on a factor, blue arrows a positive influence, and purple arrows indicate that a factor can be positive or negative. As an example, natural wildfire regimes contribute to a dynamic forest ecosystem (positive influence). In contrast, suppressing fires contribute to larger, more intense burns, which can destroy suitable habitat for the species (negative influence).

4.5 Analysis of Current Condition

Forest Service found fewer than ten adult butterflies during the 2020 survey season and did not locate any larval tents. It is thought that low numbers are due to major threats, which mainly impact habitat conditions. Low habitat conditions lead to correspondingly low population numbers, which reduces the overall viability of the species.

4.5.1 Meadow Units

We analyzed the Sacramento Mountains checkerspot butterfly's current condition within ten meadow units based on survey sites identified by Forest Service (Figure 9). It is important to note that butterflies might occur in colonies outside of these areas (Forest Service 2010, pp. 8–11). Yet, the legacy plots established by the Forest Service have been surveyed intensively over the past 20 years, giving us a frame of reference to which we can compare current ecosystem conditions and species health. The meadows surrounding each monitoring plot cover the most occupied areas within the species range and give the most accurate representation of species and

habitat conditions available. Thus, we believe the meadow units are analogous to functional metapopulation units and are the appropriate level to assess the species' condition.

These meadow units include Bailey Canyon, Pines Meadow Campground, Horse Pasture Meadow, Silver Springs Canyon, Cox Canyon, Sleepygrass Canyon, Spud Patch Canyon, Deerhead Canyon, and Pumphouse Canyon, and Yardplot Meadow. As noted, the Yardplot meadow was sold and developed, while the habitat in Horse Pasture meadow was destroyed by logging (Forest Service 2017, p. 3). No adults or caterpillars have been detected within Pumphouse Canyon since 2003, and the species has likely been extirpated at that site (Forest Service 2017, p. 3).

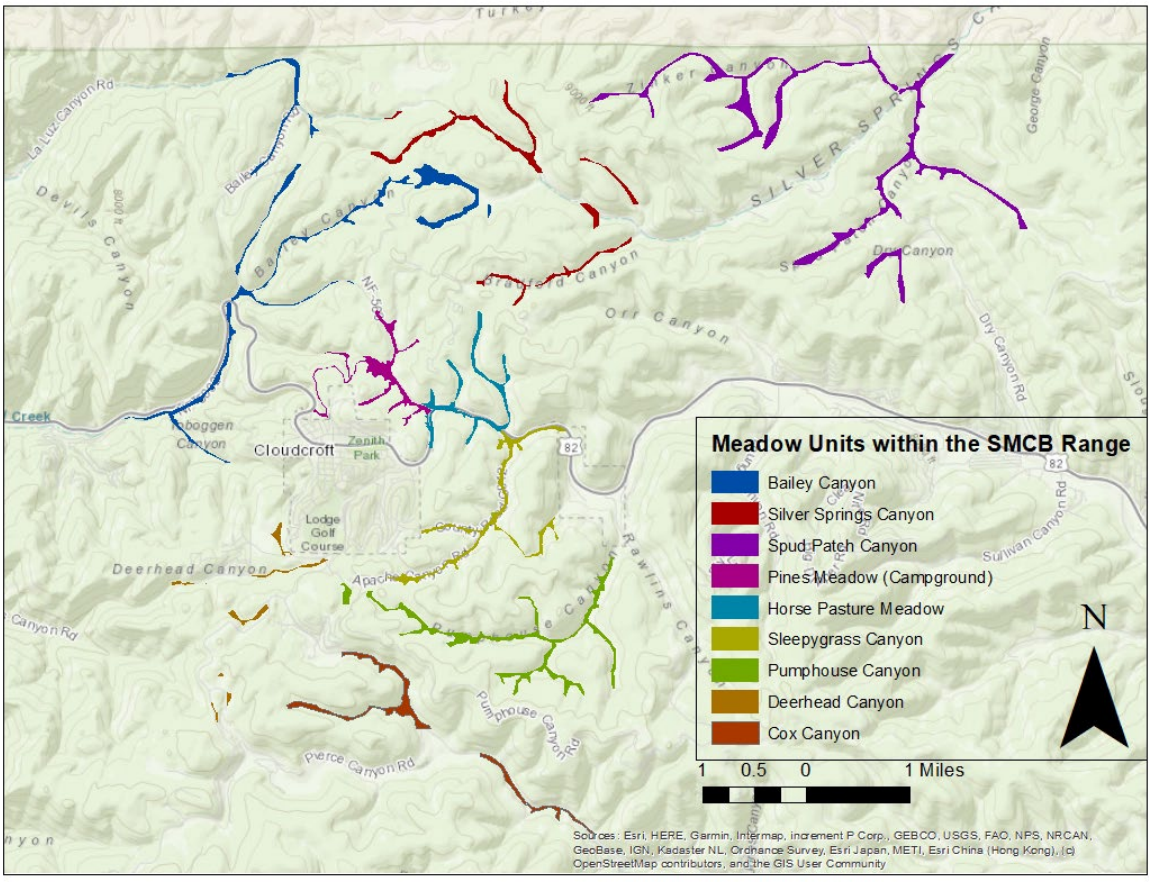

Figure 9. Meadow units within the range of the Sacramento Mountains checkerspot butterfly. The Yardplot meadow was sold before meadows were digitized for computer analysis and therefore is not included in this map.

