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 clouldcrofti*) (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 may 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. The Forest Service, Service, and private partners have been implementing actions to conserve the species since that time. 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

The Sacramento Mountains checkerspot butterfly was first collected at Pines Meadow Campground near Cloudcroft, New Mexico, in 1964 (Forest Service 1999, p. 1). The species 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 to one another, but can be distinguished by several subtle traits, such as darker overall colors, and wide, dark brown or black bands separating the checkered pattern of orange and cream (Ferris and Holland 1980, p. 5).

2.2 Physical Description

2.2.1 Adults

The Sacramento Mountains checkerspot butterfly is small and checkered with dark brown, red, orange, cream, and black spots, punctuated with dark lines (Figure 1). The butterfly's antennae have yellow-orange clubs at the tip, and they have orange legs and eyes (Glassberg 2017, p. 207) (Figure 1).

Figure 1. The top (left) and bottom (right) patterns of the Sacramento Mountains checkerspot butterfly.

During 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 2) (Service 2005, p. 7).

2.2.2 Caterpillars

Figure 2. 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 (Pittinger and Yori 2003; Service 2005).

2.3 Range and Distribution

2.3.1 Biogeography

The Sacramento Mountains are an isolated mountain range in south-central New Mexico. The mountains rise from desert grasslands, which stretch for miles. Due to their elevation, local conditions atop the mountains are colder and wetter than the surrounding area, which has resulted in unique flora and fauna at high elevation. 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.

2.3.2 Historic Range

The Sacramento Mountains checkerspot's historic range is not known. 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.

2.3.3 Metapopulation Structure

Metapopulation-level processes appear to be critical to the long-term persistence of the Sacramento Mountains checkerspot. These processes are characterized by the extirpation of local populations and colonization of unoccupied habitat patches. The range of the Sacramento Mountains checkerspot butterfly has always been discontinuous and fragmented (Figure 3). Spruce-fir forests punctuate 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). Many species of *Euphydryas* have a similar metapopulation structure in western landscapes (Ehrlich *et al.* 1975, p. 221). The movement rate of individuals between meadows within the butterfly range is probably low (Ryan 2021a, pers. comm.).

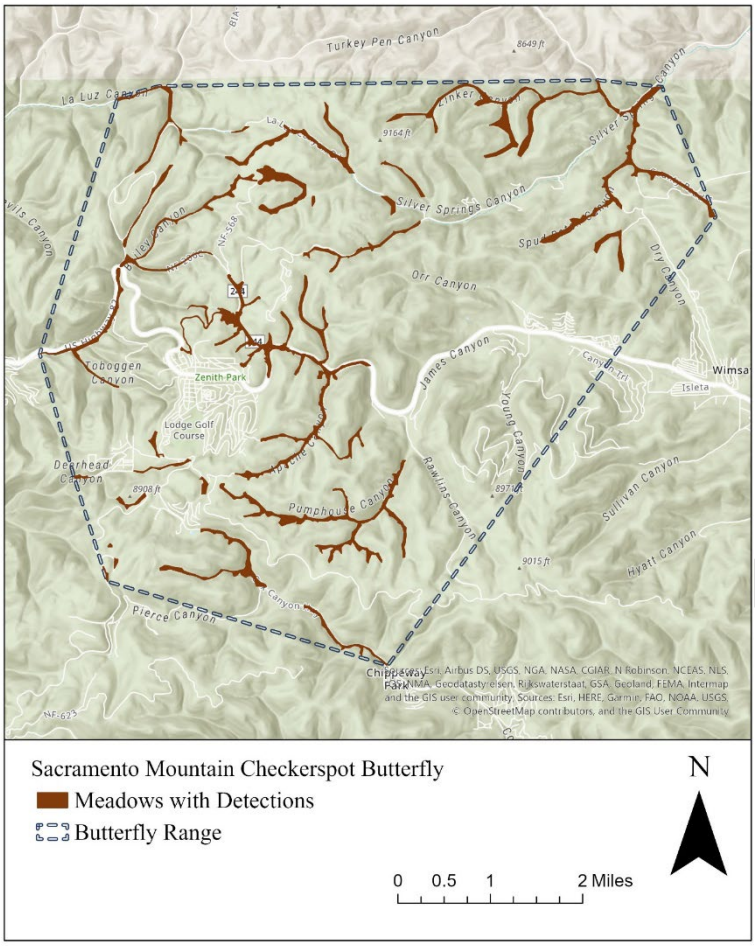

Figure 3. Distribution of the Sacramento Mountain checkerspot butterfly on the Lincoln National Forest in south-central New Mexico. Occupied meadow records for the subspecies were provided by the U.S. Forest Service, Sacramento Ranger District (Forest Service, 2020a).

