U.S. Fish & Wildlife Service

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

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

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

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

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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

Date: XXXXXXXXXXXXXXXXXX

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U.S. Fish and Wildlife Service. 2015. Draft Recovery Plan for Laguna Mountains Skipper (*Pyrgus ruralis lagunae*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 43 pp.

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

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

Acknowledgements

The recovery planning process has benefitted from the advice and assistance of a number of individuals, agencies, and organizations. This Draft Recovery Plan for the Laguna Mountains Skipper was compiled by Alison Anderson at the Carlsbad Fish and Wildlife Office (CFWO). Current and former CFWO staff who also contributed to preparation of drafts used for development of this draft Recovery Plan include: Emilie Luciani, Eric Porter, Jesse Bennett, Bradd Baskerville-Bridges, Kelly Goocher, Mary Beth Woulfe, Susan Wynn, Tyler Grant, Marci Koski, Cara McGary, Joel Pagel, Kurt Roblek, and Pete Sorensen.

We also thank our partners who play an active role in Laguna Mountains skipper conservation. Numerous agencies provided information through surveys and research, and these agencies helped manage habitat and implement recovery actions. Their support over the years has contributed to a better understanding of this species, which has subsequently helped develop this draft Recovery Plan. In particular we thank: David and Tom Mendenhall; David Faulkner (Forensic Entomology Services), Daniel Marschalek and Douglas Deutschman (San Diego State University), Jana Johnson (Moorpark College); Travis Longcore (Urban Wildlands Group and University of Southern California); Ken Osborne (Osborne Biological Consulting); Jack Levy (independent consultant); Gordon Pratt (University of California, Riverside, retired); Arthur Shapiro (University of California, Davis); Kirsten Winter, Lance Criley, and Jeffrey Wells (U.S. Forest Service); the California Department of Fish and Wildlife; and Lisa Fields (California State Parks) for their coordination and collaboration. We appreciate these efforts and look forward to continued collaboration as we refine methodologies and implement actions that support Laguna Mountains skipper recovery.

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 6C, which indicates the species faces a high degree of threat and has a low recovery potential. 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 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.

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 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 Laguna Mountains skipper populations are resilient, redundant, and genetically representative. 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 to:

1. Further develop the population ecology model to advance our ability to model population viability of Laguna Mountains skipper 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.

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.

Downlisting Criteria

1. On Palomar Mountain, an adequate amount of suitable habitat is protected and supports resilient populations in two Management Units (MUs) to ensure adequate redundancy and preserve the species' remaining genetic diversity. Resilience is demonstrated by an average summer to spring peak abundance ratio of 0.5 (representative of stable population growth) over at least 8 years (based on past data, a period of 8 years represents a population able to withstand fluctuations in population size) with evidence of reproduction for the last 2 years to allow for natural variation in population size. A population must be documented for 2 years (representing a reproducing population) 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 which is considered persistent, but does not yet meet the definition of resilient (Factor E).

3. Disturbance is managed to optimize habitat successional stage and minimize direct and indirect impacts to Laguna Mountains skipper from grazing, fire, and succession in the three MUs that meet downlisting criterion 1 (Factors A and C).

Delisting Criteria

1. On Palomar Mountain, resilient populations are protected in three MUs. Another population is documented for 2 years (representing a reproducing population) in a fourth MU on Palomar Mountain. (Factors A and E).

2. Off Palomar Mountain an additional resilient population is protected in a MU (Factors A and E).

3. A climate-smart conservation plan is developed and implemented to adapt to and mitigate 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, predation, and disease) to determine impacts and measures implemented to minimize threats in all MUs determined necessary 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 2015 (Service 2007; Service 2015).

Laguna Mountains skipper is assigned a Recovery Priority Number of 3C (Service 2015, p. 4). 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 2015 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).