4.5.2 Resiliency

As discussed above, we analyzed the current condition of the Sacramento Mountains checkerspot butterfly in ten meadow units. Preliminary genetic evidence suggests little gene flow between these units (Ryan and Milligan 2009; Ryan 2021a, pers. comm.). For a butterfly population to be considered in high condition, it must meet the needs listed in Chapter 2 of this report. We used the confidence terminology below to assess the condition of each meadow unit (Table 3).

Table 3. This table of confidence terminologies explains how we analyzed the chance of persistence when we characterize our confidence levels in our current condition tables. Ten years was chosen as a benchmark for persistence; the species has one generation per year, and if it can survive for 10 years, persistence is thought to be adequate for viability.

Terminology	Definition
High	There is a >90% chance that the species will persist over the next ten years.
Moderate	There is a 60–89% chance that the species will persist over the next ten years.
Low	There is a 30–59% chance that the species will persist over the next ten years
Very low	There is a 1–29% chance that the species will persist over the next ten years.
Extirpated	The meadow unit is considered locally extirpated.

We identified habitat needs as host plants, nectar sources, and habitat connectivity at the individual and population levels. Demographic factors include the density of adult butterflies and larval density. These factors were chosen after consultation with experts and careful consideration of available data (Table 4).

Table 4. Condition category table describing high, moderate, low, very low, and extirpated circumstances for demographic and habitat factors used to assess the Sacramento Mountains checkerspot butterfly's resiliency.

	Demographic Factors Habitat Factors				
Condition	Adult Estimate Density	Larval Density	Host Plants	Nectar Sources	Connectivity
High	> 50 ind/ha[1]; and/or multiple colonies (small groups) exist within a meadow	> 500 larvae/ha observed	There are multiple, large patches of host plants or one patch covering a large area of the meadow[3]. There are many plants 0.6 meter in height that are robust and leafy	Enough preferred nectar source plants are blooming during the adult's flight period, providing resources for a colony to carry out a life cycle[4]	Yes (≤800m)[5]
Moderate	25 – 50 ind/ha; there is at least one colony within a meadow	100-500 larvae/ha observed	There are multiple small patches or many plants sporadically throughout the meadows; plants are mostly <0.6 meter high	Enough nectar sources are blooming during the adult flight period for a colony to persist	Yes (>800m)
Low	5 – 25 ind/ha; There is one colony within the meadow	0 - 100 larvae/ha observed some empty tents observed	Plants are sparse within meadows; no plants are >0.6 meter high	There are abundant nectar sources within meadows, but climatic conditions are such that they do not bloom or provide resources for colonies to persist	No
Very Low	<5 adults observed during recent (within one year) annual surveys	No larva found during recent (within one year) annual surveys	Few plants within meadows; plains mainly exist as basal rosettes close to the ground (flowering stalks absent or consumed)	There are adequate nectar plants but few blooms during the adult flight period, limiting reproduction and persistence	No
Extirpated	No adults have been observed during surveys for >3 of the most recent consecutive years[2]	No evidence of reproduction during 3 of the most recent consecutive annual surveys	Few host plants exist, meadows have large patches of bare ground or invasive plants	There are not enough nectar plants within meadows to provide resources for adult survival.	No

1 When meadows have an estimated density above 50, successive populations were less likely to decrease in subsequent years (Pittenger and Yori 2003, pp. 24-27).

2 Forest Service reports show the butterfly might not recolonize an area if no adults or larvae have been found at the site after >3 years of surveys (2017, pp. 3-4).

3 A population of butterflies needs hose plant foliage for caterpillars to carry out their life stages. There can be a few large, robust plants (McIntyre 2021, pers. comm.) or patches containing many smaller individual plants (Forest Service 2017, p. 2).

4 Butterflies mainly rely on orange sneezeweed for nectar but can use other nectar sources. Plant phenology is directly impacted by micro-and macroclimate, which can influence butterfly populations' persistence (Service *et al.* 2005, p. 12).

5 Metapopulations need habitat connectivity to persist. Pittenger and Yori (2003) found that butterflies can disperse up to ~800 meters (p. 44).

The criteria presented in our condition category tables were used to assess the Sacramento Mountains checkerspot butterfly's overall current condition at a meadow unit level. We analyzed the current condition of demographic factors, adult (estimated) density, and larval density for each of the ten meadow sites. Based on survey reports from previous years, most meadow units' demographic factors are very low or extirpated (Table 5).