2.4 Habitat

The Sacramento Mountains checkerspot butterfly inhabits high-altitude meadows in the upper-montane and subalpine zone at elevations between 2,380 and 2,750 meters (m) (7,800 and 9,000 feet (ft)) (Service *et al.* 2005, p. 9). The ecosystem at this elevation usually is cool and wet, supporting diverse and robust plant life, including the butterfly's preferred host plant: New Mexico beardtongue (*Penstemon neomexicanus*). It is likely that the meadow habitat upon which the Sacramento Mountains checkerspot butterfly relies were spatially dynamic, driven by a historical fire regime (Brown *et al.* 2001, pp. 116–117).

2.4.1 Host Plant

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 figwort family (Oxelman *et al.* 2005, p. 425). 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 prefers areas with loose soils or where there has been recent soil disturbance, such as eroded banks and pocket gopher burrows (Pittenger and Yori 2003, p. ii).

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).

2.4.2 Nectar Sources

The preferred adult nectar source is orange sneezeweed (*Helenium* (*Hymenoxys*) *hoopsii*), a native perennial forb (Service *et al.* 2005, p. 9). Forest Service personnel observed butterflies observed on orange composite flowers (family Asteraceae), including orange sneezeweed, as much as 90 percent of the time during surveys (Forest Service 2000, p. 4). Although orange sneezeweed flowers are most frequently used, the butterfly has been observed collecting nectar on 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.

2.4.3 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). 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).

2.4.4 Local Climate

In the Sacramento Mountains, small daily rainstorms (monsoons) are common during the summer months. 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 are most active during sunny days when temperatures remain near 70 °F

(Forest Service 1999, p. 4). The optimal temperature range is 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.).

2.5 Life Cycle

The Sacramento Mountains checkerspot butterfly is univoltine, meaning there is one generation per year (Figure 4). 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 flight can vary dramatically from one year to the next (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.

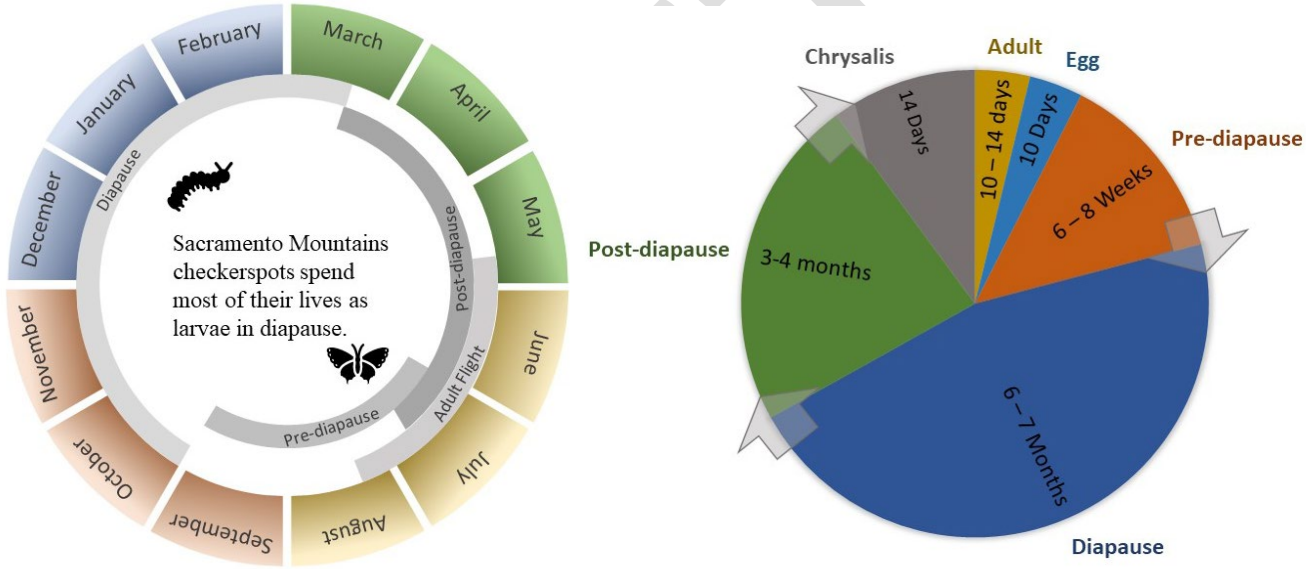

Figure 4. Life cycle and annual cycle of the Sacramento Mountains checkerspot butterfly

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 some 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 a full 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 they were in the fall, moving on average 2.6 m (8.5 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 (Swengel 1997, p. 5).