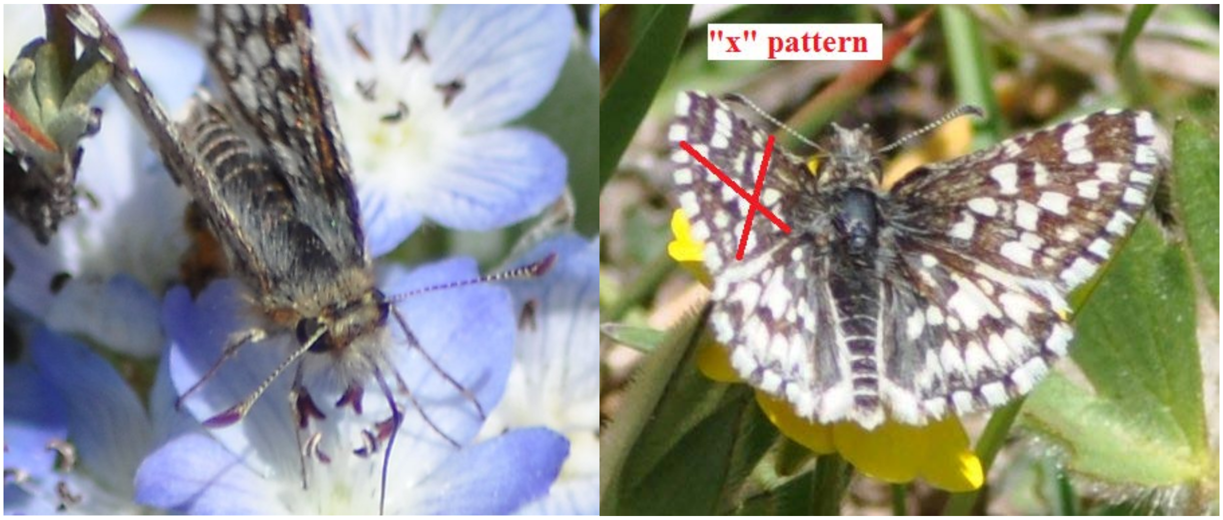

Figure 1. Adult Laguna Mountains skippers (photos courtesy of Tom Mendenhall). Notice the forewing pattern that resembles an "X".

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). Known and historical occurrences are geographically broad and include multiple areas of suitable habitat in 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 – which were 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 **(Other 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	2015[1]	Private, State, and USFS
French Valley (Upper French Valley, Palomar Observatory Trail, and Palomar Observatory Meadows)	Extant	Extant	2007[2]	Private and USFS
Mendenhall Valley* (Mendenhall Valley and Observatory Campground)	Extant	Extant	2015[1]	Private and USFS
Pine Hills (Jeff Valley, Dyche Valley, and Will Valley)	No records	Extant	2001[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 Campground)	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: Marschalek 2015[1]; Grant *et al.* 2009[2]; Osborne 2002[3]; Pratt 1999[4] (characteristic feeding damage).

