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The lost butterflies of New Mexico's Sacramento Mountains

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Abstract: In 2022, the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*) was listed as Endangered by the U.S. Fish and Wildlife Service. This decision brought renewed attention to the Sacramento Mountains of south-central New Mexico, USA, a region distinguished both by its exceptional concentration of rare and endemic taxa and by persistent conflicts over natural resource use. The checkerspot's long-term decline appears closely linked to these ongoing environmental pressures. Yet, this subspecies represents only one of nine butterflies endemic to the range, all potentially threatened by similar factors. A review of available records reveals that, in addition to the checkerspot's apparent disappearance, three other endemic butterflies have not been observed in over a decade: the Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus*), the Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento*), and the Sacramento Mountains coral hairstreak (*Satyrrium titus carrizozo*). Here, we compile and analyze historical records for these taxa, emphasizing the urgent need for targeted surveys, habitat assessments, and conservation planning. Our findings highlight both the limited knowledge of these narrowly distributed butterflies and the potential for further, undocumented declines within this biologically unique region.

Keywords: hairstreak, checkerspot, Capitan, *Euphydryas*, *Callophrys*, *Satyrrium*

Conservation statement: Land management in the Sacramento Mountains of New Mexico, USA, is challenged by the region's remarkable biological diversity and the ongoing tension between conservation and human activities such as grazing, development, agriculture, water and other resource extraction, and recreation. The decline of endemic butterflies underscores the urgent need to protect and restore suitable habitats. With numerous rare taxa across multiple taxonomic groups, proactive conservation is critical to avoid further Endangered Species Act listings and the extinction of these imperiled butterflies. High levels of endemism among well-studied groups also suggest that additional, undescribed subspecies and species, particularly insects, remain to be discovered in the region. Safeguarding and restoring habitats while mitigating ongoing threats will be vital to preserving the unique and vulnerable ecological communities of the Sacramento Mountains.

Resumen: La mariposa ajedrezada de Las Montañas Sacramento (*Euphydryas anicia cloudcrofti*) fue declarada en peligro por el Servicio de Pesca y Vida Silvestre de los Estados Unidos en 2022. Esta decisión renovó el interés en Las Montañas Sacramento del centro-sur de Nuevo México, una región con una concentración

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excepcional de taxones raros y endémicos, así como también conflictos persistentes por el uso de los recursos naturales. El declive a largo plazo de esta mariposa parece estar relacionado con estas presiones ambientales. Sin embargo, esta subespecie representa solo una de las nueve mariposas endémicas de la zona, todas ellas potencialmente amenazadas por factores similares. Una revisión de los registros disponibles revela que, además de la aparente desaparición de la mariposa ajedrezada, otras tres especies de licénidos endémicos no se han observado en más de una década: la mariposa le líneas verdes de Las Montañas Sacramento del occidente (*Callophrys affinis albipalpus*), la mariposa de líneas blancas de Las Montañas Sacramento (*Callophrys sheridanii sacramento*) y la mariposa de líneas coral de Las Montañas Sacramento (*Satyrium titus carrizozo*). En este trabajo, recopilamos y analizamos registros históricos de estas especies, destacando la urgente necesidad de investigaciones específicas, evaluaciones de su hábitat y planes de conservación. Nuestros hallazgos revelan que existe un conocimiento limitado sobre estas mariposas de distribución restringida y evidencian posibles declives no documentados en esta región biológicamente única.

Palabras clave: licénidos, mariposas ajedrezadas, Capitan, *Euphydryas*, *Callophrys*, *Satyrium*

Estado de conservación: La gestión de paisaje en las Cordilleras de Sacramento, de Nuevo México, Estados Unidos, enfrenta un gran desafío debido a que la biodiversidad de la región mantiene una fuerte y constante tensión entre la conservación y las actividades humanas, como pastoreo, expansión urbana, agricultura, extracción de agua y otros recursos, así como actividades recreativas. La disminución de las mariposas endémicas evidencia una necesidad urgente de proteger y restaurar los hábitats adecuados. Ante la presencia de numerosos taxones raros en múltiples grupos taxonómicos, la conservación proactiva resulta extremadamente fundamental para evitar nuevas inclusiones de especies en listas de especies en peligro y prevenir extinciones de estas mariposas altamente amenazadas. Altos niveles de endemismo entre los grupos más estudiados sugieren que en la región aún quedan por describir subespecies y especies aun no descritas, especialmente insectos. La protección y restauración de los hábitats, junto con la mitigación de las amenazas actuales, será un proceso esencial para la conservación de comunidades ecológicas únicas y vulnerables de las Montañas Sacramento.

INTRODUCTION

The Sacramento Mountains are an isolated mountain range located in south-central New Mexico, United States, as described by the U.S. Fish and Wildlife Service (USFWS 2023). The butterflies and other wildlife in these mountains became genetically isolated approximately 11,000 years ago (Holland 2009, 2010). Since that time, the southwestern United States has experienced pronounced aridification associated with the transition from the cool, moist conditions of the glacial Pleistocene to the warmer and drier interglacial period (Seersholm et al. 2020). This climatic shift forced many taxa to shift their distributions northward or upward in elevation, many of which soon found themselves stuck in high-elevation refugia separated by miles of inhospitable desert (Holland 2010).

The Sacramento Mountains are one such refugium and, due to their geographic isolation, have evolved into a remarkable center

of endemism, supporting at least 26 endemic species of plants and animals and many more endemic subspecies (Cary and Toliver 2024; Holland 2010; Lee-Chadde and Huenneke 1997; NM-RARe 2024). Some notable examples include the Sacramento Mountains thistle (*Cirsium vinaceum*), the Sacramento Mountains salamander (*Aneides hardii*), Cockerell's bumblebee (*Bombus cockerelli*), and at least nine endemic subspecies of butterflies (Cary and Toliver 2024; Holland 2009, 2010; Lee-Chadde and Huenneke 1997; NM-RARe 2024).

Despite this exceptional biological richness, the high number of endemics in the Sacramento Mountains face complex environmental management challenges due to decades of intense conflicts over natural resource use and conservation and region-wide aridification (Kaufmann et al. 1998; Williams et al. 2022). These conflicts have intensified over the years. Until the 1950s, almost everyone in the region lived on single family farms with small pas-

turelands. The associated agricultural practices caused intense conflicts over water, which led to the eradication of beavers, much agricultural irrigation, and damming that permanently depleted the amount of natural water storage, reduced baseflows, and degraded riparian systems (USFWS 2010). Even though these farms have largely been abandoned and the region has been reforested, conflicts over water have persisted. Severe hydrologic stress in the mountains continues due to the ongoing aridification of the Southwest as well as various land use pressures. These pressures, including continued livestock grazing, feral horse activity, water diversion, and the historical beaver eradication, have placed many endemic taxa at risk of extinction and, in recent years, have contributed to the apparent loss of four butterflies unique to the region: the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti* Ferris and Holland, 1980), the Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus* Gorelick, 2005), the Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento* Scott, 2006), and the Sacramento Mountains coral hairstreak (*Satyrrium titus carrizozo* Holland, 2010).

Natural history

Each of these rare butterfly taxa in the Sacramento Mountains is narrowly restricted to high-elevation montane environments and depend on open, early successional habitats maintained by natural or anthropogenic disturbance. Collectively, these four butterflies occur in meadows, drainages, grasslands, canyon bottoms, forest openings, and mountain slopes within upper montane and subalpine coniferous forest, generally above 2,100 m and in some cases exceeding 3,600 m in elevation (Cary and Toliver 2024; Gorelick 2005; Holland 2010; NM-RARE 2024).

The Sacramento Mountains checkerspot occupies open meadows, drainages, and grasslands within upper montane and subalpine coniferous forest at elevations between 2,400

and 2,750 m (McIntyre 2010; Pittenger and Yori 2003; USFWS 2023). Its primary larval host plant is New Mexico penstemon (*Penstemon neomexicanus*), a regional endemic that is an early successional, stress-tolerant perennial typically found in disturbed sandy to rocky loam soils (Ferris and Holland 1980; Lee-Chadde and Huenneke 1997; USFWS 2004, 2023).

The Sacramento Mountains western green hairstreak is also an early successional habitat specialist, historically occurring in open meadows, canyons, and disturbed areas at or above 2,100 m (Cary and Toliver 2024; Gorelick 2005; NM-RARE 2024). The subspecies is bivoltine with extreme flight dates ranging from March 25 to August 31 and with peak flights in May and June (Cary and Toliver 2024). Its preferred larval host plant appears to be Fendler's buckbrush (*Ceanothus fendleri*), although larvae may also use buckwheats (*Eriogonum* spp.), particularly winged buckwheat (*Eriogonum alatum*) (Cary and Toliver 2024; Gorelick 2005; NM-RARE 2024). All known host plants for this subspecies are associated with landscapes experiencing frequent fire, suggesting that fire plays an important role in maintaining suitable habitat, although other forms of disturbance may occasionally provide similar conditions (Cary and Toliver 2024).

The Sacramento Mountains white-lined hairstreak occurs on mountain slopes and in openings within montane coniferous forests at elevations above 2,100 m (Cary and Toliver 2024). This subspecies is univoltine, with flight records extending from April 9 to July 5 and peak abundance observed in May and June (Cary and Toliver 2024). Its sole known larval host plant is Wooton's wild buckwheat (*Eriogonum wootonii*), another regional endemic (Cary and Toliver 2024; Sivinski 2007).