Table 5. A current condition table shows the status of demographic factors within the meadow units throughout the Sacramento Mountains checkerspot butterfly range. These meadow units are analogous to metapopulations. Most units are probably extirpated based on our understanding of demographic factors.

	Demographic Factors	
Unit	Adult Density	Larval Density
Bailey Canyon	Very Low	Very Low
Pines Meadow (Campground)	Very Low	Very Low
Cox Canyon	Ex	Ex
Silver Springs Canyon	Ex	Ex
Pumphouse Canyon	Ex	Ex
Sleepygrass Canyon	Ex	Ex
Spud Patch Canyon	Ex	Ex
Deerhead Canyon	Ex	Ex
Horse Pasture Meadow	Ex	Ex
Yardplot Meadow	Ex	Ex

To assess each meadow's overall condition based on habitat factors, we assigned a numerical score to each demographic and habitat factor. For our analysis, each factor was assigned a zero for extirpated, one for very low, two for low, three for moderate, and four for high. Each meadow then received a numeric score relative to each category, based on the meadow's current condition relative to each category. Then we summed the score for each meadow to give an overall condition estimate. The meadow's overall condition score was translated to the overall condition category of high, moderate, low, very low, or extirpated based on the overall condition (Figure 10). The overall condition represents the current resiliency (likelihood of persistence) of each population. The current habitat condition for each of the populations is described and summarized in Table 6.

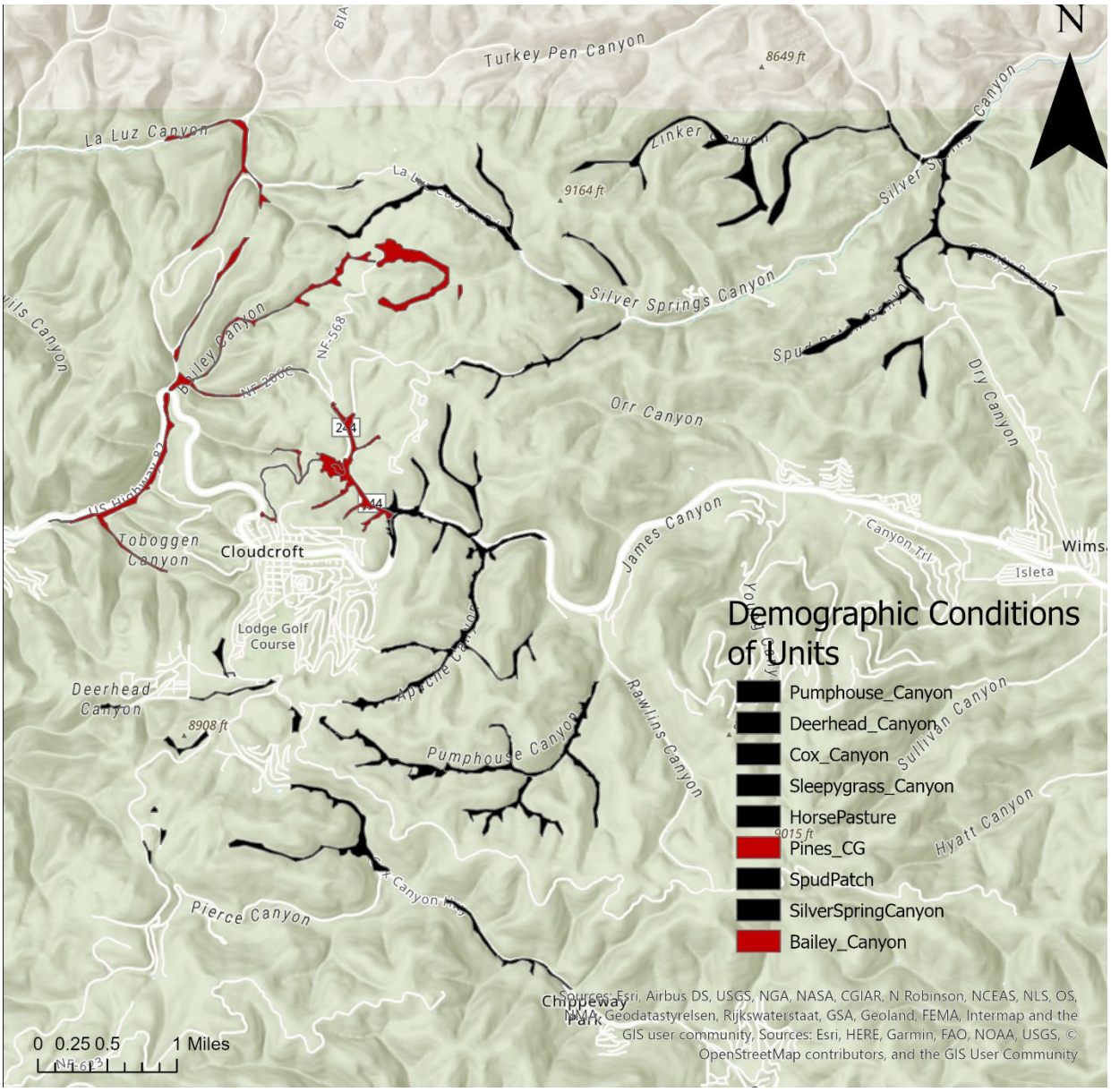

Figure 10. The demographic condition of all analysis units throughout the range of the Sacramento Mountains checkerspot butterfly. Based on our analysis most units are probably functionally extirpated red units show areas where the population is extant, but in very low condition. Black areas are currently considered extirpated.