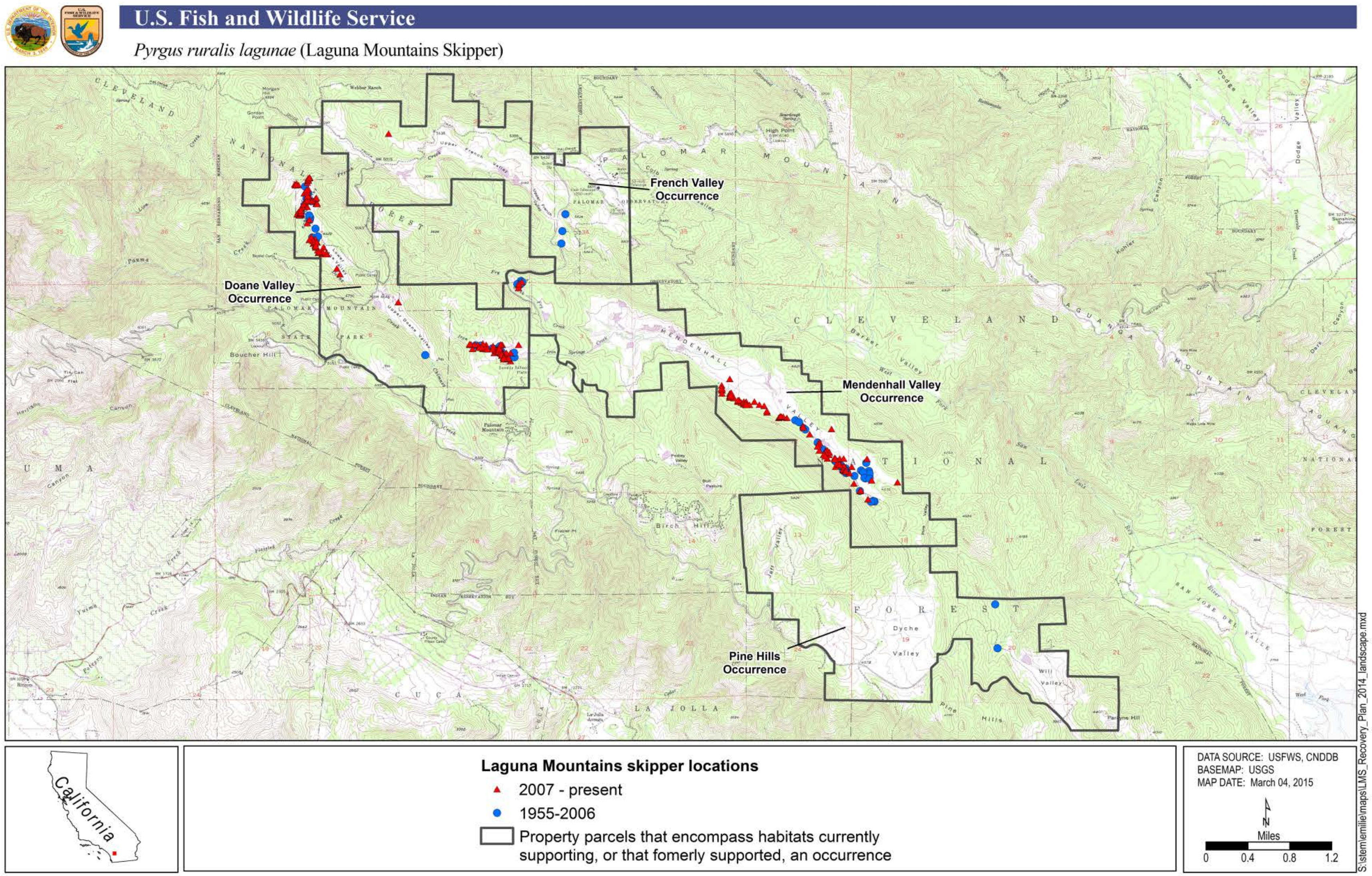

Figure 2. Distribution of Laguna Mountains skipper on Palomar Mountain.