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

2.6 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, and habitat connectivity between occupied spaces to facilitate natural re-colonization and appropriate climatic conditions across the range.

2.6.1 Individual Needs

2.6.1.1 Host Plant

The most crucial habitat factor for the Sacramento Mountains checkerspot is the New Mexico beardtongue's presence and abundance (McIntyre 2021a, pers. comm.). The Sacramento Mountains checkerspot's larvae rely nearly entirely upon the New Mexico beardtongue during pre-and post-diapause. Because of the Sacramento Mountains checkerspot's dependency on New Mexico beardtongue, it is vulnerable to any type of habitat degradation, which reduces host plant health and abundance.

2.6.1.2 Nectar Source

Access to nectar sources is needed for adult Sacramento Mountains checkerspot butterflies to properly carry out their life cycle. 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.

2.6.2 Population Needs

2.6.2.1 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 mate and reproduce. Higher densities and more abundant individuals result in more successful mating attempts and ensure species viability.

2.6.2.2 Habitat Connectivity

Before human intervention, the habitat of the Sacramento Mountains checkerspot was dynamic, 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. Preliminary genetic research suggested no gene flow across the species' range or between meadows surveyed (Ryan 2021a, pers. comm.). If new sites are to become colonized or recolonized by the butterfly, meadow areas will need to be connected enough to dispersal from occupied areas. Habitat connectivity is needed for genetically healthy populations across the species' range to persist into the future.

2.6.3 Species Needs

The Sacramento Mountains checkerspot needs to have sufficient quality and quantity of habitat for resilient populations, numerous populations to create redundancy through catastrophic events, and enough genetic diversity to allow for adaptations to changing environmental conditions (representation) to achieve viability. The genetic interchange between separate metapopulations is needed for the species to increase 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

The three Rs	Requisites of Viability	Description
Resiliency (ability to withstand stochastic events)	There are healthy, 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 drying out.

	Metapopulation density and abundance.	Larger, more dense populations are more likely to facilitate colonization events and increase genetic health.
	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 spread across the range to prevent the loss of the species during catastrophic events.	Multiple metapopulations extirpation reduce risk from catastrophic events (such as wildfires).
Representation (adaptive capacity)	Populations are genetically diverse.	Genetic diversity provides adaptive advantages.
	Habitat connectivity between metapopulations.	Habitat connectivity facilitates gene flow across the range.

CHAPTER 3: CURRENT CONDITION

3.1 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 2020, p. 2) (Figure 5). The butterfly is currently only found in two meadows on the Lincoln National Forest (Forest Service 2020b, p. 1). During the 2020 survey season, only 8 butterflies were detected.

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. 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; Phillip Hughes 2020, pers. comm.).

