U.S. Fish & Wildlife Service

Recovery Plan for Laguna Mountains Skipper
(*Pyrgus ruralis lagunae*)

Mendenhall Valley (photo courtesy of Alison Anderson, Service), Laguna Mountains skipper (photo courtesy of Tom Mendenhall).

Recovery Plan for Laguna Mountains Skipper
(*Pyrgus ruralis lagunae*)

Region 8
U.S. Fish and Wildlife Service
Sacramento, California

Approved: ______________________

Regional Director, Pacific Southwest Region, Region 8,
U.S. Fish and Wildlife Service

Date: 5/2/19

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An electronic copy of this recovery plan will be made available at:

http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=I0LW

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EXECUTIVE SUMMARY

Species Current Status
We, the U.S. Fish and Wildlife Service (Service), listed the Laguna Mountains skipper (*Pyrgus ruralis lagunae*) as endangered in 1997 (Service 1997), under the Endangered Species Act of 1973 (Act), as amended. Laguna Mountains skipper is assigned a Recovery Priority Number of 3C, which indicates the species faces a high degree of threat, has a high recovery potential, and conflict with economic activities. At the time of listing, the subspecies occurred in the Laguna Mountains and on Palomar Mountain in San Diego County, California. Laguna Mountains skipper is currently restricted to Palomar Mountain where there are four extant occurrences. They inhabit large wet mountain meadows and associated forest openings at elevations above 3,900 feet (ft) (1,189 meters (m)) in elevation. Adult occupancy is also associated with surface water such as streams and wet seeps, and population growth appears positively correlated with rainfall levels. Laguna Mountains skipper's primary host plant is *Horkelia clevelandii* (Cleveland's horkelia).

Threats
The best available scientific information indicates primary current threats to survival of the Laguna Mountains skipper are habitat modification through succession, climate change, cattle grazing, and small isolated populations susceptible to catastrophic events such as drought and fire.

Recovery Strategy
Resilient populations of sufficient size are necessary to withstand natural stochastic events (extremes of otherwise normal conditions that temporarily reduce population size). Redundant populations are necessary to withstand catastrophic events (unpredictable rare events that may cause population extirpation). Both are needed to preserve populations with genetic composition representative of maximum remaining diversity (genes likely to be required for survival under current and future ecological states) and withstand climate change driven increased vulnerability to grazing pressure and loss of habitat suitability. Therefore, the highest priorities for recovery are management of grazing to balance positive and negative impacts, captive propagation and reintroduction, modeling of population demographics, climate change adaptation and mitigation planning, and monitoring to ensure Laguna Mountains skipper populations are resilient. It will greatly advance recovery to involve stakeholders and partners in all applicable actions.

Recovery Goal, Objectives, and Criteria
The goal of this recovery plan is to control or reduce threats to the Laguna Mountains skipper to the extent that the subspecies no longer requires protections afforded by the Act and therefore, warrants delisting. To achieve this goal, the recovery plan's objectives are:

1. Collect data needed to inform conceptual modeling efforts to understand Laguna Mountains skipper demographics, threats, and drivers. Further develop the population ecology model to advance our ability to assess resilience of Laguna Mountains skipper populations and inform management practices.

2. Increase abundance and ensure long-term persistence of Laguna Mountains skipper through reduction and management of threats to the subspecies and its habitat throughout its current range (where it occurs).

3. Ensure population redundancy of Laguna Mountains skipper through reestablishment (where needed) and documentation of multiple resilient and genetically representative populations within its historical range.

Downlisting Criteria

1. On Palomar Mountain, occupied habitat is conserved and managed in perpetuity and supports resilient populations that occupy the entire historical distribution (Table 1, Figure 2) in two management units (MUs) to ensure adequate redundancy and preserve the species' remaining genetic diversity (for example, distribution in the Doane Valley occurrence must include occupancy in Lower French Valley, Lower Doane Valley, Upper Doane Valley, and Iron Springs). The population trend based on the adult spring flight season or their offspring is stable or increasing over an 8-year period and resilience is demonstrated during this time by an average summer to spring peak abundance ratio of over 0.5 (or using a new metric if one is developed that represents stable population growth) with evidence of reproduction for the last 2 years. Based on past data, a period of 8 years represents a population able to withstand fluctuations in population size, averaging over that period allows for natural variation in population size. A reproducing population must be documented for 2 years in a third MU on Palomar Mountain. Reproduction is demonstrated by detection of a summer flight season. (Factors A and E)

2. Off Palomar Mountain, another reproducing population is documented for 6 years (persistent, but may not yet meet the definition of resilient). (Factor E)

3. Service-approved management is in place in perpetuity to maintain disturbance regime for optimal habitat successional stage and minimize direct and indirect impacts to Laguna Mountains skipper from grazing, fire, and succession in the three MUs on Palomar Mountain (Criteria 1) and the population off Palomar Mountain (Criterion 2). (Factors A and C)

Delisting Criteria

1. On Palomar Mountain, habitat occupied by resilient populations that occupy the entire historical occurrence (Table 1, Figure 2) is protected in three MUs (resilience must be demonstrated for 8 years prior to delisting). Another reproducing population is documented for 2 years in a fourth MU on Palomar Mountain. (Factors A and E)

2. Off Palomar Mountain an additional resilient population (demonstrated for 8 years prior to delisting) occupies protected habitat in a new MU. (Factors A and E)

3. A climate-smart management plan is developed and implemented that identifies the conservation needs of the species and includes adaptive management that mitigates the

anticipated and observed climate change effects, including any changes in fire frequency and intensity, on otherwise resilient populations. (Factors A and E)

4. All potential Factor A and C threats have been investigated (for example hydrological modifications and groundwater removal, nonnative predators, and disease) to determine impacts, and measures implemented to minimize all significant threats in all MUs used to meet delisting criteria 1 and 2. (Factors A and C)

Estimated Date and Cost of Recovery:

Date of recovery: 2045
Cost of recovery: $3,090,000 + TBD

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I. BACKGROUND

We, the U.S. Fish and Wildlife Service (Service), listed the Laguna Mountains skipper (*Pyrgus ruralis lagunae*) as endangered in 1997 (Service 1997), under the Endangered Species Act of 1973 (Act), as amended. Critical habitat was later designated for this species on December 6, 2006 (Service 2006). A threats assessment and review of the biological status was conducted in 5-year status reviews for the species in 2007 and 2019 (Service 2007; Service 2019).

Laguna Mountains skipper is assigned a Recovery Priority Number of 3C (Service 2019, p. 5). This number indicates that the taxon is a subspecies that faces a high degree of threat, a high potential for recovery, and conflict with economic activities (Service 1983a, pp. 43098–43105; Service 1983b, p. 51985).

Recovery plans focus on restoring the ecosystems on which a species is dependent, reducing threats to the species, or both. A recovery plan constitutes an important Service document that presents a logical path to recovery of the species based on what we know about the species' biology and life history, and how threats impact the species. Recovery plans help to provide guidance to the Service, States, and other partners on ways to eliminate or reduce threats to listed species and measurable objectives against which to measure progress towards recovery. Recovery plans are advisory documents, not regulatory documents, and do not substitute for the determinations and promulgation of regulations required under section 4(a)(1) of the Act. A decision to revise the listing status of a species or to remove it from the Federal List of Endangered and Threatened Wildlife (50 CFR 17.11) or Plants (50 CFR 17.12) is ultimately based on an analysis of the best scientific and commercial data available to determine whether a species is no longer an endangered species or a threatened species.

The following discussion summarizes characteristics of Laguna Mountains skipper biology, demography and distribution, population status, and threats that are relevant to recovery. Additional information is available in the 2019 5-year review (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=I0LW) and associated literature.

A. Species Description and Taxonomy

The Laguna Mountains skipper (*Pyrgus ruralis lagunae*) is one of two subspecies of the two-banded checkered skipper (*Pyrgus ruralis*), a small butterfly in the skipper family (Hesperiidae). The Laguna Mountains skipper was first described by Scott (1981, p. 7) based on population isolation and color differentiation. The genus Pyrgus has three other species in San Diego County, including the common checkered skipper (*P. communis*), small checkered skipper (*P. scriptura*), and western checkered skipper (*P. albescens*). The taxonomic classification of the Laguna Mountains skipper has not changed since it was listed.

Adult Laguna Mountains skippers have a wingspan of about 1 inch (in) (2.5 centimeters (cm)) and are distinguished from the northern, more common two-banded checkered skipper subspecies (*Pyrgus ruralis ruralis*; rural skipper) by extensive white wing markings that give adults, particularly males, an overall appearance of more white than black and by the banding patterns on the hind wings (Scott 1981, p. 7; Levy 1994, p. 5). They are further distinguished from the co-occurring common checkered skipper by the forewing pattern that resembles an "x" (Figure 1).

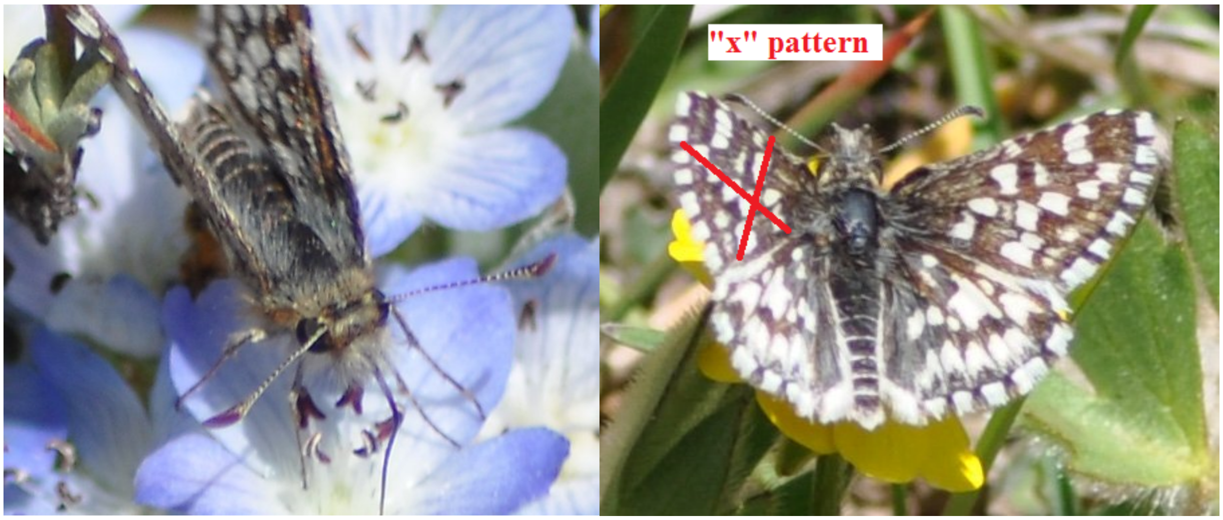

Figure 1. Adult Laguna Mountains skippers (photos courtesy of Tom Mendenhall). Notice the forewing pattern that resembles an "X".

B. Range and Distribution

The Laguna Mountains skipper was historically found in meadow habitats within the Peninsular Range on Palomar Mountain and in the Laguna Mountains in San Diego County, California, but is currently restricted to Palomar Mountain (Table 1; Figures 2 and 3). The two mountain areas where the subspecies was historically recorded are geographically too distant for natural Laguna Mountains skipper movement between them. Known and historical occurrences in each mountain area include multiple suitable habitat patches in relatively close proximity to each other (see Table 1 for additional place names associated with each occurrence). The listing rule (Service 1997, p. 2314) described the subspecies as extant at the El Prado [Meadow] in the Laguna Mountains, and being "currently found at four sites" on Palomar Mountain, citing Levy (1994). Although the listing rule did not name the Palomar Mountain sites, a review of Levy (1994, pp. 10 and 11) indicated they were Mendenhall Valley, the Observatory Campground, Observatory Trail (at easternmost end of Upper French Valley), and Lower French Valley (Figure 2). The four Palomar Mountain sites referenced at listing are incorporated in three of the four extant occurrences identified in this document (currently known as: Mendenhall Valley, which incorporates the Observatory Campground; French Valley, which incorporates Observatory Trail; and Doane Valley, which includes Lower French Valley). The fourth extant occurrence is Pine Hills, which was documented after listing (Figure 2). We also identify two extirpated occurrences in the Laguna Mountains – Laguna Meadow (incorporates El Prado Meadow known at listing) and Crouch Valley (documented after listing) (Figure 3).

Table 1. Laguna Mountains skipper occurrence information based on data from reports cited in text. Current status is based on the most recently available information. The majority landowner is listed first.

Occurrences and Management Units **(Associated locations in the literature and on maps.)**	**Status at Listing**	**Current Status**	**Last year observed**	**Ownership**
Palomar Mountain				
Doane Valley (Lower French Valley, Lower Doane Valley, Upper Doane Valley, and Iron Springs)	Extant	Extant	2018[1&2]	Private, State, and USFS
French Valley (Upper French Valley, Palomar Observatory Trail, and Palomar Observatory Meadows)	Extant	Extant	2007[3]	Private and USFS
Mendenhall Valley* (Mendenhall Valley and Observatory Campground)	Extant	Extant	2018[1&2]	Private and USFS
Pine Hills (Jeff Valley, Dyche Valley, and Will Valley)	No records	Extant	2016[3]	Private and USFS
Laguna Mountains				
Laguna Meadow (Big Laguna Lake, El Prado Meadow, Laguna Campground, Horse Heaven Group Camp, Boiling Spring Ravine, and Agua Dulce Meadow)	Extant	Extirpated	1999[4]	USFS and private
Crouch Valley (Meadows Kiosk and Joy Meadow)	No records	Extirpated	1999[4]	USFS and private

Abbreviations: State of California (State); United States Forest Service (USFS).
*Includes two "sites" from the listing rule.
Sources: Faulkner 2018[1]; Osborne 2018[2]; Marschalek 2016[3]; Grant *et al.* 2009[3]; Pratt 1999[4] (characteristic feeding damage).