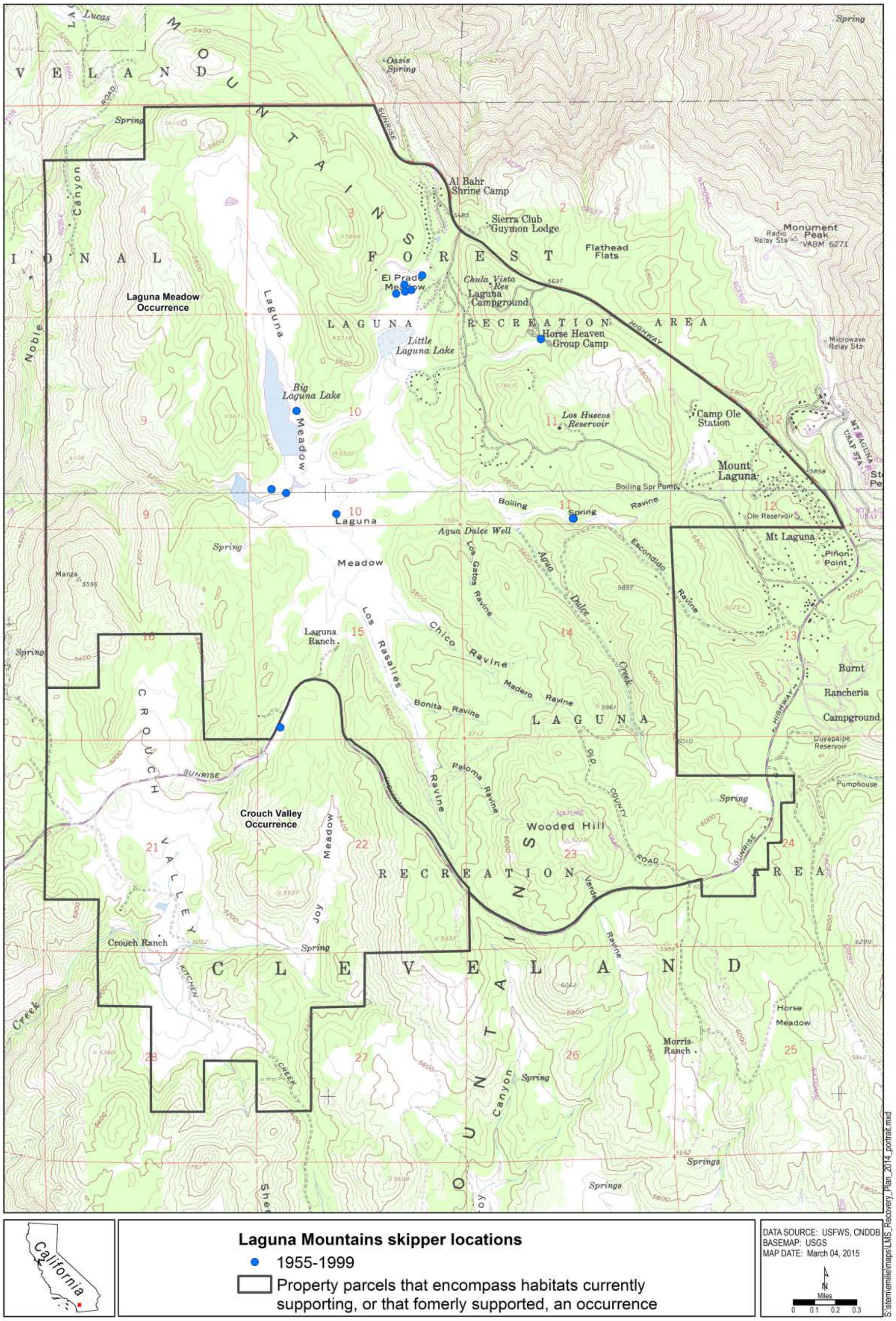

Figure 3. Historical distribution of Laguna Mountains skipper on the Laguna Mountains.

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* is a relatively rare species with a greater range than the Laguna Mountains skipper; it is distributed patchily 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).

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 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. The Cuyamaca Mountains are in the Laguna Mountains skipper's historical range between Palomar Mountain and the Laguna Mountains, and they 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).

The Sierra San Pedro Mártir may also contain suitable habitat, but are approximately 136 mi (220 k) south of the Laguna Mountains and outside of the Laguna Mountains skipper's known historical range. Another area that may have suitable habitat is the San Jacinto Mountains, though this mountain range is north of the Laguna Mountains skipper's known historical range and lacks comparable large wet meadows (Osborne 2003, pp. 10 and 12).

The presence of host plants in the habitat is important as 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 upper host plant leaves at heights of 3 to 5 in (8 to 13 cm) above the ground (Osborne 2008, p. 35) and feed on the host plant during development. 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, *Potentilla glandulosa* is not believed to independently support any populations (Osborne 2002, pp. 13 and 14), and it is uncertain if *Potentilla glandulosa* can be used independent of *Horkelia clevelandii*.

While nectar sources for adults are diverse and not typically limiting during spring (Grant *et al*. 2009, p. 52; D. 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 that supports 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.

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 (day 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. When rainfall totals approach the historical average (660 mm), population growth should occur at a replacement rate, that is no increase or decrease in 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.

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.

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.

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 forego 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 host plant moisture levels or humidity during larval development (Pratt 1999, p. 3; G. Pratt 2015, pers. comm.). 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 4. This was developed to represent the Laguna Mountains skipper life cycle and population dynamics using hypothetical example values based on captive rearing observations (egg production and hatch rate); information in Table 2 (spring to summer peak abundance ratio); surrogate values for larval survival; and discussions with experts. The conceptual model also identifies likely drivers (surrounding text) of productivity, illustrates the significance of summer brood production to annual population growth potential, and should serve as a framework for more complex models. The numbers are conservative examples of growth parameters for a year where the population does not change.