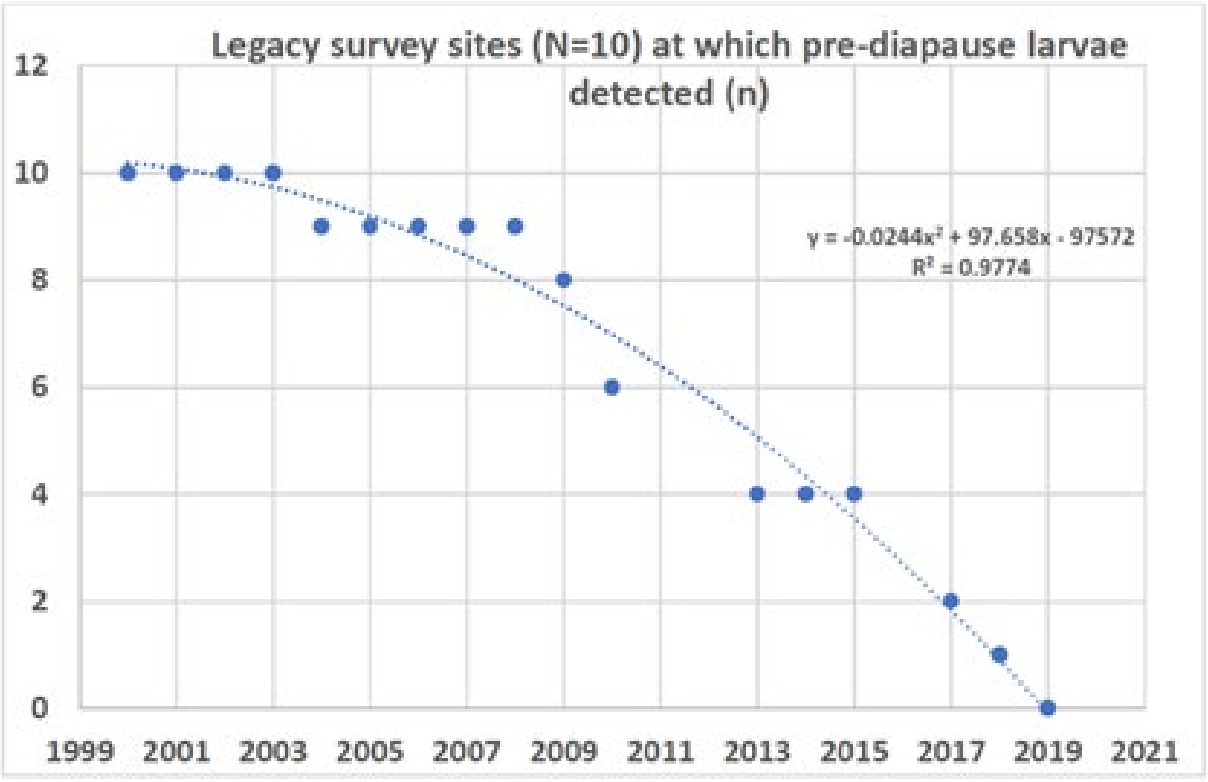

Figure 5. Populations of the Sacramento Mountains checkerspot butterfly have declined over the past two decades (Forest Service 2020b).

3.2 Factors Influencing Species Viability

Here we consider the anthropogenic and environmental factors influencing the Sacramento Mountains checkerspot butterfly's resiliency, which contributes to the species' overall viability. Climate change, incompatible grazing, 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.

3.2.1 Minor Factors

We define minor factors as those which have a small impact on overall species viability. In the butterfly's case, 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.

3.2.1.1 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 checkerspots (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 checkerspot's viability.

3.2.1.2 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 (Scott 1986, pp. 70, 71). It is possible, especially with high levels of human recreation within the Lincoln National Forest (see section 3.2.2.2 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.

3.2.1.3 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 parasites 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.

3.2.1.4 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.

The application of Btk is a direct threat to individual Sacramento Mountain checkerspot butterflies (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 (Forest Service 2007b, p. 2). 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.

Conservation recommendations and 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, pers. comm.). From 2007 until the present, there have been no future looper moth outbreaks, and the threat of insecticide use has abated. However, if another looper moth outbreak develops then insecticide use could become a major threat to the species again. Currently, no butterfly populations are at risk from insecticide use. However, care should be used if future insect outbreaks occur with the range of the species.

3.2.1.5 Habitat Loss

Habitat loss has occurred previously 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 45396). While it is unlikely that private development has a significant impact on the species at this time (Service 2009, p. 10), care needs to be taken to protect the species' remaining habitat.

3.2.1.6 *Livestock Grazing*

Forest Service permits livestock grazing in select allotments on the Lincoln National Forest in the Sacramento Mountains. Livestock grazing can potentially impact the butterfly directly through trampling or ingestion of individuals and indirectly through the reduction in ground cover (Service *et al.* 2005, pp. 29–30). Because penstemons serve as the larval food plant for the butterfly, reducing available plants may impact the species' presence and survival (McIntyre 2010, pp. 94–104). Grazing can also degrade meadow habitat quality by altering the vegetative understory composition (Forest Service 2008, p. 70; Forest Service 2019, p. 21) and compacting soil (McIntyre 2010, pp. 76–77).

The butterfly occurs only within about 17 acres (ac) (7.2 hectares (ha)) of the Russia Canyon Allotment (Forest Service 2004, entire), which has two grazing permittees. 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 Pumphouse Allotment also contains suitable and occupied butterfly habitats open to livestock grazing (Service 2005, p. 1; Forest Service 2009, p. 1).

Livestock grazing can potentially impact the butterfly directly through trampling and ingestion of individuals, and indirectly through the reduction in ground cover and the removal of the larval food plant, New Mexico beardtongue (Service *et al.* 2005, pp. 29–30). Currently, Forest Service management and monitoring of livestock grazing standards on allotments within the range of the butterfly are compatible with the continued existence of the species. Although the potential for impacts to the butterfly exists, our review found no information indicating that livestock grazing

significantly affects the butterfly's status now or will do so in the foreseeable future. Therefore, we conclude that livestock grazing is not a significant threat to the butterfly.

3.2.2 Major Factors

We define major factors as those which have a significant impact on the overall species viability. For the butterfly, these are factors that currently affect the species and have a high chance of regularly occurring or affecting large portions of the species' range.

3.2.2.1 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.

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). Should elk herds expand beyond natural levels, browse pressure from elk, especially during times of resource scarcity, can pose a significant threat to the butterfly's habitat and viability (McIntyre 2010, pp. 73–75).