A third hairstreak, the Sacramento Mountains coral hairstreak, is endemic to the highest northern reaches of the Sacramento Mountains complex, with known localities restricted to Nogal Peak, Carrizo Peak, and Sierra Blanca Peak (Cary and Toliver 2024; Global Biodiver-

sity Information Facility [GBIF] 2025; Holland 2010; NM-RARE 2024). These sites represent some of the highest elevations in the range, with colonies documented at approximately 2,680 m on Nogal Peak, around 3,050 m on Carrizo Peak, and up to 3,650 m on Sierra Blanca Peak (GBIF 2025; Holland 2010). Little is known

about the life history of this subspecies; however, all records have been obtained on or near mountain summits above 2,680 m, suggesting a strong affinity for alpine or subalpine environments. The known colonies of this subspecies appear to be closely associated with chokecherry (*Prunus melanocarpa*), which serves as

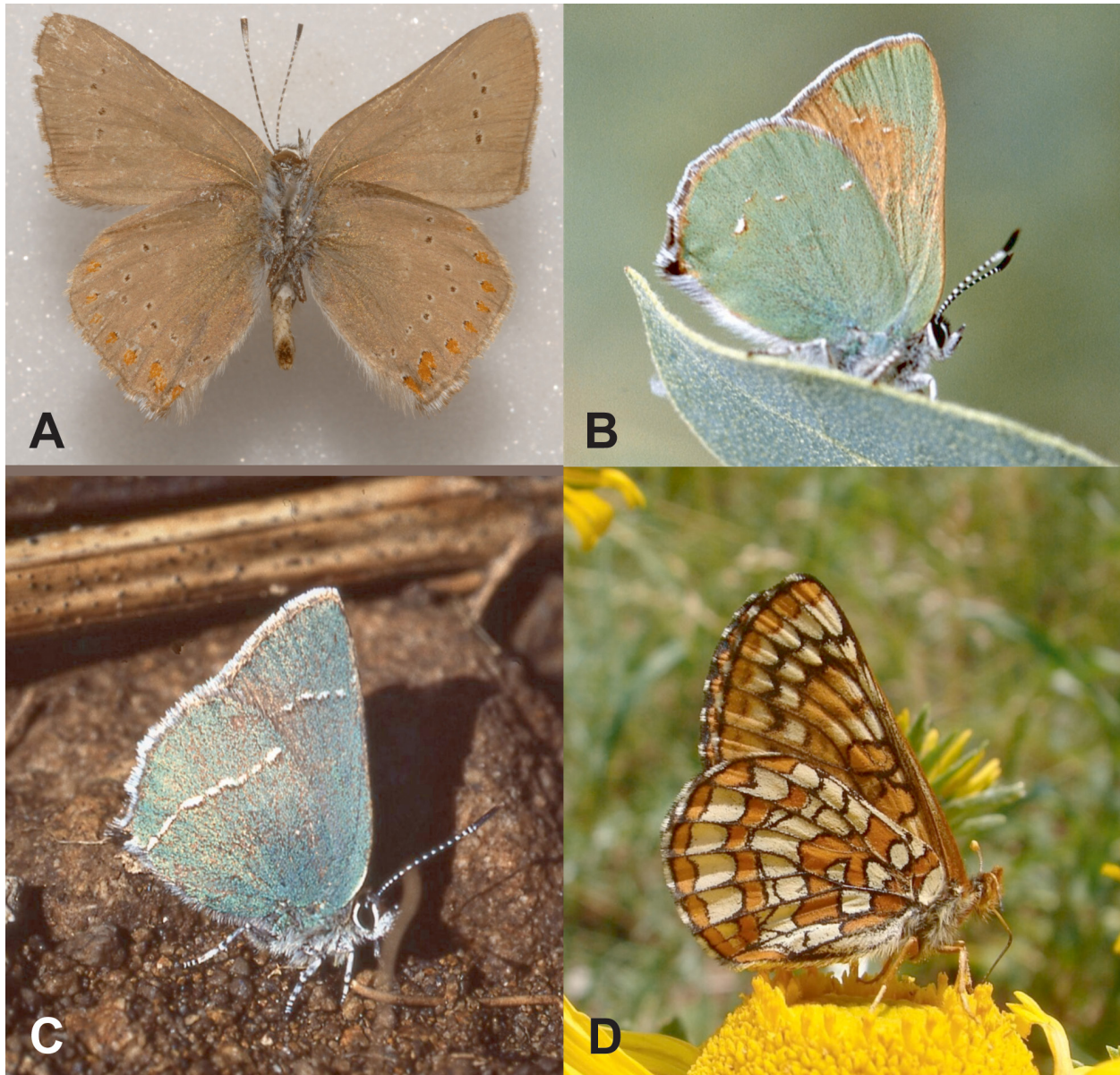


Figure 1. (A) Sacramento Mountains coral hairstreak (*Satyrium titus carrizozo* Holland, 2010), paratype of a male *Satyrium titus carrizozo* located at the Museum of Southwestern Biology, Division of Arthropods. Collected 1975 in the Sacramento Mountains. Photo credit, Simon Doneski. (B) Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus* Gorelick, 2005). Photo credit, Steve Cary. (C) Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento* Scott, 2006). Photo credit, Steve Cary. (D) Sacramento Mountains checkerspot (*Euphydryas anicia cloudcrofti* Ferris and Holland, 1980). Photo credit, Steve Cary.

the larval host plant for all other *Satyrium titus* populations in New Mexico and is presumed to fulfill the same role here (Cary and Toliver 2024; Holland 2010; NM-RARe 2024). This butterfly is univoltine in New Mexico, with flight activity generally occurring from mid-July to mid-August (Holland 2010). Occurrence records for this subspecies range from June 30 to August 9 (GBIF 2025; Holland 2010; Toliver et al. 2001).

Systematics

The Sacramento Mountains checkerspot, *Euphydryas anicia cloudcrofti* (Ferris and Holland, 1980), is in the tribe Melitaeini (Lepidoptera: Nymphalidae). It was originally described as *Occidryas anicia cloudcrofti* by (Ferris and Holland 1980) and was later transferred to *Euphydryas* following subsequent taxonomic treatments (Center for Biological Diversity 1998). The Sacramento Mountains checkerspot is the only representative of the genus *Euphydryas* in the Sacramento Mountains.

Although many species of *Euphydryas* are widespread, several subspecies are rare and threatened, including *Euphydryas editha quino*, *E. editha taylori*, and *E. anicia chuskae* (NM-RARe 2024; USFWS 1997; USFWS 2013). At the species level, *E. anicia* is listed as a New Mexico Species of Greatest Conservation Need by the New Mexico Department of Wildlife (NMDW 2025). *Euphydryas anicia cloudcrofti* occurs at the southern extreme of the species' range, highlighting its potential genetic and ecological distinctiveness within the *E. anicia* complex.

The closest known relatives to *E. a. cloudcrofti* are in the Sangre de Cristo Mountains with three described subspecies existing in the mountain range in New Mexico: *E. a. carmentis* on the west side of the range, *E. a. capella* on the east side of the range, and *E. a. brucei* on the high elevation peaks (Cary and Toliver 2024). Two additional subspecies are also described from the Gila region of New Mexico, those being *E. a. hermosa* and the high-elevation *E. a. magdalena* (Cary and Toliver 2024).

The Sacramento Mountains support multiple endemic or range restricted hairstreak butterflies (Lepidoptera: Lycaenidae: Theclinae), several of which belong to the genus *Callophrys*. The Sacramento Mountains western green hairstreak, *Callophrys affinis albipalpus* Gorelick, 2005, has generally exhibited taxonomic stability since its description, although James Scott questioned the validity of the subspecies during his description of *Phyciodes cocyta apache* (Scott and Opler, 2017). Despite this, subsequent authors have continued to recognize *C. a. albipalpus* as a valid subspecies (NM-RARe 2024; NMDW 2025; Warren et al. 2024). The closest relative to *C.a. albipalpus* seems to be *C.a. homoperplexa* in the Sangre de Cristo Mountains to the north, however, there is also a described subspecies in the Gila region, *C. a. apama* (Cary and Toliver 2024).

A second *Callophrys* taxon, the Sacramento Mountains white-line hairstreak, *Callophrys sheridanii sacramento* Scott, 2006, has remained taxonomically stable since its description (Scott et al. 2006). Hairstreak butterflies are commonly associated with high levels of endemism and habitat specialization. This butterfly's closest relative is the nominate subspecies in the San Juan Mountains of northern New Mexico and Colorado.

The Sacramento Mountains coral hairstreak, *Satyrium titus carrizozo* Holland, 2010, was the last of three endemic hairstreaks and five endemic lycaenid butterflies described from the Sacramento Mountains. Its taxonomy has remained stable since its description (Cary and Toliver 2024; Holland 2010). The genus *Satyrium* is large and cosmopolitan, comprising dozens of species worldwide. In the Sacramento Mountains, two species of *Satyrium* are known to occur: *Satyrium titus* and *Satyrium favonius* (Cary and Toliver 2024). The closest relative of *S. t. carrizozo* is also to the north but with closer populations than any of the other four with *S. t. immaculosus* being known to occur in the Jemez Mountains and historically in the Sandia Mountains as well as the Sangre de Cristo Mountains (Cary and Toliver 2024).

Is it not surprising that these four subspecies in particular out of the regional butterfly fauna are the ones that appear to be extremely rare or declining; both checkerspots (*Melitaeini*), and blues and hairstreaks (*Lycaenidae*) are groups of butterflies that are disproportionately identified as threatened by the International Union for Conservation of Nature (IUCN 2025) and others (Cushman and Murphy 1993; Erlich and Hanski 2004). This is largely attributed to high rates of diversification in these groups which gives rise to greater numbers of ecologically and geographically restricted taxa (Wagner 2026).

Geography

All four focal butterfly taxa are restricted to the Sacramento Mountains sky island in southern New Mexico and are present as geographically isolated populations within a broader North American context. Their distributions are highly localized within the range, reflecting a combination of habitat specialization, elevational restriction, and long-term historical isolation.