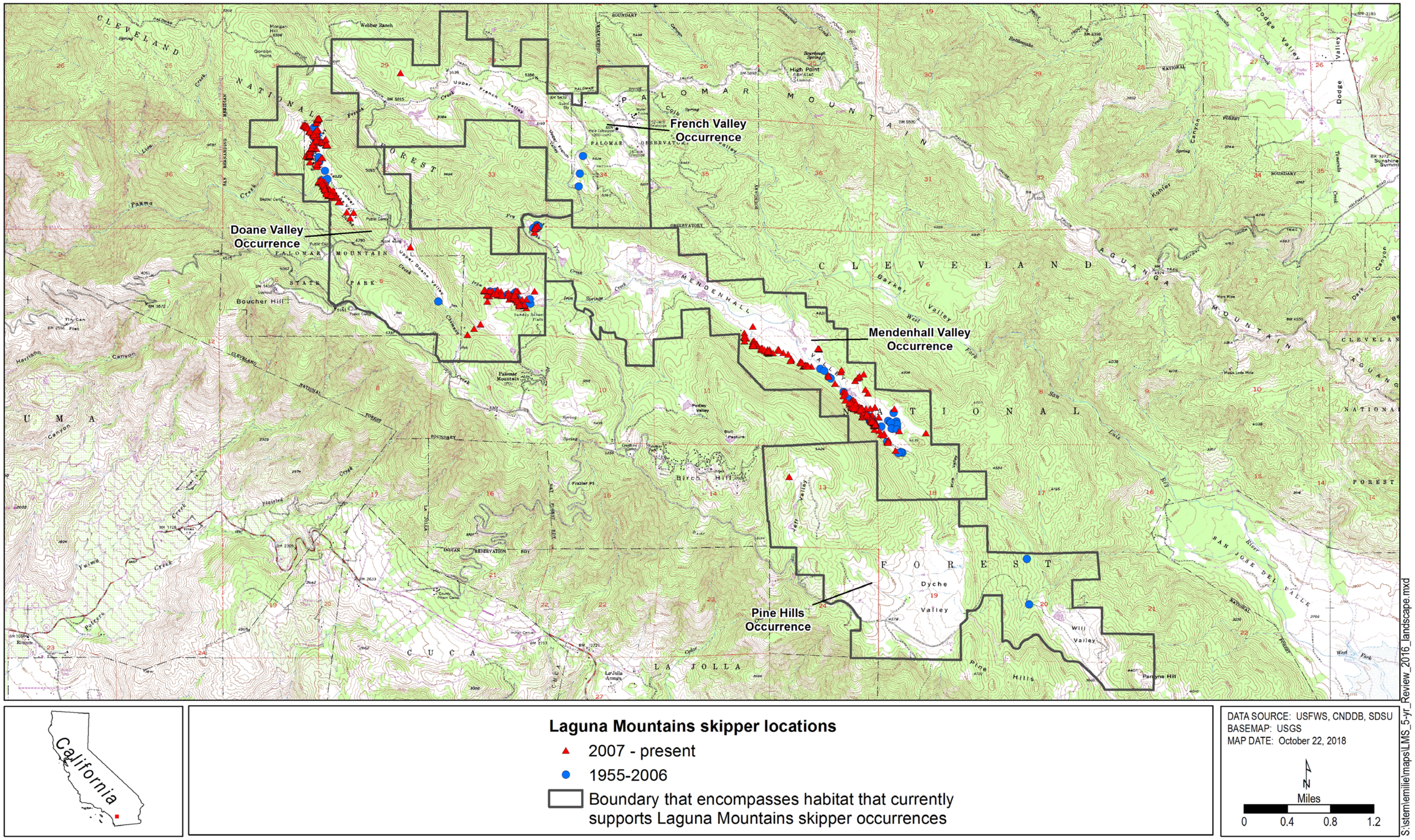

Figure **2. Distribution of Laguna Mountains skipper on Palomar Mountain and Management Units.**

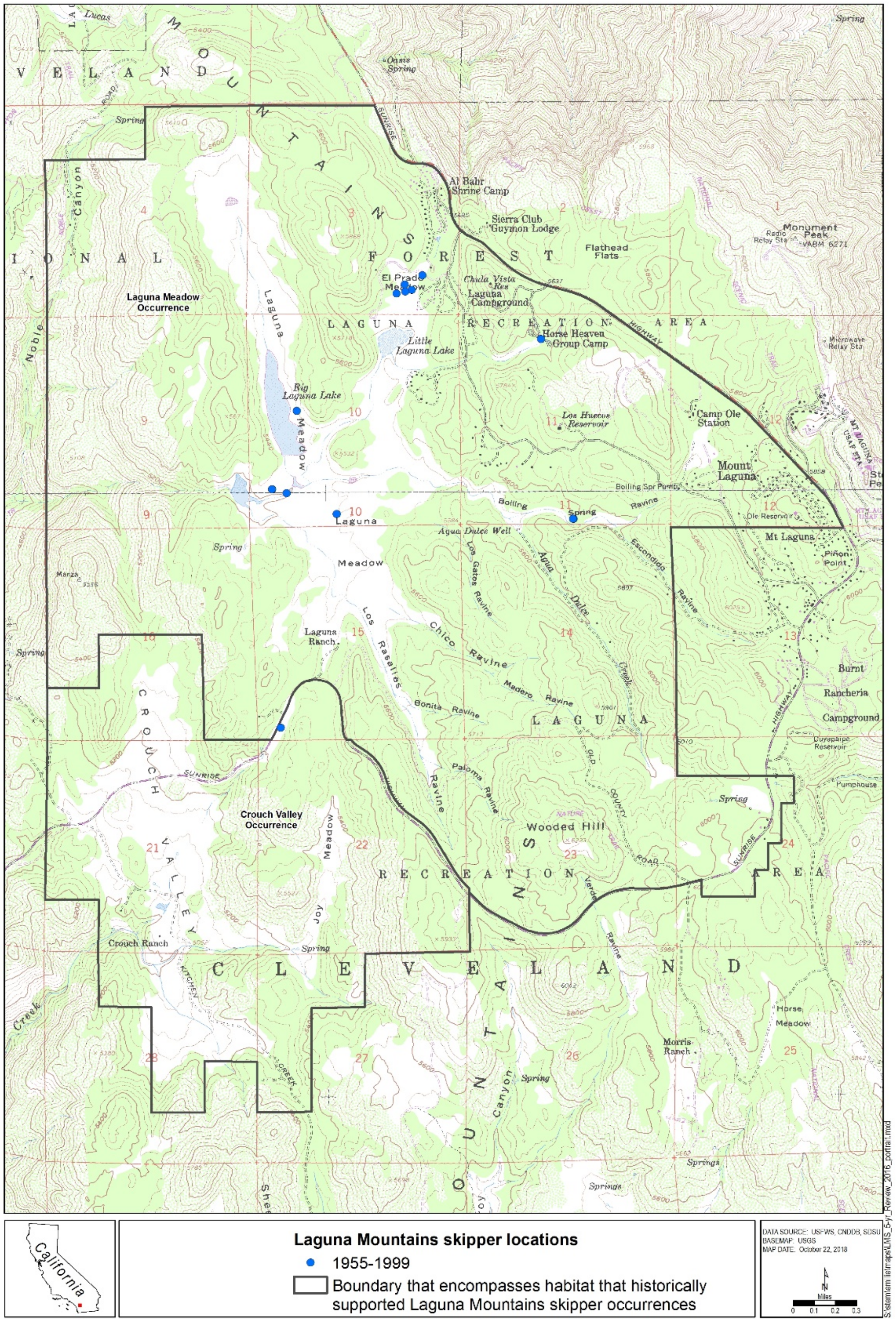

Figure 3. Historical distribution of Laguna Mountains skipper in the Laguna Mountains and Management Units.

C. Habitat and Ecosystem Characteristics

A key component of Laguna Mountains skipper habitat is its primary larval host plant, *Horkelia clevelandii* (Cleveland's Horkelia) (Service 1997, p. 2314). *Horkelia clevelandii* populations are relatively rare, but the species has a greater range than the Laguna Mountains skipper; it has been documented in areas throughout the Peninsular Range, including Palomar Mountain and the Laguna and San Jacinto Mountains of southwestern California in the United States (Osborne 2003, pp. 12 and 13; Baldwin *et al.* 2012, pp. 46 and 1182; Calflora 2014) and the Sierra de San Pedro Mártir in northwestern Baja California Norte, Mexico (Thorne *et al*. 2010, p. 30; Encyclopedia of Life 2014).

To determine which additional areas may be suitable to support the Laguna Mountains skipper, mountain areas within the range of *Horkelia clevelandii* were reviewed using topographic relief and satellite imagery. It was noted that only the Cuyamaca Mountains in the United States and the Sierra San Pedro Mártir and Sierra de Juarez in Mexico contain large wet meadows above 3,900 ft (1,189 m) elevation similar to those known to have historically supported the subspecies on Palomar Mountain and the Laguna Mountains (Figure 4). As commonly defined, wet meadows have mineral, seasonally saturated soils with little or no peat accumulation (Rains-Jones 2011, p. 3). These meadows are surrounded by large ridges and mountains, forming true valley "basins" over 2 mi (3.2 km) long. Given what we know about historical occupancy, mountains occupied by Laguna Mountains skippers under modern climate conditions have a concentration of flatter habitat at mid-elevations, below higher peaks or ridges. The Cuyamaca Mountains are in the Laguna Mountains skipper's historical range between Palomar Mountain and the Laguna Mountains, and were probably historically occupied (Brown 1991, p. 5; Levy 1994, p. 10). The highest precipitation within the historical range typically occurs on Palomar Mountain, with precipitation in the wettest years exceeding 70 in (178 cm), followed by the Cuyamaca and Laguna Mountains, respectively (San Diego County 2010, p. 5).

Figure 4. Painting of Mendenhall Valley (meadow) on Palomar Mountain during Laguna Mountains skipper flight season (courtesy of Alison Anderson).

The presence of sufficient host plants is important for reproduction, shelter, and feeding. Laguna Mountains skippers typically deposit eggs on the underside of mature or moderately mature leaves of the host plant (Osborne 2008, p. 5). Larvae then occupy silken shelters constructed with host plant leaves at heights of 3 to 5 in (8 to 13 cm) above the ground (Osborne 2008, p. 35) and feed primarily within these shelters during development (Anderson 2016 and 2017, pers. obs.). Since listing, Laguna Mountains skippers have also been documented using *Potentilla glandulosa* (common cinquefoil) as a host in the wild (Pratt 1999. p. 10; G. Pratt 2006, p. 2; Osborne 2008, p. 5). However, *P. glandulosa* is not believed to independently support any populations (Osborne 2002, pp. 13 and 14).

While nectar sources for adults are diverse and not typically limiting during spring (Grant *et al*. 2009, p. 52; Marshalek 2014, pers. comm.), during summer they are sparse and the larval host plant, *Horkelia clevelandii*, is the primary available nectar source (Levy 1994, pp. 7 and 24; Levy 1997, p. 25; Mattoni and Longcore 1998, p. 4; Osborne 2002, p. 12). Therefore, the primary host plant, *H. clevelandii*, is important for larval growth in the spring and summer, as well as a food source supporting adult activity and fecundity in the summer.

Bare or "open" ground is correlated with host plant presence (Levy 1994, p. 6; Levy 1997, pp. 9 and 30; Mattoni and Longcore 1998, p. 10; Osborne 2008, p. 4; Marschalek and Deutschman 2014, pp. 2 and 3) and is believed to contribute to habitat suitability by increasing development rates of immature Laguna Mountains skipper life stages through increased microclimate temperature. Therefore, in most soil types found in Laguna Mountains skipper habitat, disturbance is needed to prevent overgrowth of host plants by other species (Levy 1994, pp. 6, 7, 19; 1997, p. 9 and 10; Pratt 1999, pp. 17–19; Grant *et al.* 2009, p. 10).

Researchers have noted an association of Laguna Mountains skipper adults with moist soils and surface water (Levy 1997, pp. 22 and 23; Mattoni and Longcore 1997, p. 10; Osborne 2002, pp. 9 and 13, 14 and 16; 2003, p. 13; 2008, p. 33; Faulkner 2008, p. 5). They spend most of their time near host plants, or at water sources when away from host plants (Grant *et al.* 2009, p. 56). Studies show that Laguna Mountains skippers are primarily found in two types of areas: (1) far from water, close to the forest edge, on northeast slopes; and (2) close to streams, far from the forest edge, on southwest slopes (Grant *et al.* 2009, pp. 14–22). This habitat use pattern likely reflects locations with (1) high host plant availability, combined with higher soil moisture levels and water availability from sources that do not evaporate quickly, and (2) locations near surface water where a warmer climate increases butterfly metabolic rates.

Adult survey values such as those collected by Faulkner's methods (meandering but complete coverage of a reference site) or more intensive counts, such as those based on Pollard Walks (a statistically rigorous method of transect walks to determine an index of abundance), are not sufficient to estimate population size. However, these survey values can provide evidence of how Laguna Mountains skipper populations change in size over time and are affected by environmental factors such as temperature, precipitation, and grazing levels.

A review of Laguna Mountains skipper monitoring data from Mendenhall Valley from 2009 to 2013 (Faulkner 2008, p. 2; 2009, pp. 2 and 3; 2010, p. 2; 2011, p. 2; 2012a, p. 2; 2013, p. 2) suggests that changes in annual peak abundance (daily count when the maximum number of Laguna Mountains skippers was recorded per observer per season) are affected by rainfall totals (October through April) (Table 2; Appendix I). An increase in the index of peak abundance from one year to the next is correlated with above average rainfall from the previous year. Likewise, a decrease in peak abundance is correlated with below average rainfall from the previous year. Based on these correlations (trendline; Appendix I) when rainfall totals are approximately 600 mm (just below the historical average), we would not anticipate a large change in population size. The positive correlation between changes in annual peak abundance and October-April precipitation supports the hypothesis that Laguna Mountains skippers require sufficient rainfall and soil moisture, and it helps us to understand how precipitation influences population growth.

Table 2. Laguna Mountains skipper adult survey data from Mendenhall Valley. Data include an index of peak abundance, annual summer to spring peak abundance ratios, and Palomar Observatory weather station rainfall data. No comparable surveys were conducted after 2015.

Year	Spring peak (Date; peak abundance*)		Summer peak (Date; peak abundance)		Days between peaks	Summer to spring peak abundance ratio	Total precipitation Oct- April (mm)
2015	April 9	**14**[1]	July 2	**10**	84	0.71	331
2014	April 15	16[1]	No data	No data	n/a	n/a	404
2013	May 2	**4**	July 21	**2**	80	0.50	220
2012	May 10	**12**	July 16	**1**	67	0.08	235
2011	May 5	**10**	July 24	**4**	80	0.40	701
2010	May 2**	**7**	July 22	**2**	81	0.29	690
2009	April 26	**9**	June 27	**7**	62	0.78	375
2008	April 27	**8**	June 29	**5**	63	0.63	798
1997	Apr 15**	14[2]	June 30	9[2]	76	0.64	216
1994	May 20	4[3]	July 21	6[3]	62	1.50	535

Bold values are from consistent survey methods.
* Peak abundance is defined as the day when the maximum number of Laguna Mountains skippers was recorded per observer per season.
**Surveys may have started after the peak.
Surveyors: [1]Marschalek and Faulkner; [2]Pratt; [3]Levy; all others Faulkner.
Precipitation data source: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?caCPAL.

D. Population Ecology and Trends

Population Ecology

Laguna Mountains skipper population dynamics are affected by a number of key life history factors. Individuals survive fall and winter in the pupal stage by entering diapause (a period of dormancy with a low metabolic rate) in protected microhabitats on or not far from their host plant (G. Pratt 2015, pers. comm.; K. Osborne 2014, pers. comm.). Adults emerge from overwintering pupae in early spring and sometimes summer; they mate during the flight season, produce eggs (the spring or summer brood), then die. The small whitish-green eggs hatch into larvae that vary in color from yellow to green. Larvae molt their skins four times (five instars) before molting into dark brown pupae covered with powdery wax (Osborne 2008, pp. 17 and 18).

Available data indicate most pupae from the spring brood overwinter and emerge (eclose) as adults the following spring. However, a portion of the spring brood forgo diapause and emerge as adults in the summer. These adults undergo a second flight season in the summer and produce the summer brood. Summer brood individuals all enter diapause as pupae in late summer, to emerge the following spring as adults at the same time as the spring brood individuals that did not complete development the prior year (Figure 4) (Pratt 1999, p. 32; Osborne 2008, pp. 16 and 17; Grant *et al.* 2009, pp. 15 and 21). This life cycle is called "partially bivoltine" because reproduction occurs more than once per year, but not all first generation offspring complete development and reproduce during the second reproductive cycle of the year (two overlapping generations).