Feral horses were inadvertently released onto the Lincoln National Forest in the mid-2000s. Horses are not native to the Sacramento Mountains and add significant browse pressure to meadow units. Larger than elk, horses need to consume large quantities of vegetation to survive. The population of feral horses on the Lincoln National Forest continues to grow annually (Hughes 2021a, pers. comm.). Heavy browse due to increasing numbers is already negatively impacting the habitat within the butterfly's range, negatively influencing the species' viability.

Under normal habitat conditions, the host plant, New Mexico beardtongue, is not a preferred food source for large ungulates (McIntyre 2010, p. 71). However, during abnormally dry conditions, as other food plants become scarce, both horses and elk will switch to browsing New Mexico beardtongue (McIntyre 2021, pers. comm.). New Mexico beardtongue will remain small rosettes, less than an inch tall, and do not flower when there is significant browse pressure from large herbivores (Hughes 2020, pers. comm.). These small, stunted plants are not large enough to support tent colonies of caterpillars; any larvae will starve after hatching.

Together, the factors of non-native ungulate (feral horses) browsing, over-populated elk browsing, and drought due to climate change compound to significantly impact habitat within meadow ecosystems in the range of the Sacramento Mountains checkerspot butterfly. Over the past several years, sustained drought in Otero County has driven large herbivores to graze most meadow areas to the ground. Currently, vegetation is scarce in all the meadows throughout the range of the species.

3.2.2.2 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 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 vehicle (RV) 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.

Recreation can negatively affect the butterfly in several ways. Trampling and crushing the habitat can physically kill both butterflies and caterpillars. While adults can fly away, these butterflies are slow, especially on cold mornings. Recreational activities can also crush New Mexico beardtongue and orange sneezeweed. 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. This factor can also directly affect the habitat of the species. All meadow units within the range are experiencing some level of impact from this factor.

3.2.2.3 Climate Change

Climate change is beginning to impact natural ecosystems in the southwestern United States (IPCC 2014, p. 240). The unique ecosystem in which the Sacramento Mountains checkerspot butterfly resides 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). 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 3.2.2.4 below).

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 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 moisture might also encourage the butterflies to emerge from diapause as well (Ryan 2021b, pers. comm.).

Climate change will likely impact the 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.

The 2020 monsoon season 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.).

3.2.2.4 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, 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.). 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.

3.2.2.5 Altered Wildfire Regime

Fire suppression has been ongoing in the Sacramento Mountains since 1907, and dense tree growth has increased fuel loads (Forest Service 1998, pp. 3, 63). The Sacramento Mountains checkerspot 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 occurs 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). On the other hand, some level of fire activity might 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.

3.2.3 Beneficial Factors

Several habitat management actions can benefit the viability of the Sacramento Mountains checkerspot butterfly. The Lincoln National Forest has erected exclosures 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.

3.3 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 6 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.