The Laguna Mountains skipper life cycle, characteristic of a partially bivoltine species, is depicted with two flight seasons (spring and summer). The example values begin with a starting population size of 200 adults (conservative value based on Levy's 1994 estimate) and approximately 100 eggs per female and 70 percent hatch (plausible values per Tashiro and Mitchell 1985, pp. 136–138; Johnson *et al.* 2010 p.15; The Butterfly Farm 2012; Longcore *et al.* 2014, p. 9). Larval survival values are based on data for the shoulder-streaked firetip skipper (*Pyrrhopyge papius*) (Greeney *et al*. 2010), the only skipper species for which such field values are available. Larval survival values for the spring and summer broods are approximately 16 and 14 percent, respectively; survival may be slightly lower in the summer when habitat is drier. Under this plausible scenario, reproduction of the spring adult population (200 adults) would result in a spring pupal population of 2,240. The majority of individuals (95.5 percent) undergo diapause and approximately 0.05 percent emerge as adults the following spring (110 adults) (based on a spring diapause survival of 0.5 and fall-winter diapause survival of 0.1). However, a small percentage of pupae (4.5 percent) would still develop to adults during the summer and undergo a second flight season. Fecundity in this example is lower (90 eggs per female) during the second flight season, which would be the case if nectar availability was reduced, resulting in fewer viable eggs. The spring brood/summer adults produce a summer brood of 880 pupae; these diapause and emerge as adults in the spring (90 adults).

The highest population growth under any plausible scenario should be realized when the summer to spring adult population ratio is largest. This ratio is a measure of potential annual population abundance in any scenario, and should reflect the quality of environmental conditions during spring growth and breeding. If there is a decrease in the quality of environmental conditions during the spring flight season, we would expect a reduced ratio and reduced corresponding summer peak adult abundance. This model illustrates the importance of summer brood production and that the summer brood's survival is likely critical for maintaining population resilience in bivoltine species (see also Faccoli and Stergulc 2006, pp. 62 and 63). Even a small portion of the spring brood can contribute substantially to adult population size the subsequent spring. In this example, only 4 percent of the spring brood develops to produce adults during the summer, but their offspring account for over 45 percent of the spring adult population the following year.

The conceptual model (Figure 4) 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, but 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, because adult counts are not sufficient to estimate population size. The inability to detect adults during the summer indicates that the population is so small that mates would have difficulty finding each other, and a low summer to spring abundance ratio (approaching zero) is 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 larval survival) will expound on this relationship between spring and summer brood population sizes, and overall population growth potential. This information will in turn inform monitoring needs and thresholds for management actions.