The Sacramento Mountains checkerspot is confined to a small area centered around the village of Cloudcroft (Fig. 2). All historically occupied meadows are within less than a 10 km radius of the village (USFWS 2004). Within this area, the subspecies was historically known from as many as 15 meadows (McIntyre 2010). More recently, specimens housed at New Mexico State University (NMSU), collected on the Mescalero Apache Reservation, have expanded the known historical distribution, and now the current understanding is that the butterfly once spanned from somewhere on Mescalero Apache lands south to Cox Canyon (USFWS 2004).

The Sacramento Mountains western green hairstreak was first collected in 1961 near Cedar Creek Campground, approximately 10 km north of Ruidoso (Fig. 3; Gorelick 2005). It was historically recorded around New Mexico Highways 37 and 48, suggesting a once broader, but still localized, distribution in the

northern and central portions of the range. The last known occurrence came in 2004 when the taxon was found at Cienega Canyon, south of Cloudcroft (Cary and Toliver 2024; Gorelick 2005).

The Sacramento Mountains White-lined Hairstreak was historically recorded from the northern end of the Sacramentos south through the Mescalero Apache Reservation to around the Cloudcroft area (Fig. 4). The last known occurrence of this subspecies was recorded in 2002 in the vicinity of Cloudcroft (Cary and Toliver 2024; Toliver et al. 2001).

The Sacramento Mountains coral hairstreak has the most geographically restricted distribution of the four taxa and is known from only three localities within the Sacramento Mountains (Fig. 5). These include the type locality on Carrizo Peak, a population on Nogal Peak, and a third on Sierra Blanca Peak (Cary and Toliver 2024). All known sites occur at high elevations and are widely separated, underscoring the narrow endemic nature of this subspecies.

STATUS

Evidence

All four subspecies addressed herein are endemic to the Sacramento Mountains and while the checkerspot has not been seen in three years of intensive survey, the hairstreaks have not been seen in at least 20 (Table 1). Although each has their own life history attributes that may or may not limit detection, their non-detection and apparent declines have earned them similar statuses. These four subspecies are each assessed as Critically Imperiled at the state level (S1) on NatureServe (2026), and all are included in New Mexico's 2025 State Wildlife Action Plan as a Species of Greatest Conservation Need (NatureServe 2026; NMDW 2025).

Out of the four, the Sacramento Mountains checkerspot butterfly has the clearest extinction risk status and most robust recent history of data. It is additionally assessed as Critically Endangered on the IUCN Red List (Walk-

Sacramento Mountains checkerspot (*Euphydryas anicia cloudcrofti*)

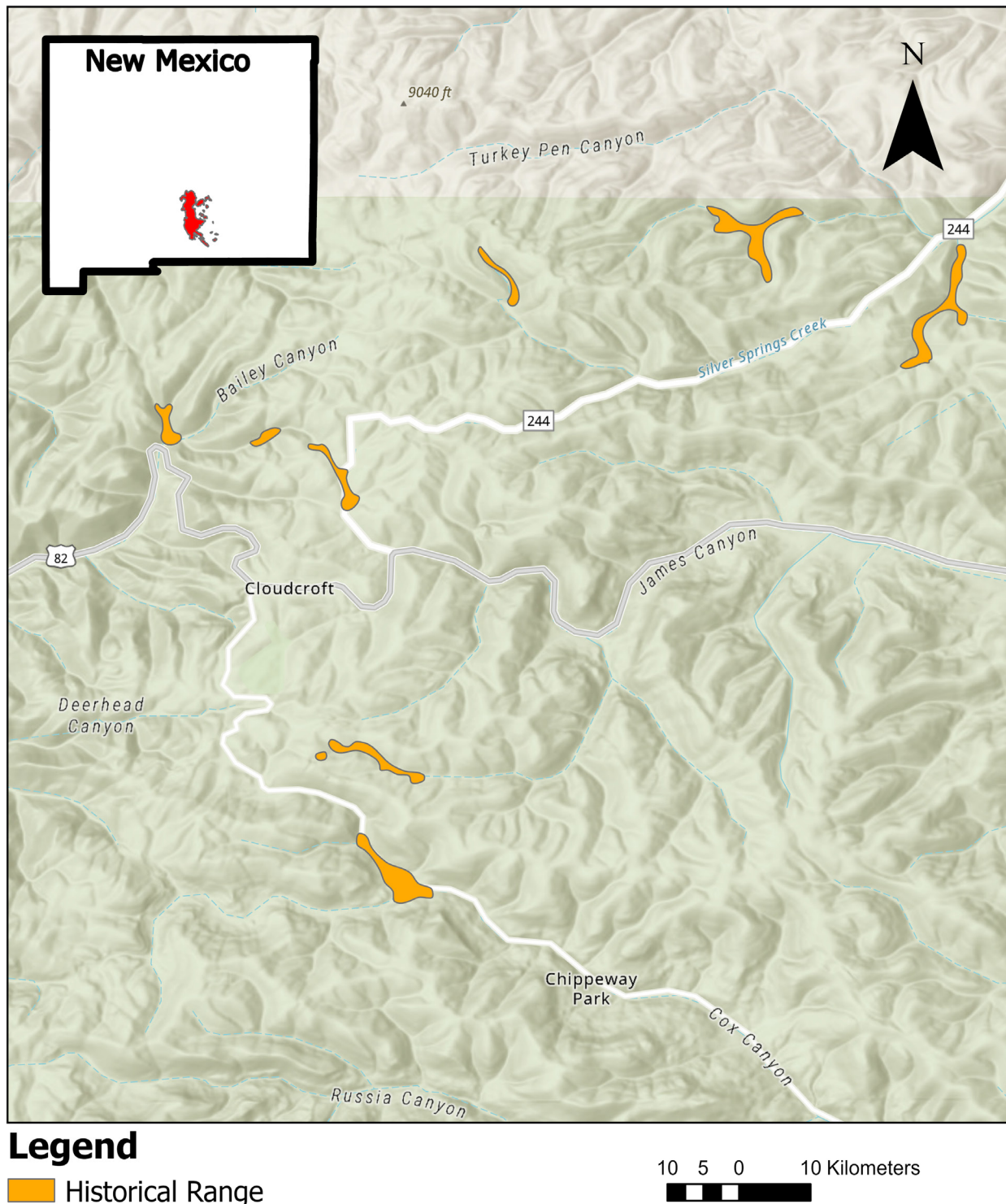


Figure 2. Map showing historical localities for Sacramento Mountains checkerspot (*Euphydryas anicia cloudcrofti* Ferris and Holland, 1980) with an inset showing the Sacramento Mountains in New Mexico.

Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus*)

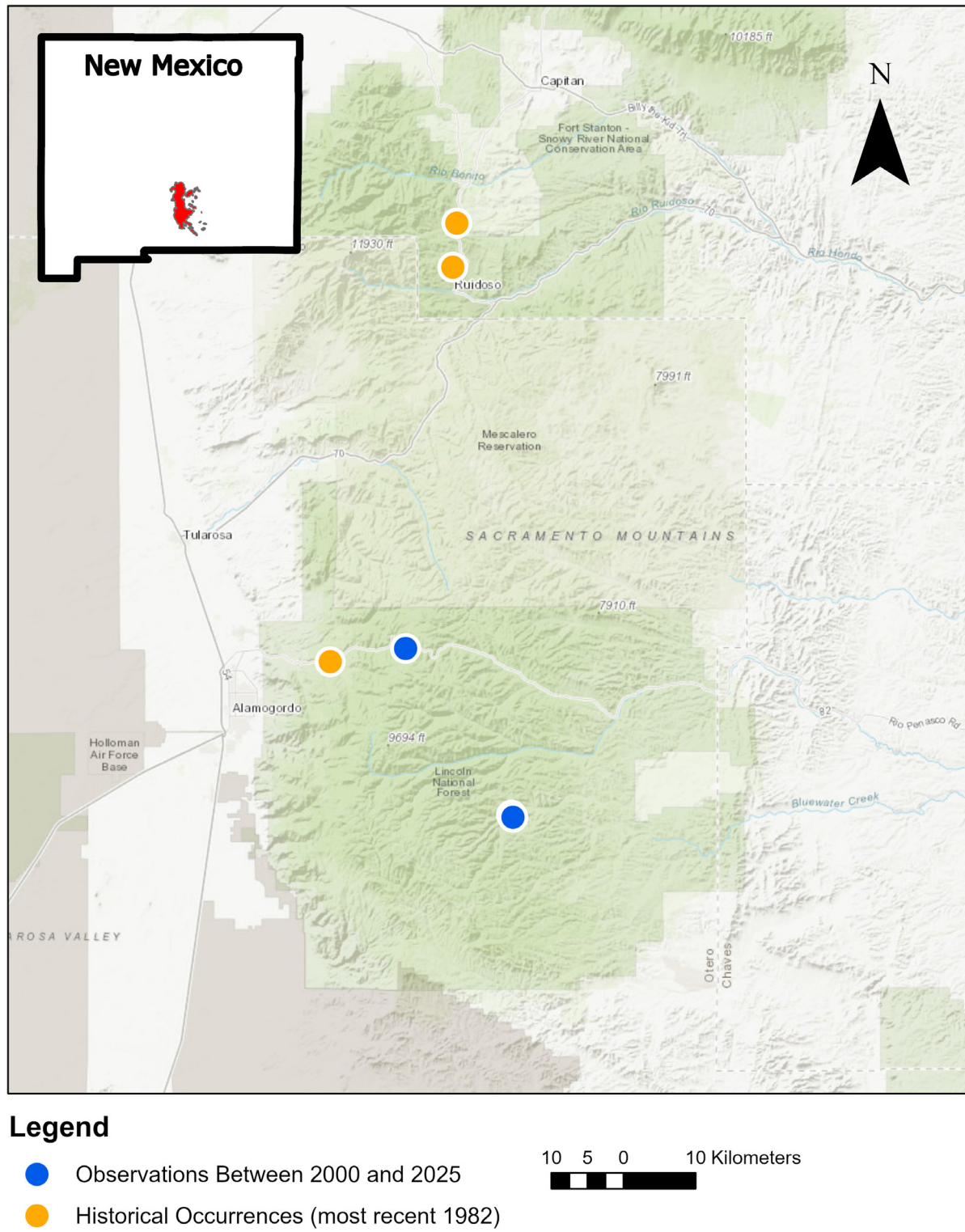


Figure 3. Map showing historical localities for Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus* Gorelick, 2005) with an inset showing the Sacramento Mountains in New Mexico.

Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento*)

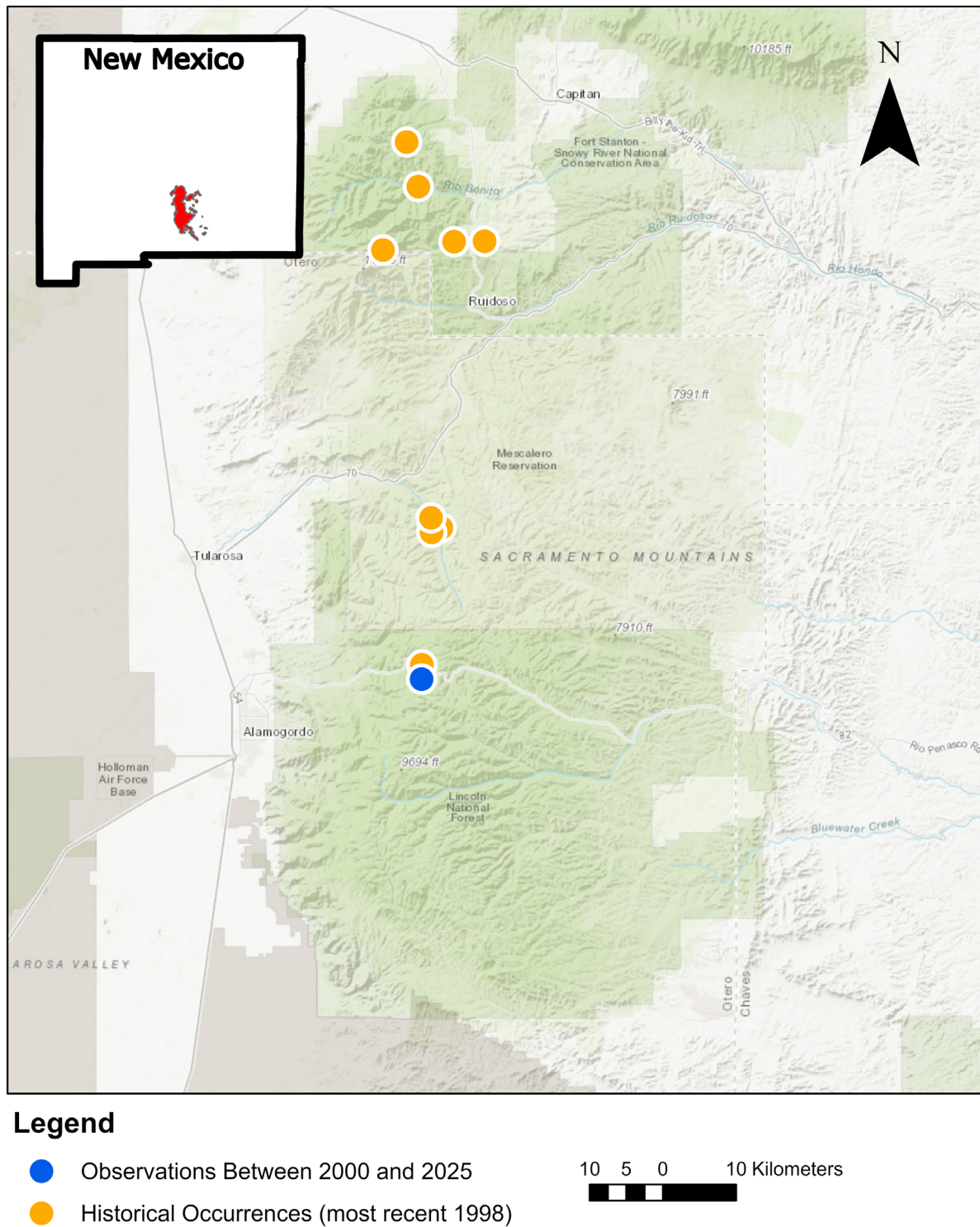


Figure 4. Map showing historical localities for Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento* Scott, 2006) with an inset showing the Sacramento Mountains in New Mexico.

Sacramento Mountains coral hairstreak (*Satyrium titus carrizozo*)

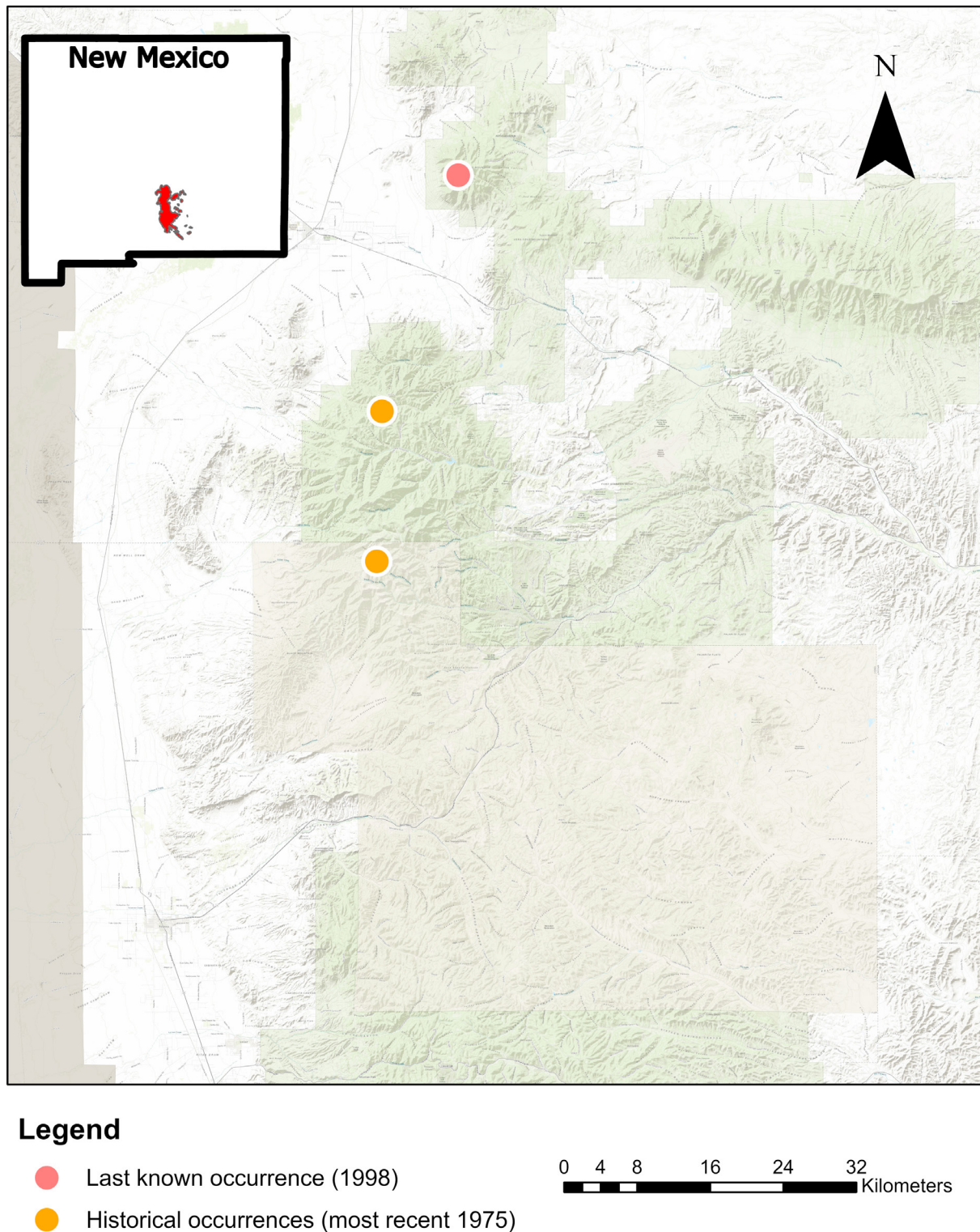


Figure 5. Map showing historical localities for Sacramento Mountains coral hairstreak (*Satyrium titus carrizozo* Holland, 2010) with an inset showing the Sacramento Mountains in New Mexico.

Table 1. Summary table of lost status of each of the four Sacramento Mountains endemic butterflies. CR = Critically Endangered, EN = Endangered, G5 = Globally Secure, T1 = Critically Imperiled (subspecies), S1 = Critically Imperiled (state-level) (NatureServe 2025; Walker et al. 2025). Search effort was determined by these authors taking into account the frequency and recency of known targeted surveys.

Subspecies	IUCN Red List Category	NatureServe Rank	Locality last observed	Year last observed	Search effort
Sacramento Mountains checkerspot	CR	G5T1 S1	Bailey Meadow, near Cloudcroft	2022	High
Sacramento Mountains western green hairstreak	EN (draft)	S1	Cienega Canyon, near Cloudcroft	2004	Low
Sacramento Mountains white-lined hairstreak	EN (draft)	S1	Cloudcroft vicinity	2002	Low
Sacramento Mountains coral hairstreak	CR (draft)	S1	Carrizo Peak	1998	Low

Table 2. Sacramento Mountains western green hairstreak (*Callophrys affinis albipalpus*) occurrence records.