Whether individuals from the spring brood complete development or enter diapause likely depends on environmental conditions, such as temperature, host plant moisture levels or humidity during larval development (Service 2019, p. 19; Pratt 1999, p. 3; G. Pratt 2015, pers. comm.). While photoperiod (day length) is the most commonly supported environmental cue that triggers diapause (Danks 2002, p. 129), if this is the case for Laguna Mountains skipper, it is also significantly reinforced by increasing temperature (McElderry 2016, pers. comm.), because there is considerable variability in peak abundance dates (Table 2). Laguna Mountains skippers are not believed to diapause for more than one fall/winter season (Pratt 1999, p. 8). Adult abundance peaks on Palomar Mountain first in April or May (spring flight), followed by a second peak approximately 60 to 80 days later in June or July (summer flight) comprised of spring brood adults (Table 2) (Scott 1981, p. 7; Levy 1994, p. 11; Mattoni and Longcore 1998, p. 3; Pratt 1999, p. 11; Goocher 2006, p. 3; Osborne 2008, p. 5; Faulkner 2008, p. 2; 2009, pp. 2 and 3; 2010a, p. 2; 2011, p. 2; 2012a, p. 2; 2013, p. 2; Grant *et al.* 2009, pp. 15 and 19).

Conceptual model for the Laguna Mountains skipper

A conceptual population ecology model for the Laguna Mountains skipper is illustrated in Figure 5. This model was developed to represent the life cycle and population dynamics (potential contribution of life stages to population growth rates and resilience). Figure 5 uses one set of example values based on captive rearing observations (egg production and hatch rate), information in Table 2 (summer to spring peak abundance ratio), surrogate species values for larval survival, and discussions with experts. The conceptual model identifies likely drivers of productivity (Figure 5, surrounding text). Multivoltine life cycles, including partially bivoltine, have potential thresholds of exponential growth, but also of catastrophic decline, depending on how subsequent generations fluctuate in size and contribute to annual population growth (Iwasa *et al.* 1992, entire). Successful reproduction by first brood individuals in the same year can contribute significantly to the following year's total population size in bivoltine populations, even exponentially if conditions are favorable (Altermatt 2009, p. 6; Figure 5). All realistic variations of values used in the model illustrate the significance of summer brood production to annual population growth potential.

The Laguna Mountains skipper life cycle, characteristic of a partially bivoltine species, is depicted in Figure 5 with two flight seasons (spring and summer). Figure 5 uses an example starting with a population size of 200 adults (conservative value based on a Levy 1994 estimate) with approximately 100 eggs per female, and 70 percent hatch (Tashiro and Mitchell 1985, pp. 136–138; Johnson *et al.* 2010, p. 9; The Butterfly Farm 2012; Longcore *et al.* 2014, pp. 8 and 9). Example spring and summer brood survival rates used are 16 and 14 percent, respectively, because survival may be slightly lower in the summer depending on larval size and availability of host plants. These larval survival values are optimistic, based on data for the shoulder-streaked firetip skipper (*Pyrrhopyge papius*) (Greeney *et al*. 2010).

Using these example values in Figure 5, a spring adult population of 200 adults produces a spring brood of 1,120 pupae. The majority of the spring brood (91 percent) undergo diapause and approximately 107 emerge as adults in the spring of the following year (based on a summer diapause survival of 0.5 and fall-winter diapause survival of 0.21; value rounded for model). In this example, a small percentage of pupae (9 percent) do not undergo diapause in the spring. Instead, these develop into 101 adults during the summer the same year, undergo a second flight season, and produce a summer brood (445 pupae). These pupae enter diapause and 93 emerge as adults in the spring with 107 of the spring brood individuals that went directly into diapause the previous year.

In the summer of 2017 researchers collected data in the field on immature Laguna Mountains skipper life stage survival (Osborne and Anderson 2018, p. 1). By following development of eggs in the field through pupation they estimated less than 10 out of 132 larvae survived to pupation (approximately 0.07 survival rate). They also placed diapausing pupa in the field in cages that excluded vertebrate predators, and recorded 85 percent survival during winter diapause. The former is likely an underestimate, as some larvae considered dead may in fact have wandered away and were not detected. The diapause survival rate is probably significantly higher than was realized by the wild population, as they were relatively protected from parasitism during larval development, and from vertebrate predation during diapause, both likely significant mortality factors for wild individuals. Based on this information we ran the model using 0.08 larval survival rates, and a 45 percent pupal diapause survival rate; other values used were those in Figure 5, with summer pupal eclosion rate adjusted to maintain the observed typical 1:2 summer to spring adult abundance ratio. This model iteration resulted in a 31 percent contribution of the summer brood to the following spring adult population size, and 29 percent population growth rate.

Based on these and other plausible iterations of the model, general principles of population dynamics, the highest Laguna Mountains skipper population growth should be realized when the ratio of the summer to spring adult population size is largest, limited only by quality of summer habitat compared to that available in spring. Therefore, this model illustrates the potential magnitude of summer brood contribution to population growth overall, and that summer brood survival is critical for maintaining population resilience in a bivoltine species (see also Faccoli and Stergulc 2006, pp. 62 and 63).

The conceptual model (Figure 5) identifies several drivers that should influence population abundance, such as host plant suitability, nectar and surface water availability, predation, temperature, mate availability, and development time. Because insect populations typically exhibit large fluctuations in abundance, "stability" is not a term typically used to characterize healthy population dynamics; rather "resilient" populations are those that can reach relatively extreme lows without crashing and being extirpated. The best currently measureable indicator of resilience for the Laguna Mountain skipper is the detection of a summer flight season and a high summer to spring adult count ratio (indicative of population growth), because adult counts are not sufficient to estimate population size (a model extrapolating counts to population size is required). An inability to detect adults during the summer would indicate the population is so small that mates would have difficulty finding each other, and a low summer to spring abundance ratio (approaching zero) would be a strong indicator that abundance will decrease the subsequent year.

Further development and validation of this model with field and captive population dynamic values (such as summer pupal eclosion rate survival) will expound on this relationship between spring and summer brood population sizes, and overall population growth potential. One peer reviewer recommended focusing data collection on diapause survival rate, as this stage is important to demographics, and it would take relatively little effort to identify its regulators (Appendix IV). This information will in turn inform monitoring needs and thresholds for management actions.

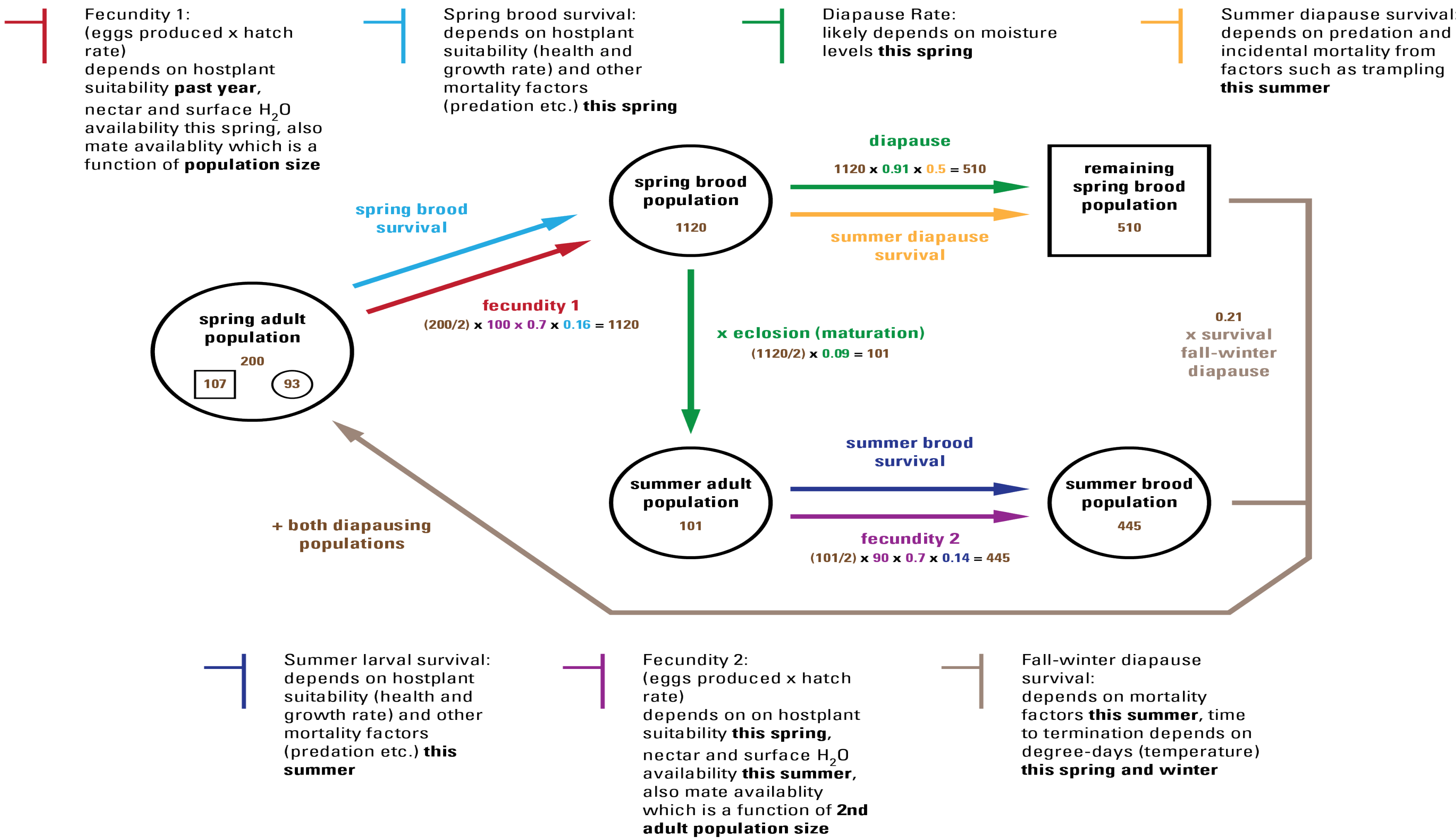

Figure 5. Life cycle and conceptual population model for the Laguna Mountains skipper, with example values. The majority of the spring brood enter diapause, while a smaller portion completes development to become the summer adult population. Hypothetical values are based on monitoring data that indicates a typical summer to spring peak abundance ratio of 0.5, which is assumed to represent stable replacement rate. Factors that may affect productivity throughout the season are illustrated on top and to the right with colored markers. Sources: Tashiro and Mitchell 1985; Levy 1994; Faulkner 2008; 2009; 2010a; 2011; 2012; 2013; Johnson *et al.* 2010; Greeney *et al.* 2010; The Butterfly Farm 2012; Longcore *et al.* 2014. Developed by A. Anderson, Service.

Population Abundance and Trends

Consistent monitoring for Laguna Mountains skipper was conducted in Mendenhall Valley for 8 years (Table 2). While we are able to look at changes in the index of peak abundance from specific areas, we do not have data of sufficient scope or sample size to estimate changes in total population size over time. A number of studies have established methods for long-term monitoring and detection of population trends (Levy 1997, p.4; Mattoni and Longcore 1998, p. 13; Grant *et al*. 2009, p. 5; Marschaleck 2014, p. 1); however, estimating abundance of Laguna Mountains skippers has proven difficult because population densities are relatively low and adults are challenging to locate and identify. Although past survey methodologies have not always been comparable, the estimated number of adults in the Mendenhall Valley population on Palomar Mountain has ranged from the low 200s in 1994 (Levy 1994, pp. 11 and 12) to over 1,400 in 1997 (Mattoni and Longcore 1998, p. 9).

Past Laguna Mountains skipper abundance estimates from the Laguna Mountains are not available, and even qualitative descriptions and comparisons to Palomar Mountain are sparse. Extensive surveys of apparently suitable skipper habitat in the Laguna Mountains during the past 15 years have not detected the subspecies (Faulkner 2000, p. 2; 2001, p. 2; 2002, p. 2; 2003 p. 2; 2004, p. 2; 2006, p. 2; Osborne 2002, p. 9; 2003, p. 2; Grant *et al.* 2009, p. 24; Marschalek 2014, pp. 3–14). Therefore, we currently consider the Laguna Mountains occurrences to be extirpated (Table 1).

E. Critical Habitat

As required by the Act, critical habitat was designated for the Laguna Mountains skipper on December 12, 2006. In total, approximately 6,242 acres (ac) (2,525 ha) fall within the boundaries of the critical habitat designation. The critical habitat is located in San Diego County, California, on lands under Federal (3,516 ac (1,423 ha)), State (381 ac (154 ha)), and private (2,345 ac (948 ha)) ownership (Service 2006, p. 74592). Based on our knowledge of the life history, biology, habitat requirements, and ecology of the subspecies at the time, we determined that the primary constituent elements of Laguna Mountains skipper critical habitat were: 1) the host plants, *Horkelia clevelandii* (primary) or *Potentilla glandulosa* (secondary), in meadows or forest openings needed for reproduction; 2) nectar sources suitable for adult feeding found in woodlands or meadows; and 3) wet soil or standing water associated with features such as seeps, springs, or creeks where water and minerals are obtained during the adult flight season (Service 2006, p. 74599).

F. Reasons for Listing and Current Threats

The following discussion is a brief summary of ongoing threats that continue to impact the Laguna Mountains skipper and its habitat. For additional information see the listing rule and the 5-year review (Service 1997; Service 2019). In determining whether to list, delist, or reclassify (change from endangered to threatened status, or *vice versa*) a species under section 4(a) of the Act, we evaluate five major categories of threats to the species: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. The final listing rule (Service 1997, pp. 2317–2320) identified the following threats to the Laguna Mountains skipper: range reduction and habitat destruction from overgrazing by domestic cattle, incidental predation by cattle, localized distribution and small population size, stochastic events, collection, vandalism, mortality due to recreational activities, displacement of host plant by nonnative species, fire, drought, localized distribution, and small population size. Existing protections at the time of listing described under Factor D were not considered sufficient absent listing under the Act. The most recent 5-year review for Laguna Mountains skipper (Service 2019, pp. 25-49) reported primary threats impacting the Laguna Mountains skipper as (in order by factor): habitat modification through cattle grazing and succession, climate change, incidental ingestion of immature life stages by cattle, and small isolated populations susceptible to events such as drought and fire. A detailed evaluation of all threats is included in the 2019 5-year review (Service 2019, pp. 25-49) and summarized below under each of the five factors and in Appendix II.

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

In the listing rule under Factor A we discussed restricted range and localized distribution (now discussed under Factor E), habitat destruction, and grazing impacts (Service 1997, pp. 2317–2318). The primary concerns were habitat destruction and degradation from overgrazing and trampling of host plants by domestic cattle (direct mortality is discussed below under factor E). Here we discuss the additional threats of succession, drought, climate change, and groundwater extraction.

Conversion of even relatively small, occupied host-plant patches for land uses such as agriculture, structure development, or water storage could also impact populations and is considered a minor threat. Occurrences lacking protection from such activities, based on the amount of habitat under private ownership with no conservation easements or other legal protective assurances, in order of vulnerability are: Pine Hills (Dyche and Will Valleys); French Valley (Upper French Valley); Mendenhall Valley (western half); and Doane Valley (Iron Springs).

Although limited grazing can be used as a positive management tool for Laguna Mountains skipper habitat, there can also be adverse impacts from incompatible grazing management. Primary impacts from excessive cattle grazing on Laguna Mountains skipper habitat include erosion of meadow structure that may cause drying and loss of soil and host plants (Osborne 2002, pp. 12 and 14; Osborne 2003, p. 16). Current information on habitat conditions and the lack of species-specific management agreements indicate the threat of habitat modification due to incompatible cattle grazing may be present on Palomar Mountain in Dyche Valley (Pine Hills occurrence) and upper French Valley (French Valley occurrence) (Anderson 2014 and 2015, pers. obs.; USGS 2015). Grazing may also reduce the availability of host plant flowers during the summer, which is likely a limiting resource for adult Laguna Mountains skippers (Levy 1994, p. 20; Mattoni and Longcore 1998, p. 4; Anderson 2016 and 2017, pers. obs.).