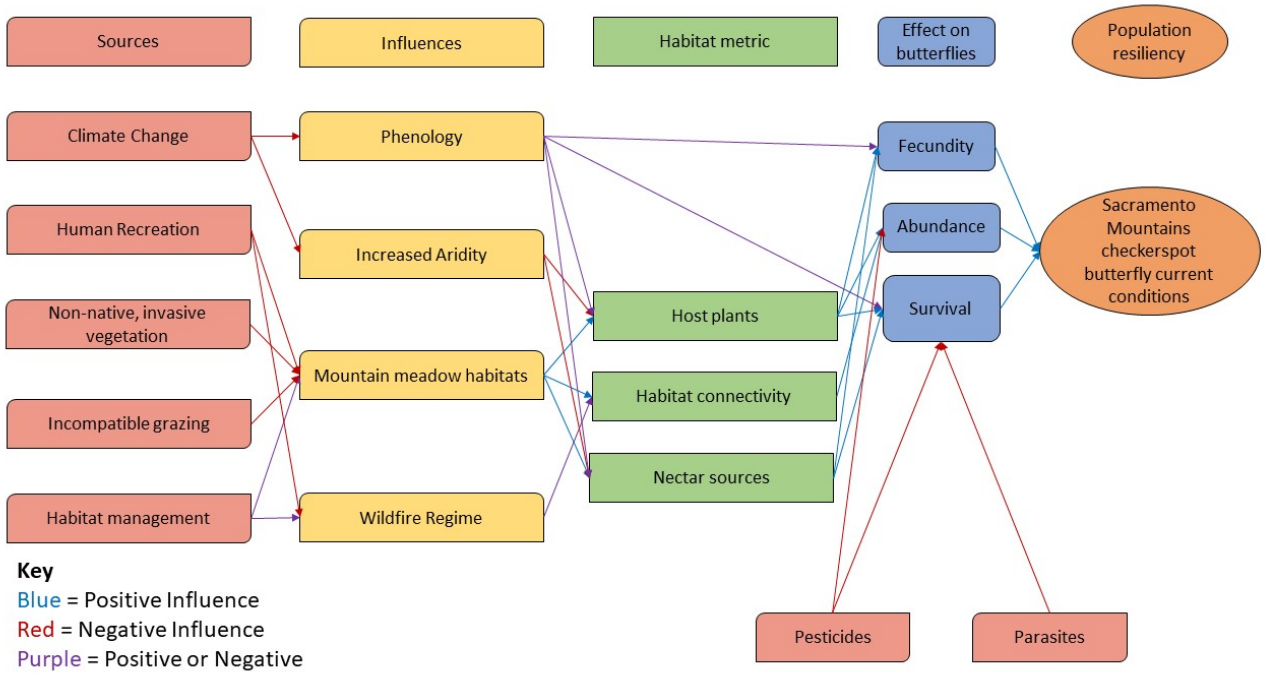

Figure 6. An influence diagram shows pathways through which various anthropogenic and environmental factors can affect the Sacramento Mountains checkerspot butterfly's habitat needs and demographic parameters. Red arrows represent negative influences on a factor, blue arrows a positive influence, and 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).

3.4 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.

3.4.1 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 7). It is important to note that butterflies can 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).

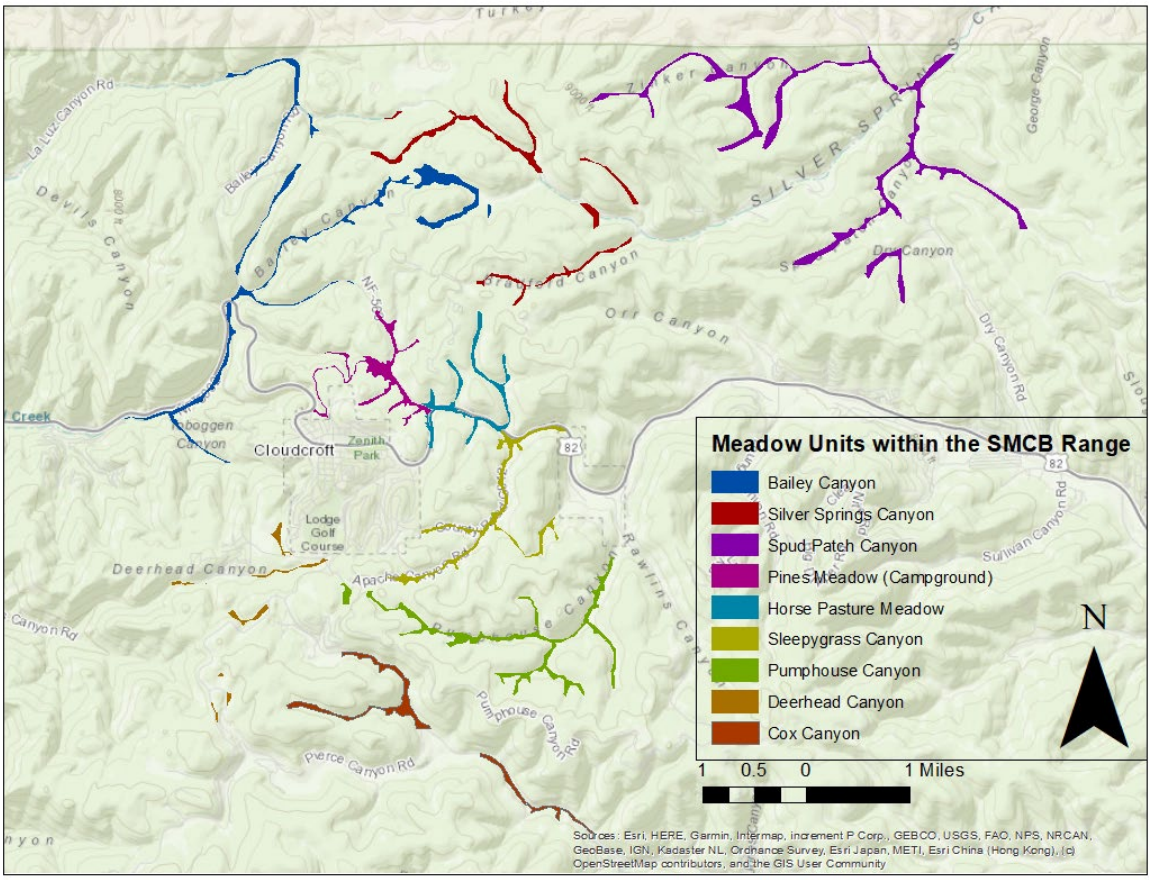

Figure 7. Meadow units within the range of the Sacramento Mountains checkerspot butterfly. The Yardplot meadow was sold before meadows were digitized for computer analysis and therefore is not included in this map.