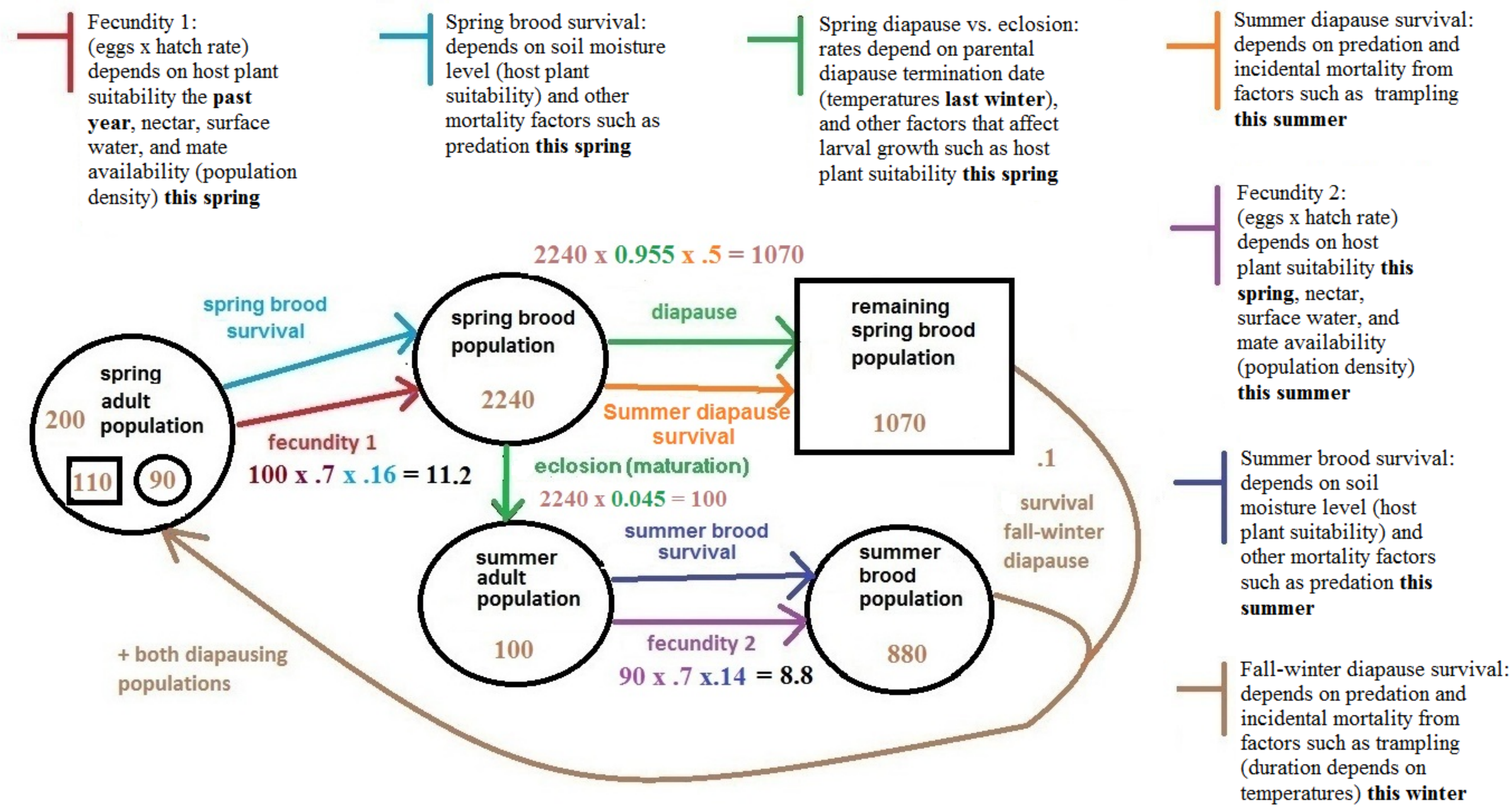

Figure 4. Life cycle and conceptual population model for the Laguna Mountains skipper. The majority of the spring brood enter diapause, while a smaller portion completes development to become the summer adult population. Hypothetical values are based on monitoring data that indicates a typical summer 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, USFWS.

Population Abundance and Trends

Consistent monitoring for Laguna Mountains skipper was conducted in Mendenhall Valley for more than 6 years (Faulkner 2006; 2007; 2008; 2009; 2010a; 2011; 2012a; 2013; Table 1). While we are able to look at changes in the annual 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. Survey methodologies have also been inconsistent in the past, but 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). While we have limited data to estimate population sizes, these two historical estimates likely represent resilient population sizes and help establish a baseline index for comparison to future estimates.

Past subspecies 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 Endangered Species 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; Figure 1). 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 2015). 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 2015, pp. 23–41) 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 2015 5-year review (Service 2015, pp. 23–41) 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

Current threats impacting Laguna Mountains skipper habitat include modification through cattle grazing, succession, and drought. Land use is also a minor threat. Climate change and surface and groundwater loss are potential threats of uncertain extent and magnitude.

Although grazing can be used as a positive management tool for Laguna Mountains skipper habitat, there can also be adverse impacts from inappropriate grazing management. Primary impacts from excessive cattle grazing on 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 inappropriate cattle grazing is ongoing on Palomar Mountain in Dyche Valley (Pine Hills occurrence) and possibly upper French Valley (French Valley occurrence) (A. Anderson, 2014 and 2015 pers. obs.; USGS 2015).

Succession can also impact the 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; K. 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 (L. 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 (National Oceanic and Atmospheric Administration (NOAA) 2014, p. 4; Figure 7). 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 all 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, 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). There was likely a synergistic effect between increased drying of the habitat and increased grazing at the time, because as drought conditions reduce preferred annual forage plants, cattle are believed to more likely feed on the tops of the greener perennial host plants where summer brood larvae occur (Levy 1994, pp. 20 and 46; Pratt 1999, p. 27; Mattoni and Longcore 1998, p. 4). Also cattle grazing pressure was more intense (Brown 1991, p. 5; USFWS 2001, p. 5; K. Osborne pers. comm. 2015) and 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 than they ever were in Mendenhall Valley where the subspecies persists. Grazing pressures in Laguna Meadow have since been reduced, but the subspecies was already extirpated.