Table 6. Current condition table rating for the Sacramento Mountains checkerspot butterfly meadow units as high, moderate, low, very low, or extirpated for habitat categories. The overall ranking is a measure of the meadow unit's current resiliency and a reflection of the subspecies status.

	Habitat Factors			
Meadow Unit	Host Plants	Nectar Sources	Connectivity	Overall Meadow Condition
Bailey Canyon	Very Low	Low	Moderate	**Low**
Pines Meadow (Campground)	Very Low	Low	Moderate	**Low**
Silver Springs Canyon	Very Low	Low	Moderate	**Low**
Sleepygrass Canyon	Very Low	Low	Moderate	**Low**
Spud Patch Canyon	Very Low	Low	Moderate	**Low**
Cox Canyon	Very Low	Low	Low	**Very Low**
Pumphouse Canyon	Very Low	Low	Low	**Very Low**
Deerhead Canyon	Ex	Very Low	Low	**Very Low**
Horse Pasture Meadow	Ex	Ex	High	**Very Low**
Yardplot Meadow	Ex	Ex	Low	**Ex**

It is noteworthy that we were cautious about giving meadows an overall condition score of "extirpated" even if adult butterflies and larvae have not been observed within a meadow during recent annual surveys. Habitat factors count towards the overall condition score, making it difficult for an entire meadow to be extirpated if there is suitable habitat for the butterfly. However, some of these meadows might no longer contain a population of butterflies. We assume that these meadows still hold conservation value, as they can be recolonized should demographic factors improve in adjacent meadows, either through reintroduction programs or natural dispersal through corridors. Therefore, even with the butterfly absent, meadows might remain in "very low" condition. Areas in "very low" condition might not contain butterflies and likely need active management to conserve the species. The only areas we determined to be currently in "extirpated" status, Horse Pasture and Yardplot, suitable habitat for the butterfly no longer exist (Figure 8).

Based on our analysis, there are two meadow units in low condition (Bailey Canyon and Pines Meadow Campground) and two known to be extirpated (Horse Pasture and Yardplot). The rest are currently in very low condition (Figure 11).