3.4.2 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 2).

Table 2. 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 data availability (Table 3).

Table 3. 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 exist within a meadow	> 500 larvae/ha observed	There are multiple, large patches of host plants or one patch covering a large portion of the meadow[3]. There are many plants >1 meter in height	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 <1 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 >1 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 (Pettinger 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 4).

Table 4. 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 8). 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 5.

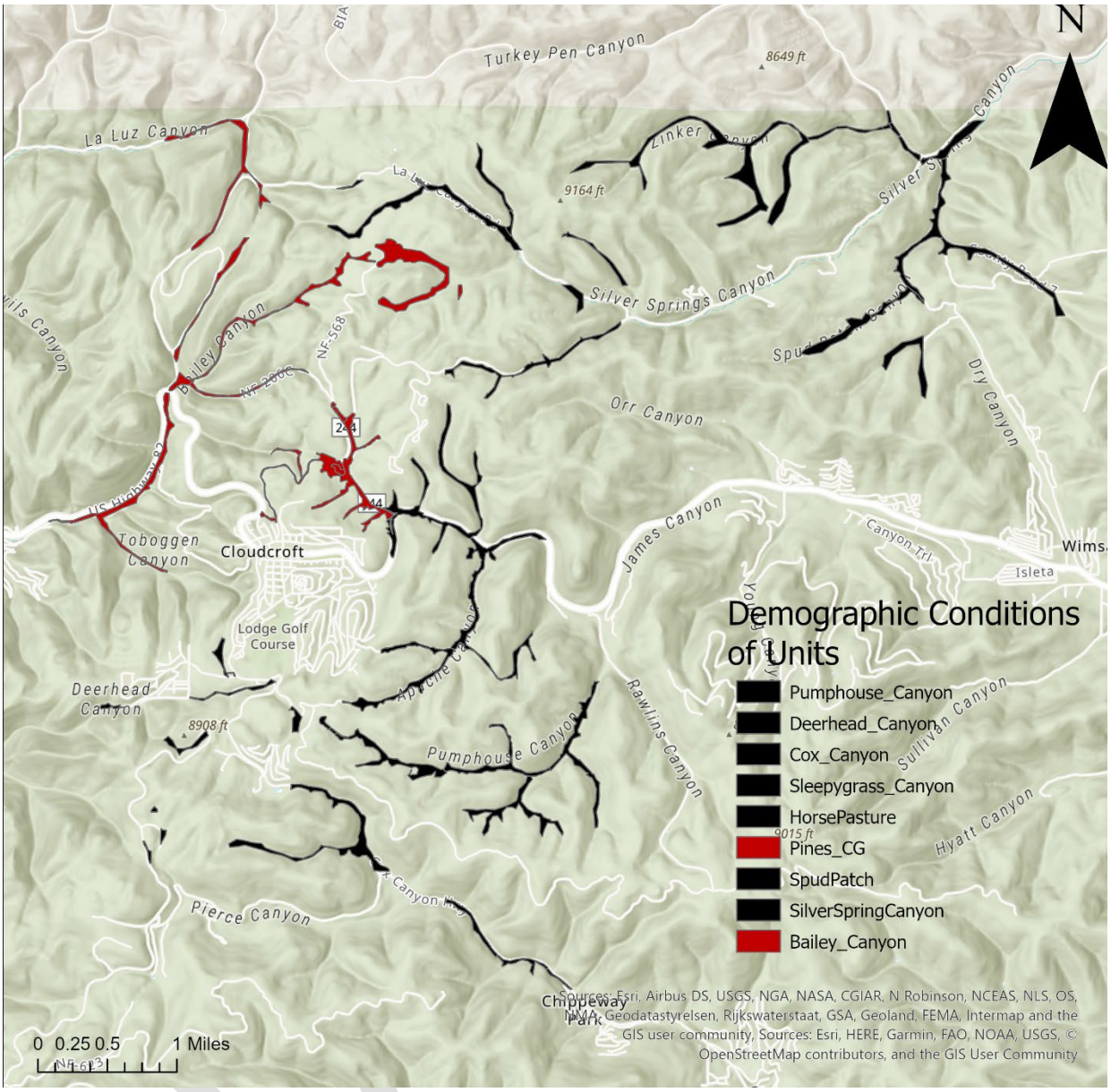

Figure 8. The demographic condition of all analysis units throughout the range of the Sacramento Mountains checkerspot butterfly. Based on our analysis most units are probably functionally extirpated.

Table 5. 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 8).