Succession can impact habitat in locations where disturbances, such as fire and grazing, do not occur. For example, grazing has been excluded for decades in Upper Doane Valley and western

Mendenhall Valley, resulting in apparent displacement of skipper host plants (Grant *et al.* 2009, p. 61; Marschalek 2014, p. 4; Winter, USFS, 2015, pers. comm.). Late-successional native plant species can reduce host plant suitability by shading and displacing host plants through competition. Impacts from nonnative plant invasion, which may also displace host plants, appears to be less of a threat than succession (Criley, USFS, 2015, pers. comm.), but early treatment of nonnative plants and ongoing management (for example grazing and controlled burns) may be needed to protect Laguna Mountains skipper habitat.

Drought was likely a contributing factor to the extirpation of the Laguna Mountains occurrences, (Appendix III), where rainfall was, and still is, typically lower than on Palomar Mountain (Grant *et al*. 2009, p. 47; County of San Diego 2010, p. 113). Current climate conditions are not improved compared to when the Laguna Mountains skipper was extirpated from its namesake region. In 2014, the 4-year precipitation deficit was the greatest on record, equivalent to the loss of an entire average year of rainfall (NOAA 2014, pp. 1 and 7). State-wide, average January to September temperature in 2014 was the highest on record since 1895, culminating a steady upward trend since the late 1970s; only 4 years since 1977 have been below the 100 year mean (NOAA 2014, p. 4). On Palomar Mountain the average January to October temperature and the 4-year precipitation deficit were the highest ever recorded (NOAA 2014, pp. 1 and 7). In 2015, record high temperatures continued, as did below-average rainfall (CDWR 2015, p. 1). Given what we now know about the reliance of Laguna Mountains skipper populations on soil moisture and surface water availability, and vulnerability to grazing during periods of dry forage (see ***Factor C: Disease or Predation*** below), we consider the current drought in California to be a threat throughout the subspecies' range.

Laguna Mountains skippers are sensitive to climate change because of their dependence on soil moisture levels and surface water availability, and because they currently inhabit a single mountaintop at maximum elevation, with no opportunity for range shift northward or upward in elevation. Comparison of the 1951-1980 mean and 1981-2009 mean annual climatic water deficit (CWD: potential minus actual evapotranspiration; a measure of soil moisture level and plant drought stress; California Basin Characterization Model (Lorraine and Alan Flint, 2014)), and consideration of Laguna Mountains skipper's dependence on habitat moisture availability strongly support that drying due to climate change was a contributing factor to subspecies' extirpation on Laguna Mountains. The California Basin Characterization Model indicates CWD was higher in the Laguna Mountains during the 30-year period when Laguna Mountains skippers declined and were extirpated, than it had been for the prior 30 years (Appendix III).

Climate change model projections indicate climate could similarly affect habitat on Palomar Mountain and the Laguna Mountains over the next 60 years (Appendix III). Given the correlation of adult occupancy with soil moisture and surface water availability, "driest" case CWD projections indicate drying may detrimentally affect habitat suitability. However, "wettest" case projections suggest CWD levels could improve over the next 30 years and then return to near current levels within 60 years. While there are opportunities for adaptation and a possibility of minimum effect, climate change is a potential threat to the Laguna Mountains skipper due to possible habitat drying. Surface water, groundwater, and soil moisture levels are all affected by the water table in meadow habitats. Therefore, considering the dependence of Laguna Mountains skipper on established meadow hydrology, removal of groundwater via wells (Mattoni and

Longcore 1998, p. 10) and diversion and storage of surface water for livestock (Grant *et al.* 2009, pp. 24 and 26) are potential threats.

Groundwater extraction for commercial drinking water is of concern on Palomar Mountain and in the Laguna Mountains because of the number of companies removing water and the apparent magnitude of withdrawals (Faulkner 2014, pers. comm.; Service 2019, Appendix IV). However, we cannot determine the magnitude of this threat at this time because we are not aware how these activities are affecting meadow water tables and, in turn, how they affect the Laguna Mountains skipper. The impact of groundwater removal for commercial drinking water should be investigated and is of particular concern.

Factor A Summary

Current threats impacting Laguna Mountains skipper habitat include succession caused by lack of fire or other disturbance, and drought. Land use change and erosion caused by grazing are also minor threats. Climate change and surface and groundwater extraction are potential threats of uncertain extent and magnitude.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Collection was considered a potential threat to the Laguna Mountains skipper and its habitat at the time of listing (Service 1997, p. 2318). However, there is no information to support that collection is impacting the Laguna Mountains skipper, and we do not consider it to be a threat at the current time.

Factor C: Disease or Predation

Predation by wild turkeys and incidental predation from livestock grazing were discussed under Factor A in the listing rule (Service 1997, p. 2318). The primary concern was incidental predation from livestock grazing and there is currently no evidence that predation by turkeys is a concern. Here we also discuss the possible impacts due to predation by nonnative and native grazers, predatory insects, and a parasite.

Incidental ingestion and trampling of immature life stages by cattle was considered a threat to Laguna Mountains skipper at the time of listing, and has been a concern of researchers for some time (Brown 1991, p. 5; Mattoni and Longcore 1998, pp. 4 and 6; Osborne 2003, pp. 14, 36–38; 2008, p. 35; Pratt 2006, pers. comm.; Longcore and Osborne 2015, p. 164). Larvae, and sometimes eggs and pupae, are located in the crowns and outer margins of *Horkelia clevelandii*, plant parts that appear to be commonly consumed by cattle (Levy 1994, p. 20; Mattoni and Longcore 1998, p. 4; Osborne 2008, p. 35; Anderson 2016 and 2017, pers. obs.). Most recently, Osborne's (2008, p. 35; Osborne and Anderson 2017) rearing and field observations demonstrated larvae and pupae are located in silken shelters made from upper host plant leaves at heights of 3 to 5 in (8 to 13 cm), parts most likely to be consumed by grazing ungulates.

During this review, in part due to discussions with U.S. Forest Service (USFS) staff, it came to our attention that grazing by deer and other vertebrates has been historically overlooked as another potential source of larval mortality. Although the issue has not been explicitly studied in the field, it can be assumed that grazing by deer and cattle that commonly occur in Laguna Mountains skipper habitat impacts populations through incidental ingestion and possibly trampling. A review of the literature indicates deer and cattle are equally likely to graze on *Horkelia clevelandii* during the summer. Deer primarily browse woody forage, and cattle prefer grass, but both types of ungulate consume significant, and typically similar, amounts of forbs (Thill and Martin 1988, p. 542; Ortega 1991, p. 56; Martinez *et al* 1997, p. 253; Scasta *et al.* 2016, p. 213). Data indicates consumption of forbs is highest, and diets overlap the most, in pastures grazed regularly by cattle (Findholt *et al.* 2005, pp. 5, 11, and 13) during summer and fall (Ockenfels and Lewis 1997, p. 89; Hosten *et al.* 2007, p. 13); although deer may avoid areas where cattle actively graze (Hosten *et al.* 2007, p. 1). Cattle are also known to consume *Potentilla* (also used by Laguna Mountains skipper as a host) and *Frageria sp*., plants related to *H. clevelandii* (Pacific Rural Press 1904, p. 1; Hosten *et al.* 2007, pp. 11 and 27). When *H. clevelandii* was planted in Upper Doane Valley in the winter of 2009, the majority of the young green plants were consumed by deer, who were also reported to have destroyed frost covers protecting the plants (State Parks 2012, p. 2; Bates-Lande 2016, pers. comm.). Therefore, grazing by deer should be considered a significant factor in incidental consumption of Laguna Mountains skipper larvae, while cattle additively increase the otherwise natural grazing impacts of ungulates in occupied habitat.

Horkelia clevelandii is reportedly grazed more heavily during the summer (Levy 1994, pp. 20 and 46; Mattoni and Longcore 1998, p. 4; Pratt 1999, p. 27) when other preferred forage has been consumed. Late-season grazing may remove significant amounts of host plant flowers, where eggs are sometimes deposited during the second flight season (Levy 1994, p. 20; Mattoni and Longcore 1998, p. 4). This phenomenon may also partially explain why population growth of Laguna Mountains skipper appears especially depressed by low rainfall/dry summers (Appendix III), and how the subspecies was extirpated from the Laguna Mountains. In addition, the climate was drier in Laguna Meadow (Grant *et al.* 2009, p. 47; County of San Diego 2010, p. 113) during the years leading up to Laguna Mountains skipper extirpation (Service 2019, p. 35) than it ever was in Mendenhall Valley, where the subspecies persists. Therefore, there was likely a synergistic effect between increased drying of the habitat and increased grazing (or increased vulnerability of the subspecies to grazing impacts) at the time the species was extirpated.

One way to investigate grazing impacts is to compare grazing and butterfly history among meadows. The USFS submitted a report (Criley 2016, pp. 1 and 6) in response to "inferences to a higher grazing pressure in Laguna Meadow possibly leading to the extirpation of Laguna Mountain …," to help inform this recovery plan and "…efforts attempting to correlate grazing use with Laguna Mountain skipper population trends and distribution." It concluded Laguna Meadow and Mendenhall Valley had similar grazing histories through the apparent period when Laguna Mountain Skipper declined in the Mount Laguna area.

We considered information from the Forest Service (Criley 2016; Winter and Criley 2018, pers. comm.), additional information from the Mendenhall family on grazing practices (Mendenhall 2018, pers. comm.), and conducted additional analysis. We estimated and compared differences in grazing intensity between Laguna Meadow and Mendenhall Valley during the period of species decline. The Laguna Mountains skipper appears to have experienced a long-term decline in the Laguna Mountains, and likely crossed a threshold of irreversible decline by the early 1990s (Service 2019, p. 16). Using information provided in Criley (2016 pp. 8 and 10) and Mendenhall (2018 pers. comm.), and combining the total acreage of the currently occupied meadow area/grazing allotment in Mendenhall Valley, we calculated average annual grazing intensity (head months per acre) for Laguna Meadow and Mendenhall Valley. We found that from 1977 through 1989 (after which grazing intensity was reduced due to ongoing drought) estimated grazing intensity in Laguna Meadow was almost double that in Mendenhall Valley (1.12 vs. 0.65 head months per ac.). From 1990 through 1999 (when the last Laguna Mountains skipper was observed in Laguna Meadow), grazing intensity was similar in the two meadow areas as alluded to by Criley (2016, p. 6), even slightly lower in Laguna Meadow than in Mendenhall Valley (0.46 vs. 0.6 head months per ac.). By 1990 however, in Brown's (1991, p. 5) opinion, the species had already been in decline for over 20 years. We found that during the extreme drought years from 1987 to 1991, when Faulkner (*in* USFS 2016, p. 2) noted the species was in clear decline, average grazing intensity still appeared significantly higher in Laguna Meadow (0.8 vs. 0.6 head months per ac.), compared to Mendenhall Valley. Therefore, analysis of grazing intensity in Mendenhall Valley and Laguna Meadow, supports the hypothesis that grazing pressure during drought years contributed to extirpation of the Laguna Mountains skipper from the Laguna Mountains.

There are several assumptions required to compare grazing effects between the two mountain areas and relate them to butterfly population persistence that were not met by the analyses discussed above. First of all, such an analysis may not be robust enough to violate the assumption of no difference between habitat areas and remain valid. Habitat differences could affect resilience of Laguna Mountains skipper populations to drought and grazing impacts. For example, the Laguna Mountains typically receive less rainfall than Palomar Mountain (County of San Diego 2010, p. 113), thus Laguna Mountains skipper populations may be more vulnerable in the southern mountains to grazing impacts, especially during summer larval development. Furthermore, such an analysis may not be robust enough to violate the assumption of identical management and remain valid. While cattle have always been moved to different parts of Mendenhall Valley during the summer and winter, they are not moved to a different meadow entirely in the winter as in Laguna Meadow. Criley (2016) did not analyze grazing intensity on the private portion of Mendenhall Valley, which is part of the same skipper population distribution as the Forest Service pasture. Finally, the analysis may not be robust enough to violate the assumption of population independence within a mountain area and remain valid. There were no other Laguna Mountains skipper populations in ungrazed meadows in the Laguna Mountains to potentially provide immigrants to Laguna Meadows, compared to Palomar Mountain (such as the Doane Valley Occurrence; Figure 2) for Mendenhall Valley. Violation of those assumptions makes it difficult to infer butterfly population effects from grazing intensity data comparisons among meadows, rendering both our analysis and that of Criley (2016) inconclusive.

Several pre- and post-cattle grazing event observations by experts in the field also support the hypothesis that grazing can result in Laguna mountains skipper mortality. Inspection of host plants prior to and after movement of cattle ("trespassing" from lower-elevation private lands) through USFS pasture in the southeastern portion of Mendenhall Valley revealed apparent cropping by grazing (Osborne 2018, pers. comm.). Qualitative observation of host plant conditions during field studies in Mendenhall Valley also support this hypothesis (Osborne and Anderson 2016 and 2017, pers. obs.). *Horkelia clevelandii* in the study area (infrequently visited by cattle compared to the primary meadow) appeared to have few grazing impacts, while many plants in the primary meadow where cattle were frequently observed appeared to be close-cropped to the ground. Plants most accessible and exposed to cattle in the primary meadow resembled prostrate "mats" of vegetation, in contrast with the more erect "bushy" appearance of plants in the study area. The appearance of host plants inside the grazing exclosure (not in the area that is getting overgrown with deer grass) in the primary meadow, which does not exclude deer and other grazers, compared to those outside was also more "bushy." These observations suggest cattle grazing is the cause of the mat-like appearance of plants in the active pasture.

It is clear the USFS has invested substantial effort into conserving Laguna Mountains skippers throughout the species historical range, and minimizing grazing impacts to the species (Table 3). It is not clear what more the USFS could have done, considering the information available on Laguna Mountains skipper during the years leading up to extirpation. It may also be true the subspecies was experiencing irreversible decline in the Laguna Mountains due to a combination of climate change and land management practices before the Forest Service started managing the land. Nevertheless, all the information considered above supports the hypothesis that direct impacts of grazing (incidental ingestion and trampling) contributed to the decline and extirpation of the subspecies in the Laguna Mountains (last observed in 1999), and pose a threat to Laguna Mountain skipper at high enough densities, especially during drought conditions. The possible threat of direct mortality due to cattle grazing appears currently most severe in Dyche Valley (Pine Hills occurrence), less so in other grazed occupied meadows, depending on intensity and timing of grazing. Grazed areas in the French Valley and Pine Hills occurrences are not managed for Laguna Mountains skipper conservation.

Over the past several years, researchers have reported increasing numbers of the nonnative seven spotted ladybird beetles (*Coccinella septempunctata*) in occupied and formerly occupied Laguna Mountains skipper habitat (Faulkner 2009, pers. comm.; Grant *et al*. 2009, p. 25; A. Anderson, 2015, pers. obs.). Though not known to be a threat at the current time, ladybird beetles have been reported to prey on the eggs and early instar larvae of butterfly species (e.g. Sheppard *et al.* 2004, p. 2077).

In 2017-2018 Osborne and Anderson (2018, p. 1) discovered that minute pirate bugs (*Anthochoride: Orius sp.*) were a major early instar mortality factor during rearing and apparently in the wild field population (these were commonly observed while searching for larvae). While this predator is likely native and not therefore a threat influenced by human activity, any ecological habitat changes that might increase the abundance of this predator could negatively impact Laguna Mountains skipper population growth.

During captive propagation the presence of the disease *Wolbachia sp.*, a proteobacteria, was detected in Laguna Mountains skippers collected from Mendenhall Valley on Palomar Mountain (Longcore *et al.* 2014, p. 11). *Wolbachia* has been reported to interfere with the reproduction of butterflies and other types of insects in a number of ways, including cytoplasmic incompatibility among infected and non-infected individuals (Werren 1997, p. 593; Nice *et al.* 2009, p. 3137).