Year	Latitude	Longitude	Locality
Unknown	32.94696	-105.83469	Georeferenced general locality of High Rolls. Accuracy is low.
1961	33.35853	-105.68205	Georeferenced Cedar Creek Campground
1982	33.40443	-105.67704	Georeferenced type locality: USA: NEW MEXICO: Lincoln Co., 5 mi. N of Ruidoso, Lincoln National Forest, 7000'
1982	33.40443	-105.67704	Georeferenced type locality: USA: NEW MEXICO: Lincoln Co., 5 mi. N of Ruidoso, Lincoln National Forest, 7000'
2002	32.96085	-105.74079	Georeferenced general locality of Cloudcroft. Accuracy is low.
2004	32.78420	-105.60720	See Butterflies and Moths of North America.
2004	32.78661	-105.60893	See Butterflies and Moths of North America.

er et al. 2025). Historically, this butterfly was reportedly common and relatively abundant in the Sacramento Mountains around Cloudcroft, and its host plant, New Mexico penstemon (*Penstemon neomexicanus*) was abundant throughout not just the Sacramento Mountains but also on Sierra Blanca, and in the Capitan Mountains (Pittenger and Yori 2003). Sustained declines have been documented since population monitoring of the checkerspot began in the late 1990s (Center for Biological Diversity 2021; Hughes 2020; USFWS 2023; more detail provided below). In 1998-2000, the butterfly was consistently documented at 10 meadow units within the Lincoln National Forest. Population sizes subsequently declined, and by 2018, no adults or larvae could be detected within the meadow units (Hughes 2020). Incidental detec-

tions of larval tents outside of the units in the Cloudcroft region occurred once in 2018, and once in 2021, and adults were observed at two meadows in 2021. The last sightings in the wild of the Sacramento Mountains checkerspot were 12 adult individuals in Bailey Meadow in 2022 (Walker et al. 2025). In late 2022, the butterfly was federally listed as Endangered. The last three meadows known to be occupied by the checkerspot are Bailey Meadow, Bailey Canyon, and Pines Campground. As of the time of the writing of this manuscript, the Sacramento Mountains checkerspot has not been observed in the wild for three and a half years.

There are limited data available for the other three subspecies, and in contrast to the checkerspot, they may have always been relatively low in abundance, or difficult to detect. How-

Table 3. Sacramento Mountains white-lined hairstreak (*Callophrys sheridanii sacramento*) occurrence records.

Year	Latitude	Longitude	Locality
1940	33.40174	-105.66052	Lincoln Co.: Alto, Sacramento Mts., 25-v-40 (Burdick, 1942)
1972	32.95282	-105.73766	Otero Co.: near Cloudcroft, Sacramento Mts., 21-iv-72 (JAS);
1974	33.50314	-105.75607	Lincoln Co.: Nogal Canyon, 7500', Sacramento Mts., 5-v-74,1 (RH);
1974	33.39278	-105.78500	Lincoln Co.: Sierra Blanca Ski Area, 10,000', Sacramento Mts., 13-v-74,2 (RH);
1974	33.45762	-105.74175	Lincoln Co.: Rio Bonito above Bonito Lake, 7000', Sacramento Mts., 5-v-74,1 (RH).
1974	33.10821	-105.71357	Otero Co.: 1 mi. SE of Head Springs, Mescalero Apache Indian Reservation, 7000', Sacramento Mts., 19-iv-74,3 (RH);
1975	33.39278	-105.78500	Sierra Blanca Ski Lodge; Lincoln County, New Mexico; 26 May, 1975 9700'; leg. Charles A. Bridges; Sec 33, T10S, R12E Charles A. Bridges
1976	32.96748	-105.73739	Otero Co.: Pine Campground, 8600', near Cloudcroft, Sacramento Mts., 12-vi-76,1 (RH);
1977	33.40133	-105.69787	Lincoln Co.: 2.5 mi. W of Alto, 8300', Sacramento Mts., 15-vi-77, 3 male (Clench, 1977);
1995	33.11834	-105.72616	Otero Co.: Head Spring, Mescalero Apache Indian Reservation, 7500', E slope, Sacramento Mts., 9-iv-95, 1 male, 2 female (RH); same data, 15-iv-95, 1 male, 3 female (RH and SJC);
1995	33.10357	-105.72533	Otero Co.: 1 mi. S of Head Spring, Mescalero Apache Indian Reservation, 7500', E slope, Sacramento Mts., 9-iv-95, 1 female (RH);
1995	33.11834	-105.72616	Otero Co.: Head Spring, Mescalero Apache Indian Reservation, c. 7200', Sacramento Mts., 15-iv-95,4 (RH and SJC).
2002	32.95282	-105.73766	Otero Co.: Cloudcroft, Sacramento Mts., 23-v-02 (CM coll.; fide HKC);

Table 4. Sacramento Mountains coral hairstreak (*Satyrrium titus carrizozo*) occurrence records.

Year	Latitude	Longitude	Locality
1971	33.37424	-105.80859	Sierra Blanca Mountain, Lincoln National Forest
1975	33.49739	-105.80346	10,000', summit of Nogal Peak, Sacramento Mts. Complex, 9-viii-75, leg. R. Holland: males, six types and paratypes, one aberration.
1975	33.49739	-105.80346	10,000', summit of Nogal Peak, Sacramento Mts. complex, 9-viii-75, leg. R. Holland: females, two types and paratypes.
1998	33.69063	-105.72854	Lincoln Co., New Mexico, 8800', microwave relay, Carrizo Peak, leg. R. Holland [& E. Caprisecca]. Female
1998	33.69063	-105.72854	Lincoln Co.: New Mexico, 8800', microwave relay, mostly July, Carrizo Peak, leg. R. Holland [& E. Caprisecca]. Male

ever, each has now gone unobserved for over 20 years, raising serious conservation concerns.

Few historical records of the Sacramento Mountains western green hairstreak butterfly exist. The type locality is the Cedar Creek Campground, approximately 10 km north of Ruidoso (Table 2) (Gorelick 2005; Toliver et al.

2001). Recent resurveying of this area found no adult butterflies or mature food plants, and it is believed that the subspecies is now completely extirpated from the type locality (Toliver et al. 2001; S.J. Cary pers. comm. 2025). Historically, it was also recorded around New Mexico state highways 37 and 48, above 2,100 m in eleva-

tion (Gorelick 2005). Further records have been reported from Cloudcroft and High Rolls, as recently as 2000 (Toliver et al. 2001). Most recently, the subspecies was found in 2004, when two records were made near Cienega Canyon, south of Cloudcroft (Cary and Toliver 2024; Lotts and Naberhaus 2024). To the best of our knowledge, it has not been observed since.

Similarly, the last observation of the Sacramento Mountains white-lined hairstreak was made in 2002, in the vicinity of the village of Cloudcroft, which is also the type locality (Table 3) (Scott 2008; Toliver et al. 2001). Historically it was also documented farther north, in the ski area of Sierra Blanca and in the White Mountains in the 1970s, and further south on the Mescalero Apache Reservation in the 1990s.

The Sacramento Mountains coral hairstreak has not been observed since 1998, when it was last seen on Carrizo Peak. The only other sightings of this butterfly occurred in September of 1975 on Nogal Peak in the White Mountains, and in 1971 on Sierra Blanca (Table 4) (Holland 2010).

Search effort

It is unknown exactly how well these butterflies have been searched for since the time of their description, and we are unfortunately limited to information from local butterfly enthusiasts, and presence-only data in online repositories. It is possible that out-of-state butterfly collectors/observers have searched for and or seen these butterflies, but we do not know much about these observations if they exist because they are either unidentified (for example, pictures only identified to genus), not digitized, or not published. We summarize the available information here.

For the Sacramento Mountains checkerspot, extensive search effort has been ongoing since the late 1990s and continues to the present. Following a petition for Endangered Species Act listing in 1999, the U.S. Forest Service established 10 stationary reference plots for adult butterflies and 10 for pre-diapause larval

tents across occupied meadows (Hughes 2020; USFWS 2023). Adults and larvae were initially present at all plots, with 139 larval tents recorded in 1999 and more than 1,600 adults recorded in 2000 (Center for Biological Diversity 2021). Subsequent monitoring documented steady declines, with adult counts reaching zero by 2014 and no larval tents detected by 2018 (Hughes 2020). In response, survey effort expanded in 2018 from fixed plots to entire meadow systems after the subspecies was deemed too rare to detect using reference plots alone; however, no larval tents were found despite this expanded effort (Hughes 2020; NM-RARe 2024; Walker et al. 2025).

In 2020, intensive range-wide surveys were conducted for both adults and larval tents, resulting in the detection of eight adults across two meadows and no larval tents (Hughes 2020; USFWS 2023; Walker et al. 2025). In 2022, 12 adults were detected in a single meadow, while no individuals were observed at a second meadow known to have been occupied in 2020 and 2021. Survey effort in 2022 was substantially expanded, with near-daily coverage throughout the flight period. Given the restricted range and the intensity of survey effort, we posit that it is unlikely that many adults were missed. Following federal listing in late 2022, near-daily surveys continued in 2023, yet no individuals were detected (Cary and Toliver 2024; USFWS 2023). Comparable effort in 2024 also failed to detect any individuals (D.L. Lightfoot pers. comm. 2025). During the 2024 and 2025 field seasons, experts conducted weekly, multi-month searches focused on the last three known occupied meadows, yet no individuals were found.