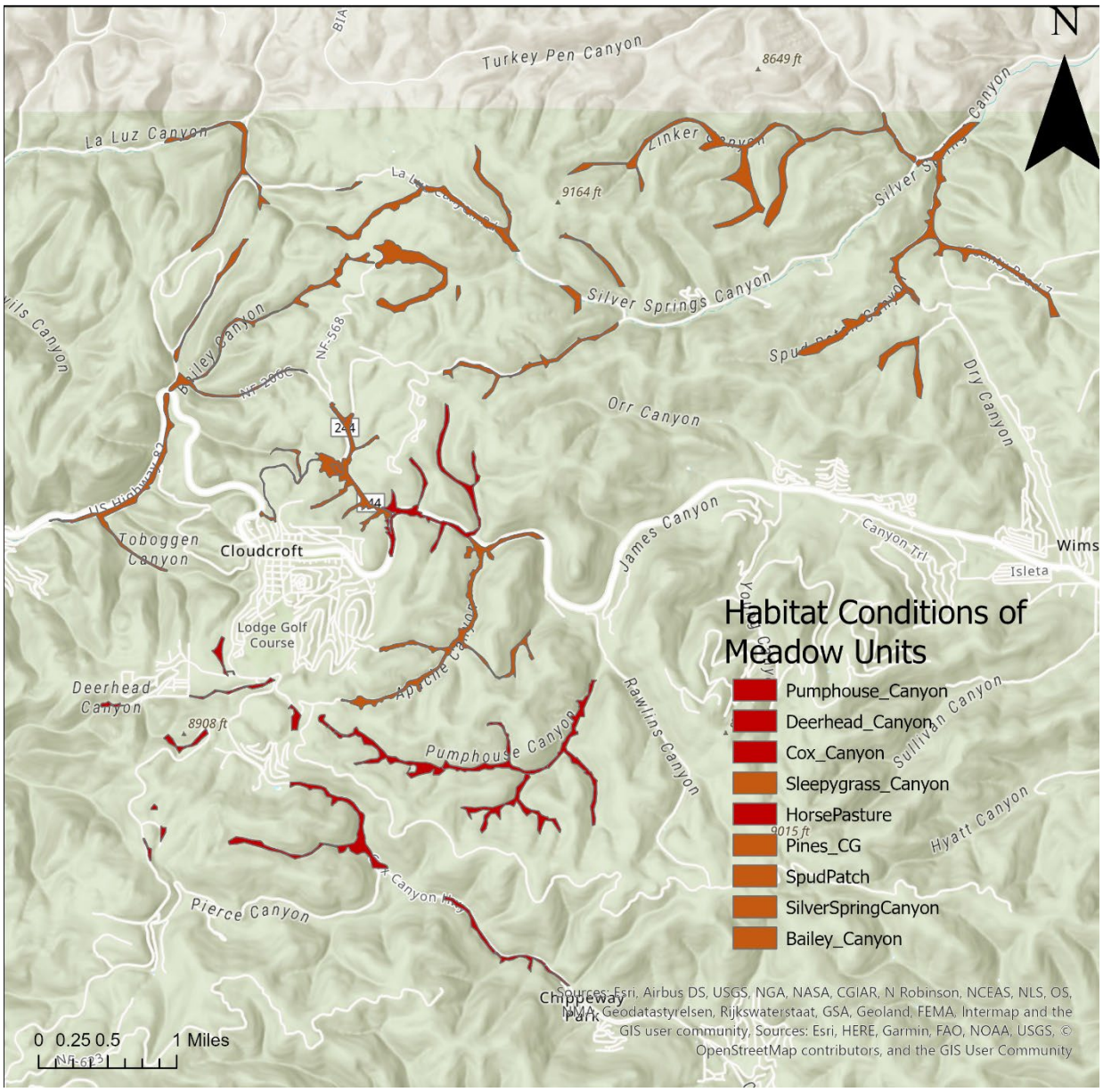

Figure 11. The current condition of the Sacramento Mountains checkerspot butterfly habitat within the species' range. Orange units are in a low condition, red is in a very low condition, and black are believed to be extirpated. Yardplot meadows is not represented on this map.

4.5.3 Representation

We define representation for the Sacramento Mountains checkerspot butterfly has having ecological and genetic diversity. There is not current genetic information available for the Sacramento Mountains checkerspot butterfly (Lightfoot 2022, pers. comm.). As a narrow range endemic, the entire range of the species is approximately 32 square miles. However, suitable habitat is limited to only about 2 square miles. This range contraction suggests that most of the original representation present within the species has declined. There is currently only one representation area for the butterfly.

Within the single representation area, Forest Service has documented occurrences of the butterfly in ten meadows in the Sacramento Mountains. Forest Service has only been able to locate the species in two meadows (Pines Meadow Campground and Bailey Canyon) during recent years. In this single representation area, the populations are small and isolated with very little to no connectivity between populations. The occupied meadows are among spruce-fir forests, so there are barriers that limit the dispersal of individuals among the populations. Due to the limited habitat connectivity of populations, individual Sacramento Mountains checkerspot butterflies rarely, if ever, travel between populations. Host plant and nectar sources have declined in both meadows (Gisler 2022, pers. comm.). This effectively restricts the transfer of genetic material, thus limiting genetic diversity. There was likely greater habitat connectivity between populations in the past due to a more natural fire regime. Therefore, overall representation has declined.

4.5.4 Redundancy

We define redundancy for the Sacramento Mountains checkerspot butterfly as having populations or metapopulations that are spread across the range. There are two extant Sacramento Mountains checkerspot butterfly populations, located in adjacent meadows, of 10 documented metapopulations within the single representation area. Several individuals have reported witnessing large numbers of Sacramento Mountains checkerspot butterflies in past years (Cary 2022, pers. comm.). Therefore, redundancy of the butterfly has declined over time.

4.6 Summary

We used the best available information to assess the current condition of the Sacramento Mountains checkerspot butterfly. Our goal was to describe the species needs and assess the viability of the butterfly in terms of resiliency, representation, and redundancy. The Sacramento Mountains checkerspot butterfly faces various risks, including domestic livestock grazing, recreation, climate change, non-native invasive plants, and increased wildfire sizes, severities, and frequencies. For representation, the butterfly has limited ecological diversity, existing within one habitat type, which in turn, likely limits genetic diversity among the populations. For redundancy, there are only two extant populations located in adjacent meadows in the single representation area. These two extant populations both have low resiliency. Overall, the risks currently negatively impact the populations' resiliency, making them vulnerable to extirpation, resulting in losses of representation and redundancy.

LITERATURE CITED

Arriens, J.V., L.M. Brown, E.E. Crone. 2020. Phenology of feeding preference in post-diapause Baltimore checkerspot (*Euphydryas phaeton*) caterpillars. Ecological Entomology. 1-8.