Longcore *et al.* (2014, p. 11) expressed concern that *Wolbachia* may have been responsible for the infertility of a wild adult female captured for rearing. However, *Wolbachia* is not considered to be a current threat to the Laguna Mountains skipper.

Factor C Summary

Direct mortality of immature life stages due to incidental ingestion by cattle continues to impact Laguna Mountains skipper at unquantified levels where grazing occurs, and could be a threat where it is not managed to minimize impacts to Laguna Mountains skipper; especially during the summer, fall, and winter. Predation and disease are not known to be threats at this time, but should be further investigated.

Factor D: Inadequacy of Existing Regulatory Mechanisms

In the listing rule, regulatory mechanisms thought to have some potential to protect the Laguna Mountains skipper included: (1) California Environmental Quality Act (CEQA), (2) National Environmental Policy Act (NEPA), and (3) land acquisition and management by Federal, State, or local agencies, or by private groups and organizations for the conservation of this subspecies (Service 1997, pp. 2318–2319).

The status of regulatory mechanisms and their adequacy for protection of the Laguna Mountains skipper remains largely unchanged since the time of listing. Several State and Federal mechanisms provide a conservation benefit to the Laguna Mountains skipper. However, the Act is the primary Federal law that provides protection for this species since its listing in 1997. Critical habitat was designated in 2006 both in the Laguna Mountains and on Palomar Mountain. Other Federal and State regulations provide discretionary protections for the subspecies, but do not guarantee protection for the subspecies absent its status under the Act (Service 2019, pp. 42-47). In the absence of the Act, other laws and regulations have limited ability to protect Laguna Mountains skipper throughout a substantial portion of the subspecies' range. Therefore, we continue to work with private landowners and State and Federal agencies, in particular California Department of Parks and Recreation (CDPR), California Department of Fish and Wildlife (CDFW), and USFS to implement actions to reduce ongoing threats and recover this subspecies. For additional information related to regulatory mechanisms see the 2019 5-year review (Service 2019, pp. 42-47).

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

The listing rule indicated that small population size makes Laguna Mountains skippers more vulnerable to the effects of habitat loss, degradation and fragmentation, and stochastic events. It also identified drought (discussed above under Factor A), wildfire, and recreation as sources of mortality. The listing rule did not call out any one threat as most prevalent under Factor E. Here we also discuss the possible impacts of trampling by cattle.

The threat to Laguna Mountains skipper posed by small population size and isolation has significantly increased since the time of listing due to loss of the Laguna Meadow and Crouch Valley occurrences. The remaining Laguna Mountains skipper populations are relatively small and susceptible to stochastic events, which may result in extirpation of additional populations. Small population size also increases the probability of extinction of the subspecies due to difficulty finding mates, loss of genetic diversity, and lack of colonists to repopulate habitat patches (Allee 1931, pp. 246 and 247). Low genetic diversity may decrease a species' ability to adapt to changing environmental conditions. Genetically homogenous populations may therefore be more at risk and less able to recover from environmental or demographic variability (such as drought and fire events) compared to large diverse populations. Therefore, the extremely restricted range and localized distribution make the Laguna Mountains skipper more vulnerable to extirpation by environmental events.

At the time of listing it was noted that a large fire could eliminate the Laguna Mountains skipper populations (Service 1997, p. 2319), but fire may be a necessary component for the maintenance of habitat. This characterization has not changed; we know more now about positive effects from fire activity, including reduced fuel loads and maintenance of early successional stage vegetation (Service 2019, p. 48). Grant *et al*. (2009, p. 10) expressed concern that "a single high intensity conflagration fueled by Santa Ana katabatic winds [carries high density air from a higher elevation down a slope under the force of gravity] could potentially drive the species to extinction..." Other fire-adapted species that typically survive burns have been extirpated from portions of their range (for example, Quino checkerspot butterfly; Service 2003, p. 30), and catastrophic wildfire is known to be a threat to small, isolated butterfly populations (Healy and Wassens 2008, p. 13). Therefore, wildfire continues to pose a rangewide threat with potential to extirpate populations.

At the time of listing recreation was considered a threat to the species, this has not changed, but the threat is reduced range-wide primarily because the Laguna Mountains are no longer occupied. Recreational activities that could result in crushing of host plants occupied by immature life stages, such as hiking and biking where host plants are present when larvae are active, or sledding in habitat where pupae are diapausing in the winter, could cause mortality and potentially weaken a population.

Factor E Summary

The threats to Laguna Mountains skipper under Factor E include small population size, wildfire, recreation, and trampling by cattle as sources of vulnerability and mortality. Of greatest concern are small population size and the potential for population loss due to fire.

G. Conservation Efforts

At the time of listing, conservation efforts for Laguna Mountains skipper have primarily consisted of surveys and monitoring, habitat research, and captive rearing efforts (Table 3). Approximately 6,242 ac (2,525 ha) of critical habitat was designated for the Laguna Mountains skipper on December 12, 2006 (Service 2006, entire). Conservation efforts have greatly increased our knowledge of the subspecies, its vulnerabilities, and recovery needs (Marshaleck 2014, pp. 1–4.; Service 2019, pp. 23-25). Captive propagation was funded by the Service and provided important natural history and rearing information (Service 2019, pp. 24-25). Grazing and recreation have been excluded from occupied habitats on USFS lands in Mendenhall Valley and Laguna Meadow for approximately 15 years in some areas of high host plant density (Table 3, see other USFWS efforts). Initially, these grazing exclusions likely benefitted Laguna Mountains skippers, but over time the lack of disturbance appears to have reduced habitat suitability in portions of the exclusion areas that became relatively overgrown (Marshaleck 2014, p. 4; Winter 2015, pers. comm.; Anderson 2015, pers. obs.). The Mendenhall family and the USFS have worked together since the time of listing to manage grazing and other practices in Mendenhall Valley; an activity crucial to maintaining the seemingly most resilient Laguna Mountains skipper population (Mendenhall Valley occurrence). CDFW, in coordination with the Service, recently purchased a nearly 280 ac (113 ha) conservation easement through a section 6 Recovery Land Acquisition Grant (Cooperative Endangered Species Conservation Fund) on privately owned land in Mendenhall Valley to protect occupied Laguna Mountains skipper habitat from a change in land use (Service 2019, p. 25).

Table 3. Conservation efforts funded and implemented since listing to benefit the Laguna Mountains skipper.

Year	Title	Reference and/or funding Agency
1980-2000	Grazing exclosure around Little Laguna Lake and El Prado meadow, Laguna Mountains	USFS, Cleveland National Forest
1994- 2015	Annual surveys to monitor LMS population statuses	Levy 1997; Mattoni and Longcore 1998; Pratt 1999; Faulkner 2000-2013 & 2015 /USFS, Cleveland National Forest
1997-ongoing	Grazing management	USFS, Cleveland National Forest
1999-ongoing	Multiple grazing exclosures on Palomar and Laguna Mountains	USFS, Cleveland National Forest
2000	Reduced visitor capacity at Laguna Campground Meadow loop and installed LMS interpretive signs	USFS, Cleveland National Forest
2000	Closed and decommissioned Agua Dulce Campground in Laguna Mountains	USFS, Cleveland National Forest
2000-2004	Studies of habitat parameters and grazing effects on host plant	Williams and Bailey 2004/ USFS, Cleveland National Forest funding
2001	Installed split rail fencing at Laguna Mountain Visitor Center and Laguna Cabin Tract to prevent visitors and permittees from entering habitat	USFS, Cleveland National Forest
2003	Gully repair upstream of Observatory Campground to reduce erosion and enhance habitat	USFS, Cleveland National Forest
2007-2011	Land acquisition grant for easement on portions of the Mendenhall Property on Palomar Mountain	Service 2019/Service funding
2007-2010	Palomar State Park habitat restoration project	CDPR 2012/Service funded
2007 and 2008	Surveys to determine distribution, natural history, and ecology	Grant *et al.* 2009 and Osborne 2008/Service funding
2010-2012	Laguna Mountain Skipper Captive Rearing	Johnson *et al.* 2010; Longcore *et al.* 2014/ Service funding
2014	Rebuilt and expanded the exclosure at Observatory Campground (installed 1997) to protect skipper habitat	USFS, Cleveland National Forest
2012-2015	Monitoring Populations of the Endangered Laguna Mountains Skipper on Palomar and Laguna Mountains in San Diego County	Marschalek 2015/Service and CDFW funding
2014-2015	Effect of prescribed fire on habitat (experiment)	Miller 2015/USFS, Cleveland National Forest funding
2015-ongoing	Laguna Mountains skipper ranching and population Ecology	Osborne and Anderson 2018/ Disney Conservation Fund and Service funding
2018	280-acre conservation easement purchased in Mendenhall Valley	CDFW; Service 2019 p. 25

H. Summary and Synthesis

Recovery of Laguna Mountains skipper presents a number of challenges. Habitat degradation due to grazing is managed in the Mendenhall Valley occurrence, but remains a possible threat on private land in at least one occurrence on Palomar Mountain. Incidental ingestion and trampling of immature life stages could be a threat where it is not managed to minimize impacts to Laguna Mountains skipper. Succession appears to be reducing habitat quality within western Mendenhall Valley and the upper Doane Valley (Mendenhall Valley and Doane Valley occurrences) though disturbance (grazing and controlled burns) can be utilized to restore and maintain habitat. Laguna Mountains skipper populations are small, and especially susceptible to impacts such as drought and wildfire. Climate projections suggest habitat may experience extreme drying in the future, or improve over the next 30 years and then return to moisture levels consistent with current levels over the next 60 years. There is likely a synergistic effect between increased drought conditions and increased impacts of grazing by cattle. Drying of the habitat reduces other available forage for cattle, so they are more likely to feed on the tops of the greener perennial host plants where summer larvae occur. Grazing has been greatly reduced in the former Laguna Meadow occurrence since extirpation, and near-term habitat conditions are projected to change very little, or even improve. Wildfire continues to pose a rangewide threat with potential to extirpate populations.

With extirpation of the Laguna Mountains occurrences, the subspecies lost crucial population redundancy and likely also genetic diversity. Any further reduction in distribution may affect our ability to reestablish Laguna Mountain skippers in the formerly occupied southern portion of their range (due to small population size and isolation, along with other threats), and significantly increase the likelihood of catastrophic loss of all remaining populations. Attempts are ongoing to establish a captive propagation program to learn more about the biology of the Laguna Mountain skipper and develop the methodology necessary to restore populations at locations other than Palomar Mountain. While the subspecies' extinction vulnerability has significantly increased since listing, and the Laguna Mountains skipper remains in danger of extinction throughout its range, this has been partially mitigated by partnerships among stakeholders, regulators, and scientists who continue to improve our understanding of what is needed for subspecies recovery.

II. RECOVERY PROGRAM

This section describes the Laguna Mountains skipper recovery program by outlining a strategy, identifying where recovery will occur (management units), defining the recovery goal and objectives, and delineating criteria to reclassify the subspecies as threatened (downlist the subspecies) and subsequently to remove the Laguna Mountains skipper from the list of threatened and endangered species (delist the subspecies).

A. Recovery Strategy

The most pressing threats to Laguna Mountains skipper are range reduction and vulnerability due to small population size and isolation. Resilient populations, of sufficient size, are necessary to withstand natural stochastic events (extremes of otherwise normal conditions that temporarily reduce population size). Redundant populations are necessary to withstand catastrophic events (unpredictable rare events that may cause population extirpation such as wildfire). Both are needed to preserve populations with genetic composition representative of historical diversity (genes likely to be required for survival under current and future ecological states) and withstand climate change-driven increased vulnerability to grazing pressure and loss of habitat suitability. Therefore, the highest priorities for recovery are management of grazing to balance positive and negative impacts, captive propagation and reintroduction, modeling of population growth, climate change adaptation and mitigation planning, and monitoring to ensure each Laguna Mountains skipper population is resilient and genetically representative. Further research is necessary to better understand the species life history, refine grazing management practices so that they are economically feasible and desirable to ranchers, and address uncertainties regarding disease and predation. Recovery of the Laguna Mountains skipper will especially benefit from the involvement of stakeholders and partners in all applicable actions. Increasing the number of resilient populations, increasing the extent of occupied habitat, and maintaining genetic diversity are needed to help with the continued survival of this endangered species.

Management Units

Laguna Mountains skipper management units (MUs) are geographic areas defined by property parcels with a unique set of land owners or managers that encompass meadow habitats currently supporting, or that formerly supported, one of the six occurrences (Figures 2 and 3; Table 1). Each MU has the potential to support an independent and resilient population, but may require unique management actions to ameliorate threats.

Palomar Mountain

Palomar Mountain is occupied and divided into four MUs (Figure 2):

- <u>Doane Valley Management Unit:</u> Includes Lower French Valley, Lower Doane Valley, Upper Doane Valley, and Iron Springs. The majority of meadow habitat in this unit is owned and managed by the CDPR. Iron Springs is privately owned.

- French Valley Management Unit: Includes Upper French Valley, Palomar Observatory Trail, and Palomar Observatory Meadows. Meadow habitat in this unit is primarily privately owned, with some USFS and California Institute of Technology-owned land.
- Mendenhall Valley Management Unit: Includes the Observatory Campground and Mendenhall Valley. Meadow habitat in this unit is owned by a number of private landowners and the USFS.
- Pine Hills Management Unit: Includes Jeff Valley, Dyche Valley, and Will Valley. Meadow habitat in this unit is primarily privately owned; Jeff Valley and much non-meadow habitat areas are owned by the USFS.

Laguna Mountains

The Laguna Mountains are considered unoccupied and divided into two MUs (Figure 3):

- Laguna Meadow Management Unit: Includes Big Laguna Lake, El Prado Meadow, Laguna Campground, Horse Heaven Group Camp, Boiling Spring Ravine, and Agua Dulce Meadow. Meadow habitat in this unit is primarily owned by the USFS, with some private land.
- Crouch Valley Management Unit: Includes Meadows Kiosk and Joy Meadow. Meadow habitat in this management unit is primarily privately owned, with some USFS holdings.

Other Potential Management Unit Areas

Introduction of Laguna Mountains skipper may be possible in an additional area within its historical range in the Cuyamaca Mountains. This area includes Cuyamaca Meadow and Green Valley. Meadow habitat in this potential unit is primarily owned by the CDPR, with some private ownership.

B. Recovery Goal and Objectives

The goal of this recovery plan is to control or reduce threats to the Laguna Mountains skipper to the extent the subspecies no longer requires protections afforded by the Act and therefore, warrants delisting. To achieve this goal, the recovery plan's objectives are to:

1. Collect data needed to inform conceptual modeling efforts to understand Laguna Mountains skipper demographics, threats, and drivers. Further develop the population ecology model to advance our ability to assess resilience of Laguna Mountains skipper populations and inform management practices.

2. Increase abundance and ensure long-term persistence of Laguna Mountains skipper through reduction and management of threats to the subspecies and its habitat throughout the current range (where it occurs).

3. Ensure population redundancy of Laguna Mountains skipper through reestablishment (where needed) and documentation of multiple resilient and genetically representative populations within its historical range.

C. Recovery Criteria

An endangered species is defined in the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq*.), as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. When we evaluate whether or not a species warrants downlisting or delisting, we consider whether it meets either of these definitions. A recovered (or conserved) species is one that no longer meets the Act's definitions of threatened or endangered due to amelioration of threats. Determining whether a species should be downlisted or delisted requires consideration of the same five threat categories considered when the species was listed, specified in section 4(a)(1) of the Act.