Despite this extensive effort, some uncertainty remains. Historical populations are known from the Mescalero Apache Reservation north of Cloudcroft, and it is unclear whether systematic surveys have been conducted there. Lands managed by the Mescalero Apache Tribe have been less severely affected by water extraction for residential, livestock, and commercial uses, and include higher elevation peaks that receive

greater snowpack and sustain higher summer water availability. As a result, these areas may represent the most likely refugia for the checkerspot, making coordination with tribal partners essential for future conservation efforts. In addition, not all historical habitat patches have been thoroughly surveyed in recent years, and it remains possible that the butterfly persists in one or more unsurveyed or under-surveyed meadows. Private lands, particularly those with fencing to keep out horses, or greater water availability, may also support suitable habitat and should be prioritized for future surveys through collaboration with landowners.

Search effort for the other three subspecies, for which we have fewer data, has been more limited and less systematic. At least two attempts to locate the Sacramento Mountains western green hairstreak at its type locality at the former NMSU research station in the Sacramento Mountains have been made and were unsuccessful (S. J. Cary pers. comm. 2025), leading to the conclusion that it has likely been extirpated from that site. The butterfly was also searched for in April of 2025. On the 29th of April a three-person team including SMD searched Pendleton Canyon for the butterfly and found the host plant *Ceanothus fendleri* as well as the Pacuvius duskywing [*Gesta (Erynnis) pacuvius*], which also feeds on *C. fendleri*. The following day the group searched for the butterfly on the same ridge where Steve Cary had found the butterfly in 2004 but could not locate it. Another attempt at these same sites was made on 26 August 2025 by a two-person team led by Steve Cary. This team also searched Seep Canyon and Potato Canyon but could not find any Sacramento Mountains western green hairstreak (S. J. Cary pers. comm. 2025). In recent years, it has been searched for opportunistically during surveys for the Sacramento Mountains checkerspot, as the two taxa overlap in flight period and buckwheats are frequently present in checkerspot habitat. Despite this incidental effort, no individuals have been detected.

Targeted search effort for the Sacramento Mountains white-lined hairstreak has been

more limited. As far as we are aware, there have not been any targeted searches performed in the twenty-two years since it was last observed in 2002, with one exception. A focused five-day search in April 2024, and a four-day search in late April and early May of 2025 failed to detect any individuals (S.J. Cary pers. comm. 2025). These searches did locate the host plant, *Eriogonum wootoni*, in several locations, including Carrizo Mountain, Rio Bonito above Argentina Canyon, in meadows surrounding Cloudcroft, and in Pendleton Canyon. Despite searching during historic peak flight, however, no Sacramento Mountains white-lined hairstreak were observed (S.J. Cary pers. comm. 2025). As detailed above, extensive survey effort has been devoted to the Sacramento Mountains checkerspot habitat in the meadows outside Cloudcroft where *Eriogonum wootonii* is common, although adult flight periods of the two butterflies overlap little. During those checkerspot-focused expeditions in 2024 and 2025, we also searched for larvae of this subspecies, but none were found. However, detection of larvae is quite difficult, particularly on host plants with low-growing vegetation, and it is unknown if larvae hide during the day. As a result, this should be considered a fairly minimal search effort.

For the Sacramento Mountains coral hairstreak, experts have attempted to relocate two of the three known historic colonies without success. One multi-day effort targeted Nogal Peak, and three separate multi-day efforts focused on Carrizo Peak (Holland 2010; S.J. Cary pers. comm. 2025). The third site, Sierra Blanca, has apparently not been re-visited specifically for survey of this butterfly.

Threats

Butterflies endemic to the Sacramento Mountains are collectively threatened by habitat loss, degradation, and fragmentation driven by a combination of land use change, altered disturbance regimes, and climate stressors. Residential and commercial development remains

an ongoing concern, particularly in areas surrounding Cloudcroft in the south end of the mountains. For example, in 2001, Cloudcroft expanded its boundaries into Lincoln National Forest under the Townsite Act of 1958, increasing the potential for direct habitat loss, water extraction, and edge effects in adjacent meadow systems (Pittenger and Yori 2003; USFWS 2004).

Livestock grazing and browsing by wild ungulates represent major stressors across the Sacramento Mountains. Heavy grazing has been linked to reduced host plant abundance, diminished nectar availability, and altered meadow composition. Studies have documented declines in host plant health of up to 60% under grazing pressure, with selective encroachment by species such as sleepy grass (*Achnatherum robustum*) displacing native nectar plants (Hughes 2020; McIntyre 2010; NM-RARE 2024; Walker et al. 2025). These changes reduce habitat quality for multiple butterfly species and exacerbate fragmentation.

Three of the four discussed subspecies here are exclusive specialists on a single host plant species. This specificity drastically increases vulnerability to habitat loss and degradation; if the host plant taxon experiences declines or extirpation, there is no alternative host, and so there is a cascading effect on the butterflies. Both New Mexico penstemon and Wootton's buckwheat are endemics to the mountains and are Strategy Species on the New Mexico Rare Plants list (New Mexico Rare Plant Technical Council 1999).

Non-target effects of insecticide use in general have been identified as one of the leading causes of butterfly decline in the US (Edwards et al. 2025) and broad pesticide application has been widespread in the Sacramento Mountains. During spruce budworm outbreaks, carbaryl was aerially applied over more than 240,900 acres in the early 1980s, and later applications of *Bacillus thuringiensis* var. *kurstaki* were used near Cloudcroft in 2007 to suppress Janet fir looper (Bennett and Linnea 1985; Holland 2007; NM-RARE 2024; Walker et al. 2025). Such treatments directly affect all Lepidoptera,

not just the target pest, and lepidopterans are particularly prone to widespread contamination because they have a higher rate of visitation to flowering plants than other pollinators, like bees (Barrios et al. 2016). Indirect exposure is also a risk; herbicides drift from application targets to sources like dew and mud puddles, and in the air can interfere with pheromone signaling (Mallick et al. 2023). Interactions with pesticides cause both larval and adult mortality, and in lower concentrations can impact development and reduce fecundity and reproductive success (Braak et al. 2018; Mulé et al. 2017). While toxicity levels are not known from these species in particular, it is very likely that exposure puts them at increased risk of decline, especially in landscape with multiple intersecting threats.

The history of fire management in North America has had a detrimental effect on connectivity and resilience of many butterfly populations (Gates et al. 2021; Huntzinger 2003). Fire suppression has fundamentally altered forest and meadow structure throughout the Sacramento Mountains since the early 1900s, resulting in dense conifer encroachment, reduced early successional habitat, and increased fuel loads (Kaufmann et al. 1998). Over the past 50 years, at least nine large wildfires have burned more than 34,000 acres in the range. While low-severity fire may benefit some butterfly taxa by maintaining open habitat, severe or widespread fires pose risks of direct mortality and loss of host and nectar plants (Kaufmann et al. 1998; USFWS 2004; Walker et al. 2025). The Sacramento Mountains western green hairstreak, in particular, is an early successional specialist dependent on frequent fire to maintain open habitat. Decades of fire suppression have eliminated much of the habitat structure required for persistence, leading to fragmentation and likely extirpation from the type locality (Cary and Toliver 2024; Toliver et al. 2001).

Climate change has emerged as an additional, compounding threat to butterflies. From 2000 to 2021, the southwestern United States saw its driest 22-year period since 800 CE, with

projections indicating increasingly frequent, severe, and prolonged drought under future climate scenarios (Klavans et al. 2025; Williams et al. 2022). Extended drought reduces host plant vigor and recruitment, reduces nectar availability, increases environmental variability, elevates fire severity and frequency, and intensifies population stress (Hughes 2020; NM-RARe 2024). Furthermore, alpine butterflies often need high snowpack levels during diapause in order to shelter from wind and cold temperatures (Roland et al. 2021; USFWS 2025). The Sacramento Mountains Checkerspot has been suggested to be one such butterfly because in our observations, it is highly sensitive to small changes in humidity, temperature, and light conditions during overwintering in captivity (USFWS 2025). Over the last two decades the Sacramento Mountains have been reported to no longer always have consistent snowpack during the winter. This may expose larvae to extreme cold temperatures, as well as to warm temperatures, which may cause them to come out of diapause and begin moving around burning valuable energy; equally important is that lack of snow cover exposes overwintering larvae to desiccating soil conditions. Furthermore, this lack of snowpack may leave the caterpillars exposed to natural enemies for much longer periods of time throughout the year. Many butterflies respond to changing climate by shifting upslope or poleward; however, for high-elevation Sacramento Mountains endemics, suitable habitat is limited or absent beyond current ranges, and northward dispersal is constrained by surrounding desert landscapes (Ehrlich and Murphy 1987; Holland 2010; Rödder et al. 2021). The Sacramento Mountains coral hairstreak faces acute risk from climate change due to its restriction to the absolute highest elevations in the range, leaving little opportunity for upslope movement as conditions warm (Holland 2010). Additionally, in 2026, a modeling project initiated by Natural Heritage New Mexico predicted the distribution of the checkerspot host plant *Penstemon neomexicanus* under two different carbon

emissions scenarios. Under the moderate climate change scenario, a 92.8% loss of suitable habitat was predicted by 2075 and under high climate change a 99.2% decrease was predicted (Muldavin and Sadoti 2026).

Declining population sizes across taxa further increases vulnerability to genetic drift and inbreeding depression. Habitat fragmentation limits movement among remaining habitat patches, reducing gene flow and adaptive potential. In small, isolated populations, even short periods of inbreeding can lead to reduced survival and population stability (Nieminen et al. 2001; Saccheri et al. 1998). Inbreeding is identified as one of the most severe threats for the Sacramento Mountains checkerspot (Ryan and Milligan 2013) and could potentially play a serious role in the survivability of the other three butterflies treated here as well, given habitat patchiness. A 2013 study by NMSU and New Mexico Department of Game and Fish found high levels of inbreeding depression among the remaining subpopulations of the Sacramento Mountains Checkerspot (Ryan and Milligan 2013).