Banker, B. 2022. Public submission: endangered and threatened wildlife and plants; endangered species status for Sacramento Mountains checkerspot butterfly. Comment on: FWS-R2-2021-0069-0001. Pico Rivera, CA, 90660.

Brown, P.M., M.W. Kaye, L.S. Huckaby, C.H. Baisan. 2001. Fire history along environmental gradients in the Sacramento Mountains, New Mexico: Influences of local patterns and regional processes. Ecoscience. 8:115-126.

Cary, S. 2022. Peer Review of the current condition assessment report for the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*).

Cary, S. J., & Holland, R. 1992. New Mexico butterflies: checklist, distribution and conservation. Journal of Research on the Lepidoptera, 31(1), 57-82.

Center for Biological Diversity. 2021. Petition to list the Sacramento Mountains checkerspot butterfly (Euphydryas anicia cloudcrofti) as a Threatened or Endangered Species under the Endangered Species Act. Tucson, AZ. Pp. 30.

Colorado-Ruiz, G., T. Cavazos, J.A. Salinas, P. De Grau, and R. Ayala. 2018. Climate change projections from coupled model intercomparison project phase 5 multi-model weighted ensembles for Mexico, the North American monsoon, and the mid-summer drought region. International journal of climatology. 38:5699-5716.

Davis, M.A. 1992. The effects of pocket gophers on survivorship, growth, and reproduction of large beardtongue. Proceedings of the twelfth North American Prairie conference. P. 47-49 in D.D. Smith and C.A. Jacobs (eds.). University of Northern Iowa Press. Cedar Falls, Iowa.

Dick-Peddie, W.A. W.H. William, R. Spellenberg. 1993. New Mexico vegetation: past, present, and future.

Douglas, M.W., R.A. Maddox, and K. Howard. 1993. The Mexican monsoon. Notes and correspondence of the American Meteorological Society. Pp. 1665 – 1677.

Ehrlich, P.R., R.R. White, M.C. Singer, S.W. McKechnie, L.E. Gilbert. 1975. Checkerspot Butterflies: A Historical Perspective. American Association for the Advancement of Science. 188: 221-228.

Ehrlich, P.R., and D.D. Murphy. 1987. Conservation lessons from long-term studies of checkerspot butterflies. Conservation biology. 1:122-131.

Ferris, C.D., and R.W. Holland. 1980. Two new subspecies of *Occidryas anicia* (Doubleday) from New Mexico. The Allyn Museum of Entomology, Sarasota, Florida. 57. 9, pp.

Forest Guardians and Center for Biological Diversity. 2007. Re: emergency endangered species act listing request for the Sacramento Mountains checkerspot butterfly. ESA Listing Petition & Emergency Listing request. Pp. 17.

Forest Service. USDA Forest Service. 1998. Forest reference conditions for ecosystem management in the Sacramento Mountains, New Mexico. M.R. Kaufmann, L.S. Kuckaby, C.M Regan, and J. Popp. Rocky Mountains researcher station. General Technical report. 95 pp.

Forest Service (USDA Forest Service). 1999. Sacramento Mountain checkerspot butterfly 1999 survey summary. Sacramento Ranger District, Lincoln National Forest. Prepared by M. J. Crites, A Shea, and T. Narahashi.

Forest Service. 2000. Sacramento Mountain checkerspot butterfly 2000 survey summary. Prepared by D. Salas and L. Mackley. Sacramento Ranger District, Lincoln National Forest.

Forest Service. 2004. Conservation measures for the Sacramento Mountains checkerspot butterfly. Lincoln National Forest, Alamogordo, New Mexico.

Forest Service. 2005. Biological Assessment for the Pumphouse and South La Luz Allotments, Sacramento Ranger District, Lincoln National Forest. Cloudcroft, New Mexico, 35 pp. + Maps.

Forest Service. 2007a. *Nepytia janetae* winter defoliator spray project: decision notice and findings of no significant impact. Lincoln National Forest, Sacramento Ranger District, Otero County, New Mexico. 20 pp.

Forest Service. 2007b. Environmental Assessment for *Nepytia janetae* winter defoliator spray project. Sacramento Ranger District, Lincoln National Forest. 75 pages

Forest Service. 2007c. Letter to Wally Murphy, Field Supervisor of the New Mexico Ecological Services Office, U.S. Fish and Wildlife Service. July 9, 2007. 2 pages.

Forest Service. 2009. Email from Jack Williams regarding the range monitoring data from Pumphouse and Russia Allotments. Lincoln National Forest, Alamogordo, New Mexico, 2 p + reports.

Forest Service. 2010. Sacramento Mountain[s] checkerspot butterfly annual report. Sacramento Ranger District. Lincoln National Forest. Prepared by C. Cook and C. Delisle. Reviewed by P. Mercer and J. Williams. 16 pages.

Forest Service. 2013. Invasive plants and weeds of the National Forests and Grasslands of the Southwestern region: Second Edition. Compiled by M.R. White. 245 pages.