Recovery criteria are conditions that, when met, indicate a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. These recovery criteria are our best assessment at this time of what needs to be completed so that the species may subsequently be removed from the list of threatened and endangered species. Because our understanding of species' vulnerability to threats is likely to change as more is learned, a status review may indicate downlisting or delisting is warranted before all recovery criteria are met. Conversely, it is possible that recovery criteria could be met and a status review could indicate that reclassification is not warranted; for example, a new threat is identified that was not addressed by the recovery criteria.

Laguna Mountains skipper recovery is not defined in terms of absolute numbers of individuals, but by the number of resilient populations protected and sustained via natural processes and ongoing management. The recovery criteria presented below represent our best estimate for measuring when impacts from current threats have been sufficiently reduced such that the recovery objectives have been met. Downlisting and delisting will be considered for the Laguna Mountains skipper when the following conditions have been met.

Downlisting Criteria

1. On Palomar Mountain, occupied habitat is conserved and managed in perpetuity and supports resilient populations that occupy the entire historical distribution (Table 1, Figure 2) in two management units (MUs) to ensure adequate redundancy and preserve the species' remaining genetic diversity (for example, distribution in the Doane Valley occurrence must include occupancy in Lower French Valley, Lower Doane Valley, Upper Doane Valley, and Iron Springs). The population trend based on the adult spring flight season or their offspring is stable or increasing over an 8 year period and resilience is demonstrated during this time by an average summer to spring peak abundance ratio of over 0.5 (or using a new metric if one is developed that represents stable population growth) with evidence of reproduction for the last 2 years. Based on past data, a period of

8 years represents a population able to withstand fluctuations in population size, averaging over that period allows for natural variation in population size. A reproducing population must be documented for 2 years in a third MU on Palomar Mountain. Reproduction is demonstrated by detection of a summer flight season. (Factors A and E)

2. Off Palomar Mountain, another reproducing population is documented for 6 years (persistent, but may not yet meet the definition of resilient). (Factor E)

3. Service-approved management is in place in perpetuity to maintain disturbance regime for optimal habitat successional stage and minimize direct and indirect impacts to Laguna Mountains skipper from grazing, fire, and succession in the three MUs on Palomar Mountain (Criteria 1) and the population off Palomar Mountain (Criterion 2). (Factors A and C)

Delisting Criteria

1. On Palomar Mountain, habitat occupied by resilient populations that occupy the entire historical occurrence (Table 1, Figure 2) is protected in three MUs (Resilience must be demonstrated for 8 years prior to delisting). Another reproducing population is documented for 2 years in a fourth MU on Palomar Mountain. (Factors A and E)

2. Off Palomar Mountain an additional resilient population (demonstrated for 8 years prior to delisting) occupies protected habitat in a new MU. (Factors A and E)

3. A climate-smart management plan is developed and implemented that identifies the conservation needs of the species and includes adaptive management that mitigates the anticipated and observed climate change effects, including any changes in fire frequency and intensity, on otherwise resilient populations. (Factors A and E)

4. All potential Factor A and C threats have been investigated (for example hydrological modifications and groundwater removal, nonnative predators, and disease) to determine impacts, and measures implemented to minimize all significant threats in all MUs used to meet delisting criteria 1 and 2. (Factors A and C)

III. RECOVERY ACTION NARRATIVE AND IMPLEMENTATION SCHEDULE

The recovery actions identified below are those that, in our opinion, are necessary to bring about the recovery of Laguna Mountains skipper and ensure its long-term conservation. However, these actions are subject to modification as dictated by new findings, changes in the species' status, and the completion of other recovery actions. In some cases multiple alternative recovery actions below can be implemented to meet a recovery criterion, so recovery could be achieved without all actions being completed. We anticipate this recovery plan will be evaluated periodically to determine if the objectives are being achieved and will be updated as necessary to incorporate new information.

Each recovery action has been assigned a priority number according to our determination of what is most important for the recovery of the species based on the life history, ecology, and threats (see the Background section of this document). Priority numbers are defined per Service policy (Service 1983) as:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline of the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

The numeric recovery priority system follows that of all Service recovery plans. Because situations change over time, priority numbers must be considered in the context of past and potential future actions at all sites. Therefore, the priority numbers assigned are intended to guide, not to constrain, the allocation of limited conservation resources.

A. Recovery Action Narrative

1. Validate or revise the population ecology model to advance our ability to understand and monitor the status of Laguna Mountains skipper and inform management practices.

1.1 **Develop a survey protocol for estimating population size and detection of Laguna Mountains skipper populations under typical environmental conditions (Priority 2).** This would allow validation of the model through calculation of minimum detectable population size and would alert managers when populations decline.

1.2 **Refine the population ecology model for the Laguna Mountains skipper (Priority 2).** Additional population parameters such as spring and summer larval survival rates, diapause rate of the spring brood, and annual pupal survival rates will be used to refine measurement of summer brood contribution to population growth rates and model population viability**.**

2. **Increase abundance and ensure the long-term persistence of Laguna Mountains skipper through reduction and management of threats to the subspecies and its habitat throughout its current range.** Work with stakeholders as needed in all management units to assess management needs, develop partnerships, and implement recovery actions where the species occurs.

2.1 Manage grazing in occupied management units

2.1.1 Determine relationship between habitat conditions and approximate amount and timing of host plant consumption and trampling by cattle during spring and summer seasons (Priority 1). Determine grazing impacts to the Laguna Mountains skipper beyond grazing impacts of native species.

2.1.2 Determine the amount of grazing needed to minimize succession so habitat supports sufficient host plants suitable for depositing eggs to sustain a resilient population (Priority 1).

2.1.3 Work with stakeholders to determine and implement grazing management practices that simultaneously minimize cost to ranchers and impacts to Laguna Mountains skipper (Priority 1).

2.1.4 Finalize a grazing plan that includes private and USFS pasture land in Mendenhall Valley (Priority 1). The final grazing plan will be consistent with the conservation easement purchased with section 6 grant funding and the associated subgrant agreement and prepare a monitoring and management plan for these private lands.

2.1.5 Prepare a management and monitoring plan that addresses grazing Mendenhall valley consistent with the grazing plan in 2.1.4 (Priority 1).

2.2 Complete and implement a fire management plan for occupied Laguna Mountains skipper habitat areas to manage fuel loads to reduce danger of catastrophic wildfire (Priority 2).

2.3 Develop models to gain a better understanding of climate change to minimize and mitigate impacts on Laguna Mountains skipper populations and habitat (Priority 1). These models will inform strategies to reduce impacts of climate threats, including indirect effects such as changes in fire frequency and intensity, and help focus conservation and management efforts on meadows less likely to be affected by climate change (adaptation).

2.4 Investigate impacts of hydrological modifications and ground water removal on Laguna Mountains skipper habitat and manage as needed (Priority 2). Research impacts of hydrological modification on surface water levels, soil moisture levels, and long-term habitat suitability.

2.5 Conduct habitat restoration and maintenance – manage disturbance to maintain succession state and native plant diversity/composition as appropriate.

2.5.1 Manage disturbance in Doane Valley MU (Priority 2).

2.5.2 Manage disturbance in other meadows as needed to maintain resilient populations (Priority 3).

2.6 Minimize impacts from disease on Laguna Mountains skipper as needed.

2.6.1 Research impacts of disease (for example, *Wolbachia*) on population reproductive rates (Priority 3).

2.6.2 Manage impacts related to disease as necessary to ensure population resilience (Priority 3).

2.7 Minimize impacts related to sources of predation and parasitism of the Laguna Mountains skipper.

2.7.1 Research impacts of predation and parasitism (for example, the seven-spotted ladybird beetle and minute pirate bugs) on mortality and growth rates (Priority 3). Determine if, and how readily predators prey on Laguna Mountains skipper larvae.

2.7.2 Manage impacts of predation and parasitism as necessary to ensure population resilience (Priority 3).

2.8 Ensure long-term protection of habitat on Federal, State, and private lands that are occupied by Laguna Mountains skipper.

2.8.1 Establish conservation easements similar to the one in Mendenhall Valley (Priority 3).

2.8.2 Seek funding for acquisition of habitat from willing sellers (Priority 3).

2.8.3 Work with partners to acquire land for conservation (Priority 3).

3. **Ensure population redundancy of Laguna Mountains skipper through documentation and reestablishment (where needed) of multiple resilient and genetically representative populations within its historical range**. Captive propagation will be utilized to attempt

reintroduction and establishment of resilient populations, for refugia purposes if needed, and to conduct life history research.

3.1 Attempt reintroduction and augmentation of Laguna Mountains skipper within its historical range. Reintroduction will first be attempted to establish a population at the Laguna Meadow MU. Other potentially suitable areas include the Crouch Valley MU and the Cuyamaca Mountains.

3.1.1 Determine methodology necessary for captive rearing, including butterfly ranching, of the Laguna Mountains skipper, compliant with the Service's captive propagation policy (Priority 1). Butterfly ranching is typically performed on-site within a population distribution, and does not involve mating of captive adults.

3.1.2 Establish a captive rearing program to support research and reintroduction efforts (Priority 1). Rearing would be maintained until an additional resilient population is supported in the Laguna Mountains or where research indicates habitat would best support a population long-term.

3.1.3 Identify suitable reintroduction sites and evaluate potential threats at sites (Priority 2).

3.1.4 Conduct habitat restoration (for example, restore natural disturbance, augment host plants, and remove nonnative species) as needed to prepare for reintroduction of Laguna Mountains skipper (Priority 2).

3.1.5 Develop a release plan for Laguna Mountains skipper that will include methods to (Priority 1):

- Determine the number and life stage of individuals to release and the appropriate genetic makeup needed to augment or reestablish occurrences.
- Determine when the release will take place and how individuals will be transported.
- Document habitat conditions prior to reintroduction.
- Conduct pre- and post-release population monitoring until all criteria are met to document resilience of the Laguna Meadow population.

3.1.6 Implement reintroduction or augmentation of Laguna Mountains skipper to suitable sites, compliant with the Service's captive propagation policy.

3.1.6.1 Implement reintroduction to Laguna Meadow (Priority 1). Cattle grazing pressure was more intense and the climate was drier in Laguna Meadow during the years leading up to Laguna Mountains skipper extirpation. However, grazing has been greatly reduced in the Laguna

Meadow occurrence since extirpation and near-term habitat conditions are projected to change little or even improve.

3.1.6.2 Implement reintroduction or augmentation to other suitable sites (Priority 2).

3.2 Monitor the Laguna Mountains skipper for population persistence and resilience within all occupied areas (Priority 1). Survey for presence of adult population and host plant distribution and abundance. Monitor for resilience as indicated by population ecology model. Assess habitat restoration needs.

B. Implementation Schedule

The following implementation schedule outlines actions and estimated costs for this recovery plan. This schedule prioritizes actions, provides an estimated timetable for performance of actions, indicates the responsible parties, and estimates costs of performing actions. Cost estimates are provided for the entire recovery period (estimated to be 30 years) as well as detailed for the first 5 years of the recovery period. These actions, when accomplished, should further the recovery and conservation of the species.

Key to additional terms and acronyms used in the Implementation Schedule:

Definition of action durations and costs:

Number: The predicted duration of the action in years or the cost of the action.

Ongoing: An action that is currently being implemented and will continue throughout the recovery period.

Continual: An action that is not currently being implemented but will be implemented continuously throughout the recovery period once begun.

Unknown: Either action duration or associated costs are not known at this time.

Cooperating Parties:

Cooperating parties are those agencies who may voluntarily participate in any aspect of implementation of particular tasks listed within this recovery plan. Cooperating parties may willingly participate in project planning, funding, staff time, or any other means of implementation.

Service	**U.S. Fish and Wildlife Service**
USFS	**U.S. Forest Service**
CDFW	**California Department of Fish and Wildlife**
CDPR	**California Department of Parks and Recreation**
SDZ	**San Diego Zoo**
UWG	**Urban Wildlands Group**
PVT	**Private landowner**
PVTC	**Private contractor or consultant**
UNIV	**University**

Please note that additional partners may be added in the final Recovery Plan subsequent to coordination and collaboration with our partners on specific recovery actions. Identifying cooperating parties does not commit those parties to carrying out that action, nor is it intended to limit involvement by other parties.

Table 2. Implementation Schedule – Actions to be completed for Laguna Mountains skipper recovery.

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
1.1	**2**	Develop a survey protocol for estimating population size and detection of Laguna Mountains skipper populations under typical environmental conditions.	Service, USFS, CDFW, CDPR, UNIV, PVTC, PVT	4	40	20	20	20		**100**
1.2	**2**	Refine the population ecology model for the Laguna Mountains skipper.	Service, USFS, CDPR, UNIV, PVTC, PVT	5	30	30	30	30	30	**150**
2.1.1	**1**	Determine relationship between habitat conditions and approximate amount and timing of host plant consumption and trampling by cattle during spring and summer seasons.	Service, USFS, CDFW, UNIV, PVTC, PVT	2	30	30				**60**
2.1.2	**1**	Determine the amount of grazing needed to minimize succession so habitat supports sufficient host plants suitable for depositing eggs to sustain a resilient population.	Service, USFS, CDFW, UNIV, PVTC, PVT	4	30	30	30	30		**120**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
2.1.3	**1**	Work with stakeholders to determine and implement grazing management practices that simultaneously minimize cost to ranchers and impacts to Laguna Mountains skipper.	Service, USFS, PVT	8	20	20	20	20	20	**160**
2.1.4	**1**	Finalize a grazing plan that includes private and USFS pasture land in Mendenhall Valley.	Service, USFS, PVT	TBD						**TBD**
2.1.5	**1**	Prepare a management and monitoring plan that addresses grazing valley consistent with the grazing plan in 2.1.4	Service, USFS, PVT	TBD						**TBD**
2.2	**2**	Complete and implement a fire management plan for occupied Laguna Mountains skipper habitat areas to manage fuel loads to reduce danger of catastrophic wildfire.	Service, USFS, CDFW, PVT	TBD						**TBD**
2.3	**1**	Develop models to gain a better understanding of climate change to minimize and mitigate impacts on Laguna Mountains skipper populations.	Service, USFS, UNIV, PVTC	5	40	40	40	40	40	**200**

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
2.4	**2**	Investigate impacts of hydrological modifications and ground water removal on Laguna Mountains skipper habitat and manage as needed.	Service, USFS, CDFW, PVT	10	15	15	15	15	15	**150**
2.5.1	**2**	Manage disturbance in Doane Valley MU.	Service, CDPR	TBD						**TBD**
2.5.2	**3**	Manage disturbance in other meadows as needed to maintain resilient populations.	Service, USFS, PVT	TBD						**TBD**
2.6.1	**3**	Research impacts of disease (for example, *Wolbachia*) on population reproductive rates.	Service, UNIV, PVTC	3	60	60	40			**160**
2.6.2	**3**	Manage impacts related to disease as necessary to ensure population resilience.	Service, USFS, CDPR, UNIV, PVTC	TBD						**TBD**
2.7.1	**3**	Research impacts of predation and parasitism (for example, the seven-spotted ladybird beetle and minute pirate bugs) on mortality and growth rates.	Service, UNIV, PVTC	3	40	40	40			**120**