Rediscovery strategy

Immediate effort is needed to locate any remaining populations of Sacramento Mountains endemic butterflies before further extirpations occur. One tool to assist in rediscovery and possibly uncover new localities for survey would be to assess existing butterfly collections that may not be identified or digitized. It would be worthwhile for collectors and managers to check holdings of Lycaenidae in particular for localities in Otero and Lincoln counties, identify specimens, and make data public where possible. Identification assistance for unknown or potentially misidentified specimens from the study area can be coordinated through the authors of this work.

Locating extant colonies or individual adults may represent the only opportunity to initiate conservation actions such as captive breeding or habitat protection. Efforts to do this have to

focus not only on historical colonies, but especially need to focus on exploring promising new sites that have yet to be surveyed. Because these butterflies have a narrow host range, including on some known rare plants, the best data on habitat suitability and larval presence may come from regional foresters and botanists, who regularly interact with the flora of the mountains. One recommendation is to utilize occurrences of the host plant taxa, for which there are more environmental data than there are for the butterflies, to define suitability models that could outline new areas of potential habitat. Other data sets such as hydrology, soil, and fire maps, as well as aerial imagery, may assist in the identification of suitable habitat and guide survey efforts. Collaboration could be the key to rediscovery, especially given a paucity of local lepidopterists and limited public access to the high-elevation areas of the Sacramento Mountains.

Survey timing is critical for adult observation. Flight periods across these taxa generally span late spring through summer, with phenology varying by taxa and potentially shifting under climate change. Surveys should therefore be conducted across the full range of historically documented flight windows and repeated across years to account for interannual variation. Where possible, surveys should target known nectar plants, larval host plants, and other microhabitat features associated with each butterfly.

The Sacramento Mountains checkerspot, tragically, may already be extinct in the wild. However, volunteer survey teams made up of scientists, community members, and agency personnel will continue to monitor most recently occupied sites and will continue to do so in the event that the subspecies' remarkable ability to live as larvae for multiple seasons means that adults may still return to the meadows. Adults historically flew from June through mid-July, with a peak in early July (McIntyre 2010). Searches during this period likely remain the most effective strategy, although phenological shifts are possible (USFWS 2023).

Adults exhibit a strong preference for nectaring on orange sneezeweed (*Hymenoxys hoopesii*); during intensive surveys in 2000, over 80% of adult observations were made on this plant (Hughes 2020; McIntyre 2010). Surveys should therefore prioritize meadows where orange sneezeweed remains abundant. Other meadow systems should also be surveyed, as suitable habitat may persist in areas not recently examined. Historical populations were also documented north of Cloudcroft on the Mescalero Apache Reservation, and coordinated surveys or partnerships with the Mescalero Apache Tribe could substantially expand search coverage in potentially suitable habitat.

Search strategies for the Sacramento Mountains western green hairstreak should focus on early successional habitats, particularly areas affected by recent fire. Because this subspecies specializes on transient post-disturbance habitat, many historical collection localities may no longer be suitable, complicating rediscovery efforts. Nevertheless, historical sites should still be examined, and particular attention should be paid to the edges of burn scars, where host plants and adults were last observed. The most recent records from 2004 were associated with the interface between the Scott Abel Fire and the earlier Pendleton Fire, suggesting that burn boundaries may represent especially productive search areas (S.J. Cary pers. comm. 2025). This subspecies is bivoltine in most years, with flight dates ranging from early June through mid-September and apparent peaks from late June to late July (Gorelick 2005; Lotts and Naberhaus 2024; Toliver et al. 2001). Nectar use differs between broods, with the first brood often visiting annual yellow sweetclover (*Melilotus indicus*) and the second brood frequently nectaring on James' buckwheat (*Eriogonum jamesii*) (Gorelick 2005).

The Sacramento Mountains white-lined hairstreak is univoltine, with documented flight records from early April through early July, and peak abundance likely occurring in May and June (Cary and Toliver 2024; Toliver et al. 2001). Initial efforts should focus on

historical localities; however, because this subspecies uses forest openings, some former sites may no longer provide suitable habitat. As such, surveys should also target any open areas supporting Wootton's buckwheat. There is a report of a disjunct population of Wootton's buckwheat farther north in the Gallinas Mountains that might be worth visiting to survey as well (New Mexico Rare Plants Technical Council 1999). Although specific nectar plant records are lacking, adults are known to nectar opportunistically and to puddle at wet soil, suggesting that areas with moisture and flowering resources may increase detection probability (Cary and Toliver 2024).

The Sacramento Mountains coral hairstreak is also univoltine, with records spanning late June through early August (Holland 2010; Toliver et al. 2001). Searches should prioritize Carrizo Peak, Nogal Peak, and Sierra Blanca, which encompass the known historical range. Locating stands of chokecherry (*Prunus melanocarpa*) is critical, as all known records of this subspecies are closely associated with this host plant (Cary and Toliver 2024; Holland 2010). Given the extremely limited number of historical observations, surveys should be repeated across years and across the full flight window to maximize detection probability.

For all of these butterflies, collaboration is going to be an essential step towards their re-discovery. Much of the land in the Sacramento Mountains lies in the hands of tribal and private landowners. This has resulted in a lot of the range being unsampled. Given their disappearance from public lands, collaboration with these entities may be essential to these butterflies' survival and may represent our only chance of finding them.

CONCLUSION

Immediate efforts are needed to locate these four butterflies. There is serious concern regarding their persistence given the length of time since their last confirmed observations, and despite

targeted survey efforts and their designation as New Mexico Species of Greatest Conservation Need with Critically Imperiled NatureServe statuses. These taxa may also serve as important indicators of ecosystem health in the Sacramento Mountains, a regional biodiversity hotspot.

The critical habitats that support these butterflies, primarily sunny, early successional openings within an otherwise forested landscape, are themselves increasingly imperiled by climate change, altered fire regimes resulting from fire suppression, livestock grazing, water withdrawals, and ongoing land-use change. These stressors compound existing threats and further reduce the availability and quality of suitable habitat. As documented here and elsewhere, the Sacramento Mountains support a high diversity of imperiled plants, invertebrates, and vertebrates, many of which are likely experiencing parallel declines.

Together, these patterns highlight the need for immediate, coordinated conservation action focused not only on these focal butterfly taxa but on the broader community of early successional specialists in the region. Proactive management and restoration of these open habitats will be essential to preventing further biodiversity loss and maintaining ecological function in this increasingly vulnerable mountain ecosystem.

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Data accessibility

All occurrence records come from Toliver et al. (2001), Cary and Toliver (2024), Walker et al. (2025), and GBIF (2025).

Author contributions

S.D. conceived the study, created the map figures, and wrote the first draft of this manuscript. Q.B. reviewed, edited, and supported revisions of the manuscript. Both authors compiled data and life history information. Both authors read and approved the final submission of the manuscript.

Ethical standards and competing interests

Findings from this work were based on publicly available specimen records, and from notes received personally from regional Lepidoptera expert, Steven J. Cary. No permits were required to compile the information contained herein. The authors are both volunteer members of the U.S. Fish and Wildlife Recovery Team for the Sacramento Mountains checkerspot butterfly and have participated in unpaid surveys for this subspecies. The authors have no competing interests.

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Literature cited

- Barrios B, Pena RS, Salas A, Koptur S. 2016. Butterflies visit more frequently, but bees are better pollinators: the importance of mouthpart dimensions in effective pollen removal and deposition. *AoB Plants* 8: plw001. doi.org/10.1093/aobpla/plw001
- Bennett DD, Linnane JP. 1985. Western spruce budworm suppression project. Forest Pest Management Report R-3 85–11. U.S. Forest Service, Southwestern Region.
- Braak N, Neve R, Jones AK, Gibbs M, Breuker CJ. 2018. The effects of insecticides on butterflies – a review. *Environmental Pollution* 242(A): 507–518. doi.org/10.1016/j.envpol.2018.06.100
- Cary SJ, Toliver ME. 2024. Butterflies of New Mexico. <https://peecnature.org/butterflies-of-new-mexico/> (accessed 13 February 2025).
- Center for Biological Diversity. 1998. Petition to list Cloudcroft checkerspot butterfly. *Endangered Species Report* No. 41. Southwest Center for Biological Diversity. https://www.biologicaldiversity.org/species/invertebrates/Sacramento_Mountains_checkerspot_butterfly/pdfs/checkerspot-petition-11-98.pdf (accessed 18 July 2025).
- Cushman JH, Murphy DD. 1993. Conservation of North American lycaenids – an overview. Pages 37–44 in New TR, ed. *Conservation Biology of Lycaenidae (Butterflies)*. IUCN, Gland, Switzerland.
- Edwards C, Zipkin EF, Henry EH, Haddad NM, Forister ML, Burls KJ, Campbell SP, Crone EE, Diffendorfer JJ, Douglas MR, Drum RG, Fallon CE, Glassberg J, Grames EM, Hatfield R, Hershovich S, Black SH, Larsen EA, Leuenberger W, Linders MJ, Longcore T, Marschalek DA, Michielini J, Neupane N, Ries L, Shapiro AM, Swengel AB, Swengel SR, Taron DJ, Van Deynze B, Wiedmann J, Thogmartin WE, Schultz CB. 2025. Rapid butterfly declines across the United States during the 21st century. *Science* 387: 1090–1094. doi.org/10.14411/eje.2026.012
- Ehrlich PR, Murphy DD. 1987. Conservation lessons from long-term studies of checkerspot butterflies. *Conservation Biology* 1: 122–131. doi.org/10.1111/j.1523-1739.1987.tb00021.x
- Ehrlich PR, Hanski I. 2004. On the wings of checkerspots: A model system for population biology. Oxford University Press, New York.
- Ferris C, Holland R. 1980. Two new subspecies of *Occidryas anicia* (Doubleday) from New Mexico. *Bulletin of the Allyn Museum* 57: 90.
- Gates D, Jackson B, Schoville SD. 2021. Impacts of fire on butterfly genetic diversity and connectivity. *Journal of Heredity* 112: 367–376. doi.org/10.1093/jhered/esab027
- Global Biodiversity Information Facility. 2025. GBIF occurrence download. Available at: doi.org/10.15468/dl.hhezmt (accessed 12 February 2025).
- Gorelick GA. 2005. A review of *Callophrys affinis* (W. H. Edwards), with descriptions of two new subspecies from New Mexico and Mexico. *Journal of the Lepidopterists' Society* 59: 181–199.
- Holland R. 2007. Holland letter about Sacramento Mountains Checkerspot. https://pdf.wildearthguardians.org/support_docs/letter_checker-spot-butterfly_10-16-07.pdf (accessed 12 February 2025).
- Holland R. 2009. *Lepidoptera of North America 9: Butterfly distribution and dispersion across the montane islands and drainages of the Chihuahuan Desert*. C. P. Gillette Museum of Arthropod Diversity Publishing, Fort Collins, Colorado. 38 pp.
- Holland R. 2010. A new subspecies of *Satyrrium titus* (Lycaenidae: Theclinae) from South Central New Mexico. *Journal of the Lepidopterists' Society* 64: 166–171. doi.org/10.18473/lepi.v64i3.a6
- Hughes P. 2020. Population status of the Sacramento Mountain checkerspot butterfly and current tactics proposed to mitigate the probability of