Forest Service. 2015. Sacramento Mountains checkerspot butterfly end of year report. Sacramento Ranger District, Lincoln National Forest. Prepared by R. Zulueta.

Forest Service. 2017. Sacramento Mountains checkerspot butterfly end of year report. Sacramento Ranger, Lincoln National Forest. Prepared by K. Bailey.

Forest Service. 2018. Lincoln National Forest Plan Draft Assessment Report: Volume 1. Ecological Resources. Alamogordo, NM. 584 pp.

Forest Service. 2020a. Sacramento Mountains checkerspot butterfly (Data Files). Shared by Hughes, Sacramento Ranger District, Lincoln National Forest.

Forest Service. 2020b. Population status of the Sacramento Mountain checkerspot butterfly and current tactics proposed to mitigate the probability of imminent extinction. Preliminary results. 20 pp.

Forzieri, G., G. Castelli, E.R. Vivoni. 2011. Vegetation dynamics within the North American Monsoon Region. American Meteorological Society. 24:1763-1783.

Franklin, R., K. Kunkel, L. Stevens, D. Easterling. 2016. New Mexico. NOAA National Centers for Environmental Information, State Summaries. Online.

Gallien, L., F. Altermatt, M. Wiemers, O. Schweiger, and N.E. Zimmermann. 2017. Invasive plants threaten the least mobile butterflies in Switzerland. Diversity and Distributions. 23: 185-195.

Ganey, J.L., J.P. Ward Jr., T. A. Rawlinson, S.C. Kyle, R.S. Jonnes. 2020. Annual climate in Mexican spotted owl habitat in the Sacramento Mountains, New Mexico: implications for responding to climate change. Journal of Field Ornithology. 91:225-240

Gardner, D.R., and F.R. Stermitz. 1987. Host plant utilization and iridoid glycoside sequestration by *Euphydryas anicia* (Lepidoptera: Nymphalidae). Journal of Chemical Ecology. 14:2147-2168.

Giejsztowt, J. A.T. Classen, and J.R. Deslippe. 2020. Climate change and invasion my synergistically affect native reproduction. Ecology. 101:1-9.

Gisler, M. 2022. Peer Review of the current condition assessment report for the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*).

Glassberg, J. 2017. A swift guide to butterflies of North America. Second ed., Princeton University Press, pp. 207.

Hein, E. 2007. Site Visit Notes. Notes from a site visit to monitor Sacramento Mountains checkerspot.

Hughes, P. 2020. Verbal communication about the Sacramento Mountains checkerspot butterfly status during inter-agency working group meetings (August-December 2020).

Hughes, P. 2021a. Verbal communication about Sacramento Mountains checkerspot butterfly surveys during inter-agency working group meetings.

Hughes, P., 2021b. Email communication about recreation effects on the Sacramento Mountains checkerspot butterfly on the Lincoln National Forest.

Hughes, P., 2021c. Email communication. Subject: RE: Thru THURSDAY JULY 9 // RE: SMCB UPDATE through SAT. 6/26.

Huntly, N., and R. Inouye. 1988. Pocket gophers in ecosystems: patterns and mechanisms. BioScience. 38:786-793.

IPCC. 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Kennedy, K. 2020. Email. Subject: Getting Ready for today's call. (October 22, 2020).

Lightfoot, D. 2022. Peer Review of the current condition assessment report for the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*).

McIntyre, J.L. 2008. Field study to test for effects of Btk application in Nov 2007 to the Sacramento Mountains checkerspot butterfly.

McIntyre, J.L. 2010. Habitat variables, mammal interactions, and recovery approaches important to a rare, New Mexican Butterfly, *Euphydrays anicia cloudcrofti* (Lepidoptera: Nymphalidae). Dissertation, University of New Mexico. 101 pages.

McIntyre, J. 2021. Written communication on which habitat factors are essential for the Sacramento Mountain Checkerspot butterfly (January 26, 2021).

McMahan, B., M. Crimmins, D. Dubois, G. Garfin, Z Guido, N.J. Selover. 2021. January 2021 Southwest climate outlook. Climate Assessment for the Southwest. Online.

Murphy, D. D., A. E. Launer, and P. R. Ehrlich. 1983. The role of adult feeding in egg production and population dynamics of the checkerspot butterfly *Euphydryas editha*. Oecologia 56:257-263.

Murphy, D.D., & S.B. Weiss. 1988. Ecological studies and the conservation of the bay checkerspot butterfly, *Euphydryas editha bayensis*. Biological conservation. 46:183-200.

New Mexico Rare Plant Technical Council. 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. https://nmrareplants.unm.edu (latest update: 08 Jan 2021).

NMDGF [New Mexico Department of Game and Fish]. 2009. Elk in New Mexico. Santa Fe, NM.

Otero County (D. Moore). Letter to:N.J. Gloman, Acting Assistant Regional Director, Ecological Services, U.S. fish and Wildlife Service. 2007. September 28. Subject: Btk spraying in the vicinity of the Village of Cloudcroft.