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
2.7.2	**3**	Manage impacts of predation and parasitism as necessary to ensure population resilience.	Service, USFS, CDPR, PVT	TBD						**TBD**
2.8.1	**3**	Establish conservation easements similar to the one in Mendenhall Valley.	Service, USFS, CDPR, PVT	TBD						**TBD**
2.8.2	**3**	Seek funding for acquisition of habitat from willing sellers.	Service, USFS, CDPR, PVT	TBD						**TBD**
2.8.3	**3**	Work with partners to acquire land for conservation.	Service, USFS, CDPR, PVT	TBD						**TBD**
3.1.1	**1**	Determine methodology necessary for captive rearing, including butterfly ranching, of the Laguna Mountains skipper, compliant with the Service's captive propagation policy.	Service, UWG, UNIV, SDZ, PVTC	2	100	100				**200**
3.1.2	**1**	Establish a captive rearing program to support research and reintroduction efforts.	Service, UWG, UNIV, SDZ, PVTC	10	50	50	50	50	50	**500**
3.1.3	**2**	Identify suitable reintroduction sites and evaluate potential threats at sites.	Service, USFS, PVTC, PVT	TBD						**TBD**

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
3.1.4	**2**	Conduct habitat restoration (for example, restore natural disturbance, augment host plants, and remove nonnative species) as needed to prepare for reintroduction of Laguna Mountains skipper.	Service, USFS, PVTC, UNIV	TBD						**TBD**
3.1.5	**1**	Develop a release plan for Laguna Mountains skipper that will include methods to: • Determine the number and life stage of individuals to release and the appropriate genetic makeup needed to augment or reestablish occurrences. • Determine when the release will take place and how individuals will be transported. • Document habitat conditions prior to reintroduction. • Conduct pre- and post-release population monitoring until all criteria are met to document resilience of the Laguna Meadow population.	Service, USFS, UNIV, PVTC, PVT	TBD						**TBD**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	

Action number	Priority	Description	Cooperating Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
3.1.6.1	**1**	Implement reintroduction to Laguna Meadow.	Service, USFS, UNIV, PVTC, PVT	5	75	75	50	50	50	**300**
3.1.6.2	**2**	Implement reintroduction or augmentation to other suitable sites.	Service, USFS, UNIV, PVTC, PVT	TBD						**TBD**
3.2	**1**	Monitor the Laguna Mountains skipper for population persistence and resilience within all occupied areas.	Service, USFS, PVTC, PVT, UNIV	30	20	20	20	30	30	**870**
									Total	**$3,090,000 +TBD**

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VI. APPENDICES

Appendix I. Population Abundance and Growth Analyses

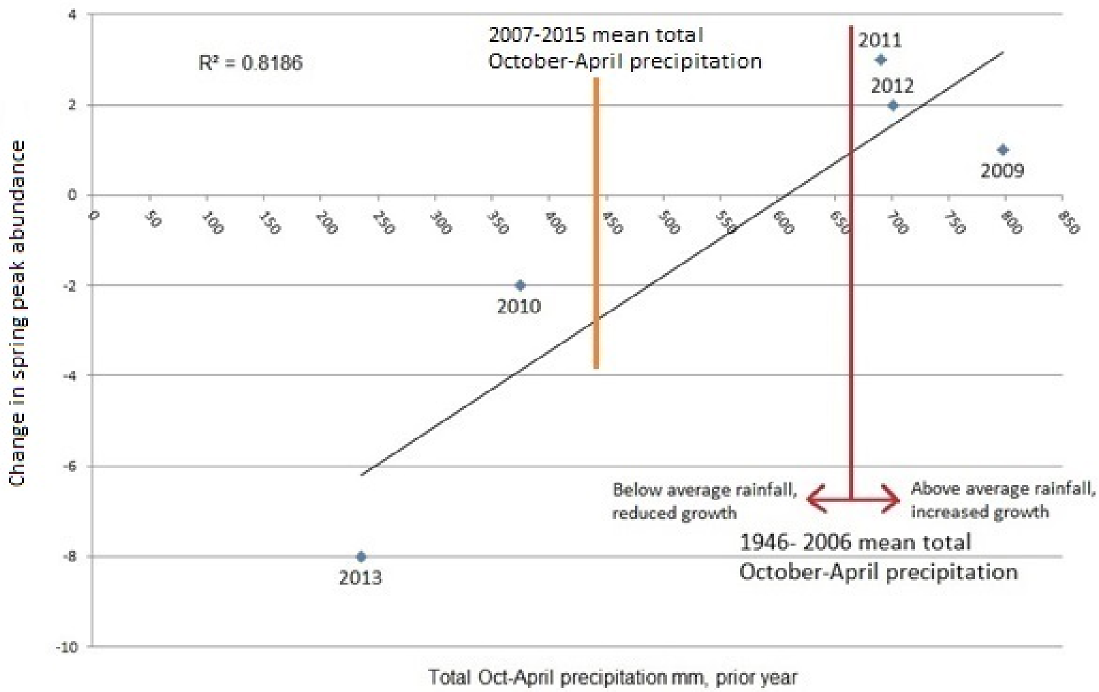

Figure 1. Monitoring data from Mendenhall Valley from 2009–2013 (Faulkner 2008, p. 2; 2009, pp. 2 and 3; 2010, p. 2; 2011, p. 2; 2012a, p. 2; 2013, p. 2) support the hypothesis that population growth increases when rainfall totals (October through April) from the previous year are above average and decreases when rainfall totals are below average (relationship illustrated by trendline). When rainfall totals approach the historical average (660 mm), we would not anticipate a large change in population size, that is no increase or decrease in the spring peak abundance (approximate x-axis intercept of trendline). The y-axis represents the change in spring peak abundance during the spring flight season from one year to the next. The red line represents the average precipitation (October – April) level between 1946 and 2006 (660 mm); the brown line represents average precipitation from recent years (2007 to 2015).

Appendix II. Laguna Mountain skipper threats table

Occurrences **(Other associated locations in the literature and on maps)**	**Ownership**	**Current threats to extant occurrences, and factors that could negatively affect a reintroduced population**
Palomar Mountain, extant		
Doane Valley (Lower French Valley, Lower Doane Valley, Upper Doane Valley, and Iron Springs)	Private, State, and USFS	Succession (State); land use change (private); climate change, small population size, water withdrawal, drought, wildfire (all)
French Valley (Upper French Valley, Palomar Observatory Trail, and Palomar Observatory Meadows)	Private and USFS	Habitat modification and incidental mortality due to grazing, land use change (private); succession (USFS); climate change, water withdrawal, small population size, drought, wildfire (all)
Mendenhall Valley (Observatory Campground)	Private and USFS	Succession, land use change (west valley); climate change, small population size, water withdrawal, drought, wildfire (all)
Pine Hills (Jeff Valley, Dyche Valley, and Will Valley)	Private and USFS	Habitat modification due to grazing, land use change, (Dyche and Will Valleys); climate change, water withdrawal, incidental mortality due to grazing, small population size, drought, wildfire (all)
Laguna Mountains, extirpated		
Laguna Meadow (Big Laguna Lake, El Prado Meadow, Laguna Campground, Horse Heaven Group Camp, Boiling Spring Ravine, and Agua Dulce Meadow)	Private and USFS	Climate change, small population size, drought, wildfire (all)
Crouch Valley (Meadows Kiosk and Joy Meadow)	Private and USFS	Habitat modification and incidental mortality due to grazing, land use change, climate change, small population size, water withdrawal, drought, wildfire (all)

Appendix III. California basin characterization model and projections

The California Basin Characterization Model (CA-BCM 2014) dataset provides historical and projected climate and hydrologic surfaces for the region that encompasses the state of California and all the streams that flow into it (California hydrologic region). The CA-BCM 2014 applies a monthly regional water-balance model to simulate hydrologic responses to climate at the spatial resolution of a 270-meter (m) grid.

Model outputs are intended for watershed-scale evaluation. Use of the data for analyses at a scale smaller than the planning watershed could yield misleading results.

Creator: Lorraine and Alan Flint, USGS
Contributor: Jim Thorne, Ryan Boynton, UC Davis
Publisher: California Climate Commons
Spatial Resolution: 270m
Temporal Coverage: 1921-2099
Date Issued: July, 2014

Source of above and for more information: http://climate.calcommons.org/dataset/2014-CA-BCM

Laguna Mountains skippers are sensitive to climate change because of their dependence on soil moisture levels and surface water availability, and because they currently inhabit a single mountaintop at maximum elevation, with no opportunity for range shift northward or upward in elevation. Comparison of the average annual climatic water deficit (CWD: potential minus actual evapotranspiration; a measure of soil moisture level or plant drought stress) between two 30 year intervals (1951-1980 mean compared to 1981-2009 mean) using the California Basin Characterization Model (Lorraine and Alan Flint, 2014) indicates CWD was higher in the Laguna Mountains during the 30 year period when Laguna Mountains skippers declined and were extirpated, than it had been for the prior 30 years (Figure 1).

Climate change model projections indicate climate will similarly affect habitat on Palomar Mountain and the Laguna Mountains over the next 60 years (Figures 1 and 2). Given their dependence on soil moisture and surface water availability, “wettest” and “driest” CWD projections indicate drying may detrimentally affect habitat suitability for Laguna Mountains skipper. However, projections suggest that conditions could improve over the next 30 years and then return to CWD levels consistent with current levels by the next 60 years.

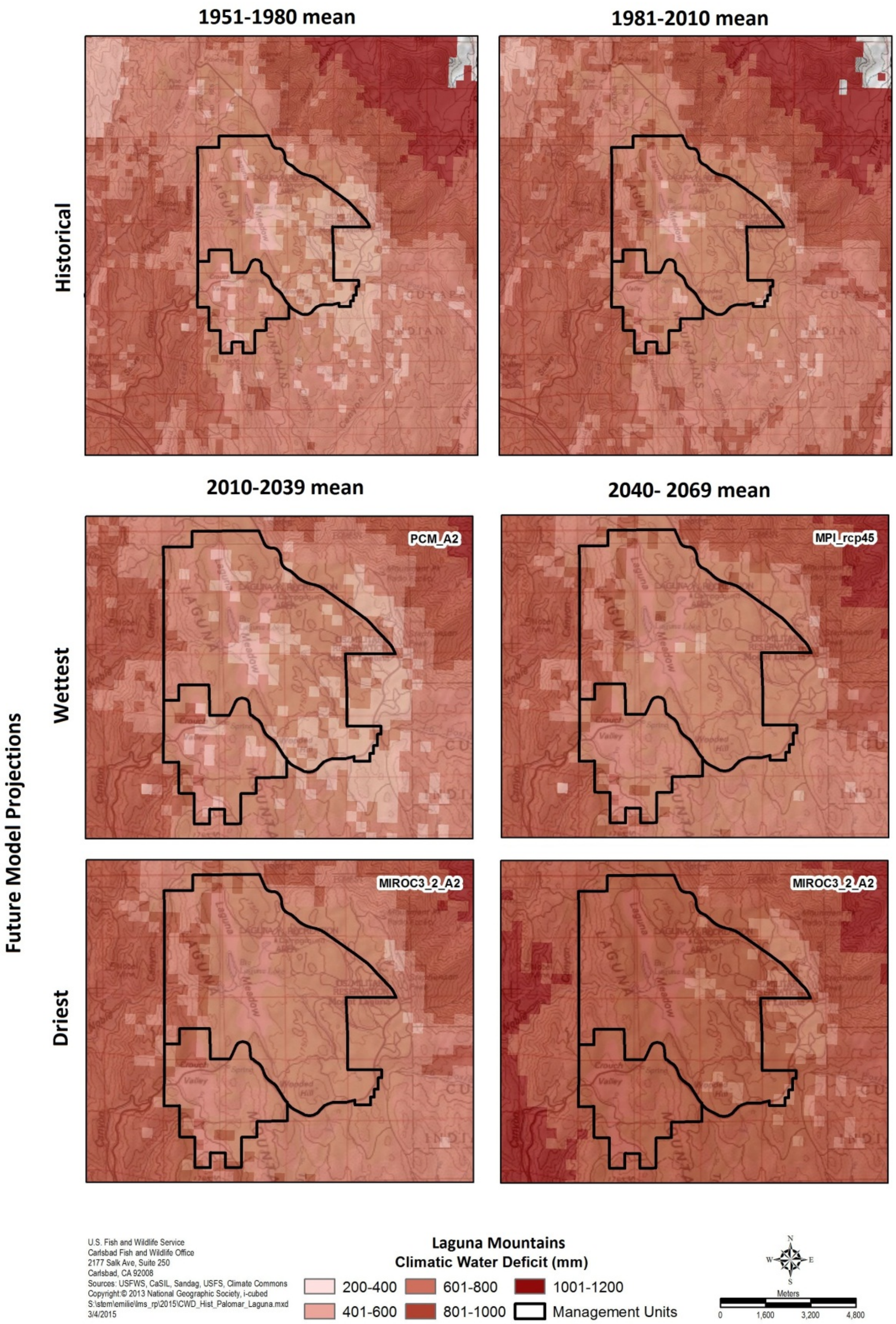

Figure 1. Historical 30 year mean modeled climatic water deficit (CWD) and future CWD projections for the Laguna Mountains, formerly occupied by Laguna Mountains skippers. Lower CWD values indicate higher soil moisture levels. Climatic water deficit can serve as an indicator of plant drought stress and soil moisture levels.

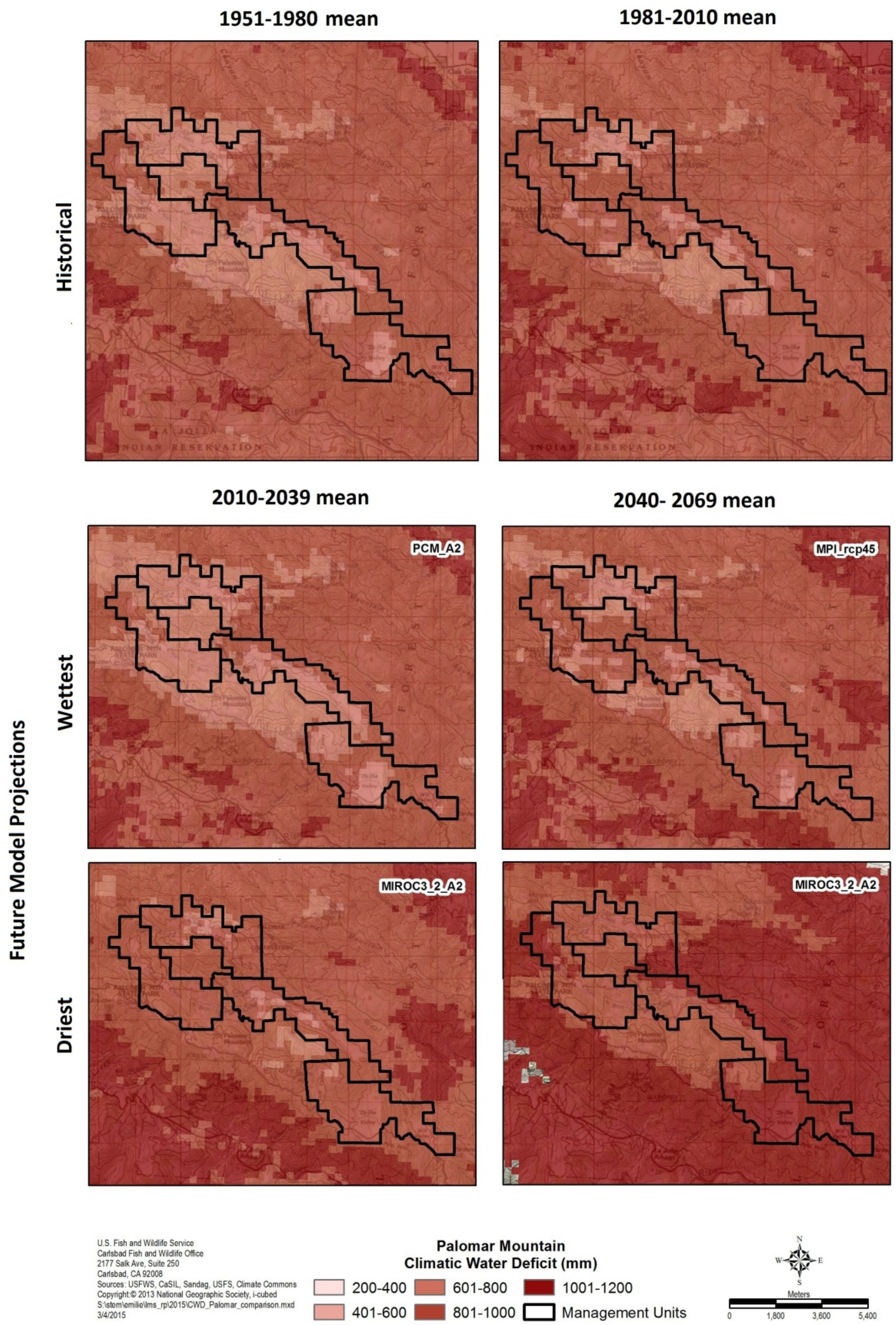

Figure 2. Historical 30 year mean modeled climatic water deficit (CWD) and future CWD projections for Palomar Mountain occupied by Laguna Mountains skippers. Lower CWD values indicate higher soil moisture levels. Climatic water deficit can serve as an indicator of plant drought stress and soil moisture levels.