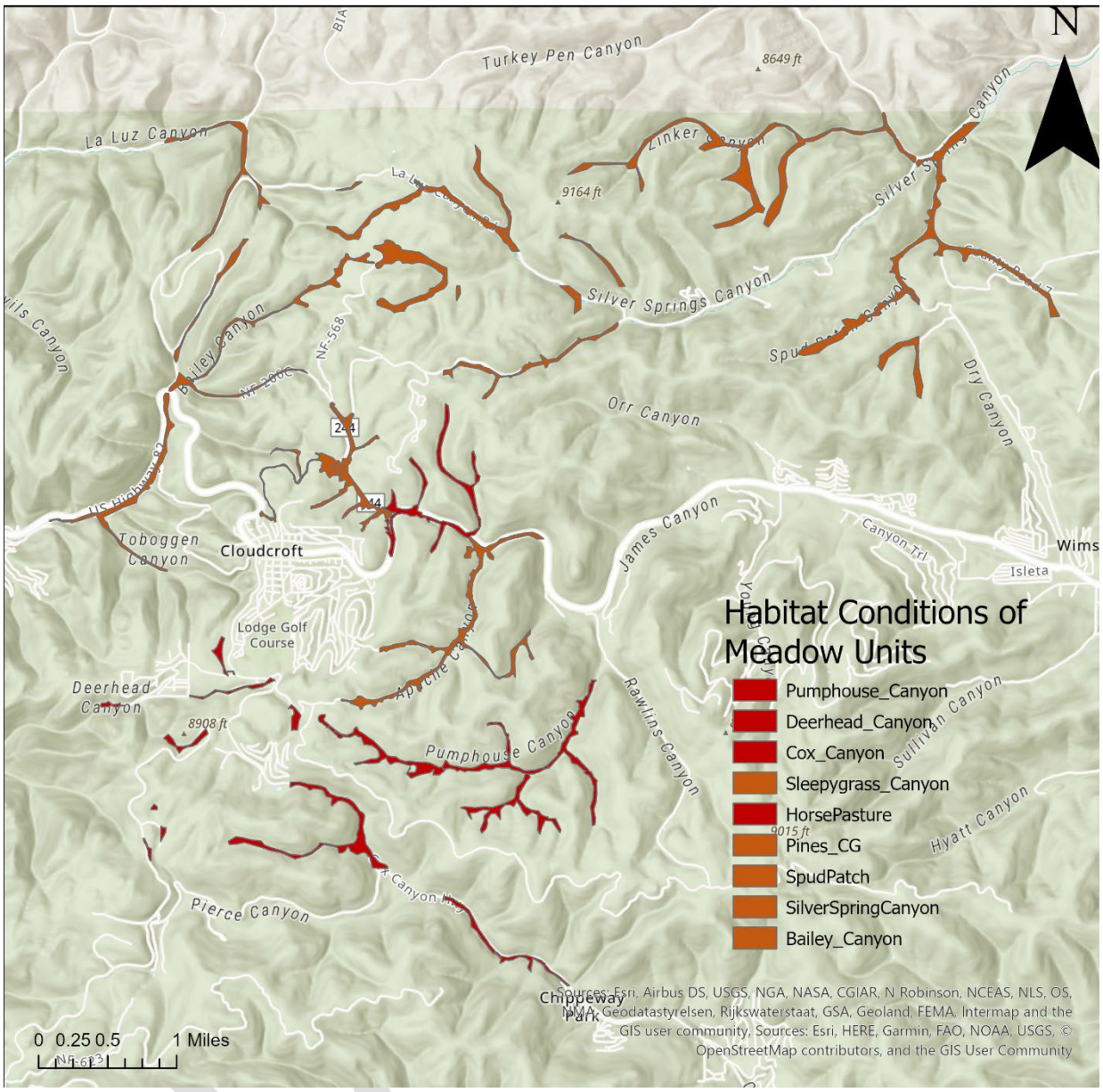

Figure 9. The current condition of the Sacramento Mountains checkerspot butterfly habitat within the species' range. Orange units are in a low condition, red is in a very low condition, and black are believed to be extirpated. Yardplot meadows is not represented on this map.

3.4.3 Representation

We define representation for the Sacramento Mountains checkerspot butterfly has having ecological and genetic diversity. 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) 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. 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.

3.4.4 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. Given the historical distribution of the butterfly, it is likely that Sacramento Mountains checkerspot butterfly populations were previously more abundant within the Sacramento Mountains. Therefore, redundancy of the butterfly has declined over time.

3.5 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 wild ungulate grazing, recreation, climate change, invasive plants, and wildfire suppression. For representation, the butterfly has limited ecological diversity, which in turn, 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.

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