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 their dependence on 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, especially where grazing is not managed appropriately.

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 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).

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, 24 and 26) are potential threats. Groundwater extraction for commercial drinking water is of concern on Palomar and in the Laguna Mountains because of the number of companies removing water and the apparent magnitude of withdrawals (Faulkner 2014, pers. comm.; Service 2015, 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.

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. 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

Direct mortality of immature life stages due to trampling and incidental ingestion by cattle was considered a threat at the time of listing, and continues to impact Laguna Mountains skipper at unquantified levels where grazing occurs; especially during the summer, fall, and winter. Larvae, and sometimes eggs and pupae, are located in the crowns of *Horkelia clevelandii*, plant parts that are commonly consumed by grazers (Levy 1994, p. 20; Mattoni and Longcore 1998, p. 4; Osborne 2008, p. 35). Trampling of host plants can also cause mortality during any Laguna Mountains skipper immature life stage. The threat of direct mortality due to cattle grazing appears currently most severe in Dyche Valley (Pine Hills occurrence), and proportionately 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. The impacts of incidental ingestion and trampling are likely greatest during dry years and seasons when other available forage is less abundant and perhaps less palatable than the perennial host plant *H. clevelandii* (Levy 1994, pp. 20 and 46; Mattoni and Longcore 1998, p. 4; Pratt 1999, p. 27). We believe there is likely a synergistic interaction under dry conditions between increased grazing pressure due to reduced forage quantity and quality for cattle and reduced skipper population growth due to reduced habitat quality, resulting in a greater combined impact to a Laguna Mountains skipper population than these factors normally have independently.

Over the past several years, researchers have reported an 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, other ladybird beetles have been reported to prey on the eggs and early instar larvae of other butterfly species (Sheppard *et al.* 2004, p. 2077).

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 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 Endangered Species Act (CESA), (2) California Environmental Quality Act (CEQA), (3) National Environmental Policy Act (NEPA), and (4) land acquisition and management by Federal, State, or local agencies, or by private groups and organization 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 2015, pp. 35–40). 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 United States Forest Service (USFS) to implement actions to reduce ongoing threats and recover this subspecies. For additional information related to regulatory mechanisms see the 2015 5-year review (Service 2015, pp. 35–40).

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

The listing rule indicated that restricted range, localized distribution, and small population size make Laguna Mountains skippers more vulnerable to the effects of habitat loss, degradation and fragmentation, and stochastic events (Service 1997, p. 2318). The 2015 5-year review again identified small population size as a threat, as well as the potential impacts from fire.

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 the Laguna Mountains skipper was thought to occur in fire-adapted ecosystems, but it was noted that a large fire could eliminate affected populations (Service 1997, p. 2319). This characterization has not changed, however we know more now about positive effects from fire activity, including reduced fuel loads and maintenance of early successional stage (Service 2015, p. 41). 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, while not considered as significant a threat as in 2009 (Grant *et al.* 2009, p. 10; Service 2015, p. 41), wildfire does pose a rangewide threat with potential to extirpate populations.

G. Conservation Efforts

Conservation efforts for Laguna Mountains skipper since the time of listing have primarily consisted of surveys and monitoring, habitat research, and captive rearing efforts. 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 2015, pp. 21 and 22). Captive propagation was funded by the Service and provided important natural history and rearing information (Service 2015, p. 21 and 22). 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. 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.; A. 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). The Service and the State also recently funded a conservation easement on privately owned and grazed land in Mendenhall Valley to protect occupied habitat from land use change (Service 2015, pp. 21 and 22).

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 threat on private land in at least one occurrence on Palomar Mountain. Incidental ingestion and trampling of immature life stages is also a threat wherever grazing occurs. 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 therefore 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.

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). 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):

- Doane Valley Management Unit: 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 California Department of Parks and Recreation. 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 Campground. 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.