Oxelman, B., P. Kornhall, R.G. Olmstead, and B. Bremer. 2005. Further disintegration of Scrophulariaceae. Taxon. 54: 411-425.

Pittenger, J.S., and K.A. Yori. 2003. Abundance, population structure, and habitat of the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*) with notes on life history and ecology. Prepared for the U.S. Forest Service, Lincoln National Forest, and the New Mexico Department of Transporation. 60 pp.

Pohl, G.R. and J. Pelham. 2016. Annotated taxonomic checklist of the Lepidopteran of North America, north of Mexico. Working paper published online by the authors at ResearchGate.net. 766 pp.

Pratt, G.F., and J.F. Emmel. 2010. Sites chosen by diapausing or quiescent stage quino checkerspot butterfly, *Euphydryas editha quino*, (Lepidoptera: Nymphalidae) larvae. Journal of Insect Conservation. 14:107-114.

Roland, J., A. Filazzola, and S.F. Matter. 2021. Spatial variation in early-winter snow cover determines local dynamics in a network of alpine butterfly populations. Ecography. 44:334-343.

Ryan, R. 2007. U.S. Forest Service study update summary for the Sacramento Mountains checkerspot (Euphydryas anicia cloudcrofti). Report. New Mexico State University, Las Cruces, NM. 20 pp.

Ryan, R., and B. Milligan. 2009. Observations of late instar larva survival of *Cotesia* (Hymenoptera: Braconidae) parasitoid attack of *Euphydryas anicia cloudcrofti* (Lepidoptera: Nymphalidae). Journal of research on the Lepidoptera. pp. 66.

Ryan, R., J. McIntyre, and P. Hughes. 2021. Expert elicitation meeting to discuss the Sacramento Mountains checkerspot butterfly (February 4, 2021).

Ryan, R. 2021a. Verbal communication during a meeting with experts while assessing the available information on the Sacramento Mountain checkerspot butterfly (January 28, 2021).

Ryan, R. 2021b. Verbal communication during Sacramento Mountains checkerspot butterfly Working Group meeting. Discussion on when to start surveys for Post-diapause larvae (March 18, 2021).

Ryan, R. 2021c. Verbal communication during Sacramento Mountains checkerspot butterfly working group meeting. Discussion on predation on predation for the Sacramento Mountains checkerspot butterfly (April 8, 2021).

Ryan, R. 2022. Verbal communication during Sacramento Mountains checkerspot butterfly Captive Rearing and Reintroduction Strategy meeting. Meeting notes (January 6, 2022).

Scott, J.A. 1986. The butterflies of North America – A natural history field guide. Stanford University Press, Stanford, California. 583 pp.

[Service] U.S. Fish and Wildlife Service, Otero County, The Village of Cloudcroft, and U.S. Forest Service. 2005. Conservation Plan for the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*). Albuquerque, New Mexico. 80 pp.

Sivinski, R.C., and P.J. Knight. 1996. Narrow endemism in the New Mexico flora. Southwestern rare and endangered plants: proceedings of the second conference. General technical report, USDA Forest Service. Pp. 286-296.

Siemann, E. J. Haarstad, and D. Tilman. 1997. Short-term and long-term effects of burning on oak savanna arthropods. The American Midland Naturalist. Pp. 349-361.

Southwest Center for Biological Diversity. 1998. Petition to list cloudcroft checkerspot butterfly: Euphydryas calcedona cloudcrofti (Occidryas anicia cloudcrofti Ferris and R. W. Holland). Tucson, Arizona. Pp. 17.

Surgeoner, G.A., and M.J. Farkas. 1990. *Bacillus thuringiensis* var. *kurstaki* (Btk) for use in forest pest management programs in Ontario with special emphasis on the aquatic environment. Report prepared for: Aquatic Criteria Development Committee Water Resource Branch. Guelph, Ontario. Pp. 90.

Swengel, A. 1997. Straight talk about butterfly population biology. North American Butterfly Association. 7 pp.

Wahlberg, M, F.J. Triepke, W. Robbie, S.H. Stringer, D. Vandendriesche, E. Muldavin, J. Malusa. 2014. Ecological Response Units of the Southwestern United States. U.S. Department of Agriculture. Forest Service, Southwestern Region. Pp. 201.

WallisDeVries, M.F., I. Raemakers. 2001. Does extensive grazing benefit butterflies in coastal dunes? Restoration ecology. 9: 179-188.

Weiss, S.B. 1999. Cars, cows, and checkerspot butterflies: nitrogen deposition and management of nutrient-poor grasslands for a threatened species. Conservation Biology. 13: 1476-1786.

White, R.R. 1986. Pupal mortality in the bay checkerspot butterfly (Lepidoptera: Nymphalidae). The journal of research on the lepidoptera. 25:52-62.