Appendix IV. Summary of public and peer review comments received.

A. Summary of Public Comments

On January 26, 2016, we published a notice in the *Federal Register* announcing the availability of the draft recovery plan for the Laguna Mountains skipper (*Pyrgus ruralis lagunae*) for public review. We received one response with multiple attachments from Cleveland National Forest (USFS) during the comment period. We received no comments from State or local agencies, the public, or Native American Tribes.

We appreciate the USFS's input. Comments ranged from providing minor editorial suggestions to specific recommendations on plan content. We have considered all substantive comments and, to the extent appropriate, incorporated the applicable information or suggested changes to the final recovery plan. Below, we provide a summary of public comments received with our responses. Some comments, such as editorial suggestions, incorporated as changes in the final recovery plan did not warrant an explicit response and, thus, are not presented here. These comments were also addressed as appropriate in the 5 year status review that was finalized prior to publication of this final recovery plan.

Comment (1): Grazing history, as described in the draft recovery plan, is not consistent with National Forest System lands records for the Laguna Mountains and Palomar Mountain and relies heavily on anecdotal information. A report was submitted as evidence to support this statement (Criley 2016). The report concluded that the similar grazing history of Laguna Meadow and Mendenhall Valley throughout the apparent period when Laguna Mountain skipper declined in the Laguna Mountains does not support the hypothesis that higher grazing pressure in Laguna Meadow lead to the extirpation of Laguna Mountain skipper in that Area.

Response: We concluded that decline cannot be entirely, or irrefutably attributed to grazing pressure in the Laguna Mountains. We revised the text discussing this issue using information in the submitted report. Our analysis of submitted data (Criley 2016, pp. 5 and 6) indicated that during 1987-1991 drought, from 1987-89, cattle were grazed at sustained higher densities (head months per acre of primary range) in the Laguna Mountains compared to in Mendenhall Valley. Please see detailed discussion above under *Threat Factor C*.

Comment (2): Monitoring, management, and recovery actions the Cleveland National Forest (CNF) has completed should be discussed in the Conservation Efforts section of the plan. A list of projects was submitted in support of this comment.

Response: Agreed. We edited the plan to incorporate this information (efforts subsequent to listing).

Comment (3): The characterization that *Horkelia clevelandii* is typically "relatively rare" is not supported by cited literature; it should be described as "locally common" based on surveys and mapping by the Forest Service and US Fish and Wildlife Service.

Response: We edited the plan to clarify the scale of our characterization. Our characterization referred to how many plant populations are known within its range, not how common individuals are within a population.

Comment (4): Check references for occurrences of *Horkelia clevelandii* in the Sierra de Juarez in Baja California (specifically Parque Constitucion de 1857). This area is closer to the historic range of Laguna Mountains skipper than the Sierra San Pedro Martir.

Response: We thoroughly searched all available sources of information for records of *Horkelia clevelandii* in Baja California, Mexico. We could not find any records from the Laguna Hanson area. We did not see meadows similar in size to those occupied by Laguna Mountains skipper in Parque Constitucion de 1857 on satellite imagery either, however there is one large linear meadow north of the park in the Sierra de Juarez oriented roughly east-west that is approximately 3.5 miles (5.6 km) long that looks like it could support Laguna Mountains skipper. We edited the text to acknowledge this comment.

Comment (5): The statement "Only Palomar Mountain, the Laguna Mountains, and the Cuyamaca Mountains in the United States, and the Sierra San Pedro Mártir in Mexico, were found to contain large relatively wet meadows comparable to Mendenhall Valley and Laguna Meadow" is incorrect. The San Jacinto Ranger District does contain large wet meadows above 3,900 feet, specifically in Johnson Meadow, which has abundant *Horkelia clevelandii*, and Garner Valley.

Response: We maintain our assertion that the San Jacinto Ranger District does not contain large wet meadows comparable to Mendenhall Valley and Laguna Meadow. We added text from the 5 year review to clarify our statement. These meadows are surrounded by large ridges and mountains, forming true valley "basins" over 2 mi (3.2 km) long. Given what we know about historical occupancy, mountains occupied by Laguna Mountains skippers can be assumed to fit the relatively rare "hourglass shape" described by Elsen and Tingley (2015, pp. 1 and 2), characterized by a mid-elevation decrease in availability of elevational surface area (concentration of flatter habitat at mid-elevations, below higher peaks or ridges).

Comment (6): Recommend using range literature and range records from the Cleveland National Forest to inform discussion of grazing. Anecdotal information on range management should only be included when made by qualified range managers. Anecdotal information from other reports is not reliable, as there is a significant body of scientific literature regarding how meadows respond to grazing management. Meadows have a complex structure and hydrology influenced by many factors. If personal communications or anecdotes are going to be cited, they need to be qualified and balanced. For example, David Faulkner has stated that grazing wasn't a major factor in decline of skippers at Mt Laguna since grazing use has been flat or declining since the late 1970's (when the Forest Service acquired the meadow), and the decline of skippers closely paralleled the extreme drought conditions over most of that time period.

Response: We sought to incorporate a range of sources for information on grazing and range management that we felt was both appropriate and constituted the best available science. While information, anecdotal or otherwise, from qualified range managers is included in that category, it was also prudent to consider the expertise of scientists in the field of butterfly ecology. Although qualified range managers are likely better suited to evaluate how meadows respond to grazing management, comprehensive recovery planning must also include consideration of qualified insights into butterfly habitat modification and potential effects on the species that such butterfly experts can provide. In including this information, we sought to make sure it was appropriately qualified, balanced, and given reasonable consideration and emphasis. We agree that the ecology and hydrology of meadow systems are complex and that causative relationships are difficult to establish firmly. As a result, we feel that recovery planning for this species benefits from an approach that includes potentially divergent perspectives, as long as those perspectives are based on valid scientific reasoning.

Comment (7): At this time there is no specific information available as to what the optimal grazing regime for Laguna Mountain skipper might be, so it seems conjectural to state that Dyche Valley and French Valley occurrences might be under greater threat of habitat modification when compared with other sites.

Response: We agree with that comment and edited the text accordingly.

Comment (8): In Mendenhall Valley and Laguna Meadow cattle graze primarily on perennial grass and *Carex* species, not annual forage plants. The relative palatability through the grazing season of these forage species and *Horkelia clevelandii* is not known. Cattle forage selectivity is a complicated process that depends on more variables than relative "greenness" of forage species. The effects of other grazing species (deer, squirrel, rabbit, gopher) are also omitted here, and these species are known to prefer grazing on forbs such as *Horkelia clevelandii*.

Response: We considered this comment carefully and further researched available grazing literature for all species. While it is true the relative palatability through the grazing season of these forage species and *Horkelia clevelandii* is not known, it is clear that cattle consume *H. clevelandii*, and trampling of immature life stages can and does occur year-round. We added a discussion based on the resulting analysis of the likelihood of cattle and other species grazing on *H. clevelandii*. Several pre- and post-cattle grazing event observations by experts in the field (ranchers and Laguna Mountains skipper experts) support this hypothesis as well. Observation of host plant conditions during scientific field studies in Mendenhall Valley (2016 and 2017) strongly supports this hypothesis as well. We agree the relative palatability through the grazing season of these forage species and *Horkelia clevelandii* is not known, and are not aware of any data on cattle forage preferences and seasonal use in Mendenhall Valley and Laguna Meadow. In addition, we further examined the effects of deer grazing and added text to reflect their likely role as grazers.

Comment (9): Developing and monitoring a grazing management plan for the conservation easement at Mendenhall Valley should be a top priority.

Response: Agreed, development of a management plan is a priority. The Mendenhall family have been grazing few cattle in recent years, and the same number grazed on their private lands are subsequently grazed on adjacent Forest Service lands. As the valley supports a single population of skippers, management should be coordinated and planned accordingly.

Comment (10): Water extraction appears to be a significant factor affecting Laguna Mountains skipper habitat. An investigation of the effects of water extraction on hydrology should be a top priority, not second tier.

Response: Agreed, although known commercial water extraction wells on Palomar Mountain do not tap subsurface water that would flow into the southeast portion of Mendenhall Valley known to be occupied by the Laguna Mountains skipper. We edited the text accordingly.

Comment (11): Given the trend of drying conditions in Southern California, the habitat at Mt Laguna may no longer be suitable for Laguna Mountains skipper.

Response: Agreed. We acknowledged that possibility in our climate change analysis, but models also indicate that the drying trend may be reversed. Because we do not know if it will become wetter or drier, establishment of a population outside of Palomar is extremely important.

B. Summary of Comments from Peer Reviewers

We also solicited independent peer review of the draft recovery plan from six individuals who have expertise and experience with the Laguna Mountains skipper or the habitat. We received comments from five peer reviewers. In general, the draft recovery plan was well-received by the peer reviewers and considered “thorough and convincing” with a good mix of “science and pragmatism.” Several peer reviewers provided specific information, including documents or citations; we thank the reviewers for these data and we have added the information where appropriate. Below, we provide a summary of specific comments received from peer reviewers with our responses. Some comments, such as editorial suggestions, incorporated as changes in the final recovery plan did not warrant an explicit response and, thus, are not presented here. These comments were also addressed as appropriate in the 5 year status review that was finalized prior to publication of the final recovery plan.

Comment (1): Creation of new hostplant patches in population distributions is necessary for recovery and this activity should be specified in the plan.

Response: We will evaluate the possible need for expanding habitat quantity and improving quality on Palomar Mt.

Comment (2): Minimization of "natural" (native) predation and parasitism threats by delisting criteria is misguided. Natural predation and parasitism does not appear to affect Laguna Mountains skipper.

Response: Agreed, edited to reflect this recommendation.

Comment (3): Slight adjustments to population ecology model values render the summer brood irrelevant. The importance of a second brood is contradicted by resilience of rural skipper populations that have only one generation per year.

Response: We appreciate the sensitivity calculations undertaken by the reviewer, and subsequent conversations with the commenter we believe resolved these expressed concerns. While some sensitivity calculations (adjusted model values) by the reviewer did eliminate the need for a second generation to accomplish population replacement, all were based on values not supported by 2016 and 2017 field data. We edited the text to reflect the additional analysis and new data. The quality of habitat, climate, and other factors affecting and population growth parameters can vary greatly among subspecies, rural skipper populations in the Sierra Nevada Mountain Range likely have more predictable or otherwise suitable habitat than Laguna Mountains skippers.

Comment (4): The assumption that mates have more difficulty finding each other as population size decreases assumes, perhaps falsely, they do not use pheromones.

Response: Agreed, the assumption may be invalid. We contend however that the general statement holds true in most cases, perhaps even if pheromones are used. This assertion assumes the size of the area over which adults move and interbreed is smaller than the area over which they can detect pheromones. Even with pheromones, ability to find mates will decrease with decreasing population size if individuals are widely enough separated in an otherwise continuous habitat patch (e.g. Laguna Meadow), and/or if wind disperses the pheromones away from potential mates.

Comment (5): Climate change is likely, even in the relatively short term, to make recovery even more of a moving target than usual.

Response: Agreed, criterion 3 states a “climate-smart conservation plan” is needed, which will allow for flexibility to deal with uncertainty.

Comment (6): Two commenters stated that further development of the population ecology model, and refinement using phenological and other field data, will be important for recovery.

Response: Agreed, we appreciate the feedback.

Comment (7): Agree “heartily” that attempted reintroduction to apparently suitable habitats where populations were relatively recently lost [the Laguna Mountains] is appropriate.

Response: We appreciate the feedback.

Comment (8): Recovery criteria may need updating as new data further inform the conceptual population ecology model.

Response: Agreed. We edited the text to acknowledge that.

Comment (9): Should rethink diapause and focus data collection on it. This stage is important to demographics, and it would take relatively little effort to identify its regulators.

Response: Agreed, we edited the text to reflect that recommendation.

Comment (10): There is a need to better understand the quality and suitability of host plant species.

Response: Agreed, that will be part of management planning.

Comment (11): Sensitivity analysis to assess the stability of each variable in the population ecology model is important for understanding how variation influences population growth rate.

Response: Agreed. Some sensitivity analysis was done, is discussed in the text, and additional information was provided by another reviewer (see response to *Comment (4)* above). We believe enough sensitivity analysis has been conducted supporting that a second summer generation is needed to maintain population resilience. Further sensitivity analysis will be conducted as additional data informs values used in the model.

Comment (12): The recovery criteria requiring "Resilience is demonstrated by an average summer to spring peak abundance ratio of 0.5 (representative of stable population growth)…" is not appropriate because stability is not expected in insect populations.

Response: Disagree, note use of the language, "an average." Agreed that stability is not expected, but it is also not appropriate to down- or delist a species exhibiting declining population sizes due to threat factors (e.g. drought). A population that is not declining may be fluctuating largely but it is reasonable to expect that on average over 8 years, as specified in the criterion, growth parameters of a resilient population will reflect a stable population growth rate.

Comment (13): There should be more justification for quantitative aspects of downlisting and delisting criteria.

Response: While recovery criteria must be measurable and "quantitative," there is not always as much data on which to base these criteria as we would like. In some cases our values are estimates based on the best scientific information available.

Comment (14): Need to be clear whether grazing impacts are occurring from livestock or herbivores in general. If other grazers, such as deer are incidentally ingesting larvae and affecting population growth, management focused on livestock grazing is not likely to be effective.

Response: Agreed. We reviewed literature on deer grazing and expanded our analysis of direct grazing impacts and edited accordingly. See also response to public *Comment (8)* above.

Comment (15): Population size estimates are not always required to monitor population status, transect counts can provide appropriate population size indices.

Response: Agreed, indices can provide comparison among populations and across years, however they do not inform population growth models that estimate stability or resilience. Both methods are valuable as management tools. We edited the text to clarify.

Comment (16): It is not realistic to establish genetically representative populations within Laguna Mountains skipper historical range because the Laguna Mountains population's unique genes have been lost.

Response: We were referring to the remaining populations. We edited the text to clarify the criteria. We believe that retaining as many extant "populations" (occupied meadows with as-yet unquantified amount of genetic mixing among them) as possible will maximize retention of remaining genetic diversity.

U.S. Department of the Interior
U.S. Fish & Wildlife Service
Region 8, Pacific Southwest Region
Sacramento, California

Copies may be obtained online (species search: Laguna Mountains skipper) at *http://ecos.fws.gov/ecp/*

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