- imminent extinction. U.S. Forest Service, Sacramento Ranger District.
- Huntzinger M. 2003. Effects of fire management practices on butterfly diversity in the forested western United States. *Biological Conservation* 113: 1–12. doi.org/10.1016/S0006-3207(02)00356-7
- International Union for Conservation of Nature. 2025. The IUCN Red List of Threatened Species. Version 2025-2. Available at: <https://www.iucnredlist.org> (accessed 17 December 2025).
- Kaufmann MR, Huckaby LS, Regan CM, Popp J. 1998. Forest reference conditions for ecosystem management in the Sacramento Mountains, New Mexico. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Klavans, JM, DiNezio PN, Clement AC, Deser C, Shanahan TM, Cane MA. 2025. Human emissions drive recent trends in North Pacific climate variations. *Nature* 644: 684–692. doi.org/10.1038/s41586-025-09368-2
- Lee-Chadde S, Huenneke LF. 1997. Rare Plants of the Sacramento Mountains. New Mexico State University Department of Biology, Las Cruces, New Mexico.
- Lotts K, Naberhaus T. 2024. Butterflies and Moths of North America. <https://www.butterfliesandmoths.org/> (accessed 13 August 2024).
- Mallick B, Rana S, Ghosh TS. 2023. Role of herbicides in the decline of butterfly population and diversity. *Journal of Experimental Zoology Part A: Ecological and Integrative Physiology* 339: 346–356. doi.org/10.1002/jez.2688
- McIntyre J. 2010. Habitat variables, mammal interactions, and recovery approaches important to a rare, new Mexican butterfly, *Euphydryas anicia cloudcrofti* (Lepidoptera: Nymphalidae). University of New Mexico, Albuquerque, New Mexico.
- Muldavin E, Sadoti G. 2026. Predicted distributions of 20 sensitive species for the years 2060, 2075, and 2090 in New Mexico under two different carbon emission scenarios. U.S. Geological Survey data release 2026. doi.org/10.5066/P1CXTSUB (accessed 3 February 2026).
- Mulé R, Sabella G, Robba L, Manachini B. 2017. Systematic review of the effects of chemical insecticides on four common butterfly families. *Frontiers in Environmental Science* 5: 32. doi.org/10.3389/fenvs.2017.00032
- NatureServe. 2026. NatureServe Explorer. <https://explorer.natureserve.org/> (accessed on 9 January 2026).
- New Mexico Department of Wildlife. 2025. State Wildlife Action Plan for New Mexico. New Mexico Department of Wildlife, Santa Fe, New Mexico.
- New Mexico Rare Arthropods Technical Council (NM-RARe). 2024. New Mexico Rare Arthropod Resource. <https://nmrare.org/> (accessed 15 July 2025).
- New Mexico Rare Plant Technical Council. 1999. New Mexico Rare Plants. <https://nmrareplants.unm.edu/> (accessed 15 July 2025).
- Nieminen M, Singer M, Fortelius W, Schöps K, Hanski I. 2001. Experimental confirmation that inbreeding depression increases extinction risk in butterfly populations. *American Naturalist* 157: 237–244. doi.org/10.1086/318630
- Pittenger J, Yori K. 2003. Abundance, population structure, and habitat of the Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti* Holland and Ferris 1980), with notes on life history and ecology. Blue Earth Ecological Consultants, Oakland, California.
- Rödder D, Schmitt T, Gros P, Ulrich W, Habel JC. 2021. Climate change drives mountain butterflies towards the summits. *Scientific Reports* 11: 1–10. doi.org/10.1038/s41598-021-93826-0
- Roland J, Alessandro F, Matter SF. 2021. Spatial variation in early-winter snow cover determines local dynamics in a network of alpine butterfly populations. *Ecography* 44(2): 334–43. doi.org/10.1111/ecog.05407
- Ryan R, Milligan B. 2013. Using metapopulation analysis and risk assessment to improve conservation of Sacramento Mountains checkerspot butterfly (*Euphydryas anicia cloudcrofti*), a species of greatest conservation need. New Mexico State University, Las Cruces, New Mexico.
- Saccheri I, Kuussaari M, Kankare M, Vikman P, Fortelius W, Hanski I. 1998. Inbreeding and extinction in a butterfly metapopulation. *Nature* 392: 491–494. doi.org/10.1038/33136
- Scott JA, Fisher MS, Kondla NG, Kohler S, Guppy CS, Spomer SM, Schmidt CB. 2006. Taxonomic studies and new taxa of North American butterflies. *Papilio (New Series)* 12: 1–73. <http://hdl.handle.net/10217/84934>
- Scott JA. 2008. Biological catalogue of North American butterflies. *Papilio (New Series)* 20: 1–50. <http://hdl.handle.net/10217/84942>
- Scott JA, PA Opler. 2017. Another endemic butterfly in the Sacramento Mountains of southern New Mexico, with a review of those endemics.

- Papilio* (New Series) 26: 1–54. <http://hdl.handle.net/10217/180839>
- Seersholm, FV, Werndly DJ, Grealy A, Johnson T, Keenan Early EM, Lundelius Jr. EL, Winsborough B, Farr GE, Toomey R, Hansen AJ, Shapiro B, Waters MR, McDonald G, Linderholm A, Stafford Jr. TW, Bunce M. 2020. Rapid range shifts and megafaunal extinctions associated with late Pleistocene climate change. *Nature Communications* 11: 2770. doi.org/10.1038/s41467-020-16502-3
- Sivinski R. 2007. New Mexico rare plants: *Eriogonum wootonii*. Wooton's wild buckwheat. <https://nmrareplants.unm.edu/> (accessed 3 August 2025).
- Toliver ME, Holland R, Cary SJ. 2001. Distribution of butterflies in New Mexico (Lepidoptera: Hesperioidea and Papilionoidea). Third edition. 187 pp. Albuquerque, New Mexico.
- U. S. Fish and Wildlife Service. 1997. Determination of endangered status for the Laguna Mountains Skipper and Quino Checkerspot Butterfly. *Federal Register* 62: 2313–2322.
- U. S. Fish and Wildlife Service. 2004. Endangered and threatened wildlife and plants; withdrawal of the proposed rule to list the Sacramento Mountains Checkerspot Butterfly as endangered with critical habitat. *Federal Register* 69: 76428–76445.
- U. S. Fish and Wildlife Service. 2010. Sacramento Mountains Thistle (*Cirsium vinaceum*) 5-Year Review: Summary and Evaluation. U.S. Department of the Interior, Fish and Wildlife Service. *Federal Register* 52: 22933–22936.
- U. S. Fish and Wildlife Service. 2013. Determination of endangered status for the Taylor's Checkerspot Butterfly and threatened status for the Streaked Horned Lark; final rule. *Federal Register* 78: 61452–61503.
- United States Fish and Wildlife Service. 2023. Endangered and threatened wildlife and plants; endangered species status for Sacramento Mountains Checkerspot Butterfly. *Federal Register* 88: 6177–6191.
- U.S. Fish and Wildlife Service. 2025. Final Recovery Plan for the Sacramento Mountains Checkerspot Butterfly (*Euphydryas anicia*). U.S. Fish and Wildlife Service, Washington, DC. https://ecos.fws.gov/docs/recovery_plan/SMCB_Final%20Recovery%20Plan_Signed.pdf (accessed 3 February 2026).
- Wagner DL. 2026. Insect biodiversity in the Anthropocene. In: Goldstein, MI, Costello MJ, Elias S, eds. *The Encyclopedia of the Anthropocene*, 2nd Ed. Elsevier, Oxford.
- Walker A, Ryan R, Hughes P, Williams J, Bainbridge E. 2025. *Euphydryas anicia* ssp. *cloudcrofti*. The IUCN Red List of Threatened Species 2025: e.T209895895A210975091. <https://dx.doi.org/10.2305/IUCN.UK.2025-1.RLTS.T209895895A210975091.en> (accessed 20 August 2025).
- Warren AD, Davis KJ, Stangeland EM, Pelham JP, Willmott KR, Grishin NV. 2024. Butterflies of America: illustrated lists of American butterflies. <https://www.butterfliesofamerica.com/> (accessed 13 February 2025).
- Williams AP, Cook BI, Smerdon JE. 2022. Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. *Nature Climate Change* 12: 232–234. doi.org/10.1038/s41558-022-01290-z