- The Cuyamaca Mountains: Includes Cuyamaca Meadow and Green Valley. Meadow habitat in this potential unit is primarily owned by the California Department of Parks and Recreation, 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) Further develop the population ecology model to advance our ability to model population viability of Laguna Mountains skipper 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; and

(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.

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, an adequate amount of suitable habitat is protected and supports resilient populations in two MUs to ensure adequate redundancy and preserve the species' remaining genetic diversity. Resilience is demonstrated by an average summer to spring peak abundance ratio of 0.5 (representative of stable population growth) over at least 8 years (based on past data, a period of 8 years represents a population able to withstand fluctuations in population size) with evidence of reproduction for the last 2 years to allow for natural variation in population size. A population must be documented for 2 years (representing a reproducing population) 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 which is considered persistent, but does not yet meet the definition of resilient (Factor E).

3. Disturbance is managed to optimize habitat successional stage and minimize direct and indirect impacts to Laguna Mountains skipper from grazing, fire, and succession in the three MUs that meet downlisting criterion 1 (Factors A and C).

Delisting Criteria

1. On Palomar Mountain, resilient populations are protected in three MUs. Another population is documented for 2 years (representing a reproducing population) in a fourth MU on Palomar Mountain. (Factors A and E).

2. Off Palomar Mountain an additional resilient population is protected in a MU (Factors A and E).

3. A climate-smart conservation plan is developed and implemented to adapt to and mitigate 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 Factors A and C threats have been investigated (for example hydrological modifications and groundwater removal, predation, and disease) to determine impacts and measures implemented to minimize threats in all MUs determined necessary 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 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 and validate 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.

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).

2.2 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 (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 3). 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 dominance 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) 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 private lands that are occupied by Laguna Mountains skipper (Priority 3). For example, conservation easements similar to the one in Mendenhall Valley.

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 propagation, 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 population to support research and reintroduction efforts (Priority 1). This 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 Evaluate sites for possible impacts from threats to prepare for reintroduction of Laguna Mountains skipper (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 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 draft 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.

<u>Key to additional terms and acronyms used in the Implementation Schedule:</u>

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.

<u>Responsible Parties:</u>

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

USFWS	**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 responsible parties may be added in the final Recovery Plan subsequent to coordination and collaboration with our partners on specific recovery actions. Including a party as being responsible for an action does not commit that party 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	Responsible 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.	USFWS, USFS, CDFW, CDPR, UNIV, PVTC, PVT	4	40	20	20	20		**100**
1.2	**2**	Refine and validate the population ecology model for the Laguna Mountains skipper.	USFWS, 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.	USFWS, USFS, CDFW, UNIV, PVTC, PVT	2	30	30				**60**

Action number	Priority	Description	Responsible Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
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.	USFWS, USFS, CDFW, UNIV, PVTC, PVT	4	30	30	30	30		**120**
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.	USFWS, USFS, PVT	8	20	20	20	20	20	**160**
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.	USFWS, 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.	USFWS, USFS, UNIV, PVTC	5	40	40	40	40	40	**200**

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

Action number	Priority	Description	Responsible 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.	USFWS, USFS, CDPR, PVT	TBD						**TBD**
2.8	**3**	Ensure long-term protection of habitat on private lands that are occupied by Laguna Mountains skipper.	USFWS, USFS, CDPR, PVT	TBD						**TBD**
3.1.1	**1**	Determine methodology necessary for captive propagation, including butterfly ranching, of the Laguna Mountains skipper, compliant with the Service's captive propagation policy.	USFWS, UWG, UNIV, SDZ, PVTC	2	100	100				**200**
3.1.2	**1**	Establish a captive population to support research and reintroduction efforts.	USFWS, UWG, UNIV, SDZ, PVTC	10	50	50	50	50	50	**500**
3.1.3	**2**	Evaluate sites for possible impacts from threats to prepare for reintroduction of Laguna Mountains skipper.	USFWS, USFS, PVTC, PVT	TBD						**TBD**
3.1.4	**2**	Conduct habitat restoration as needed to prepare for reintroduction of Laguna Mountains skipper.	USFWS, USFS, PVTC, UNIV	TBD						**TBD**

Action number	Priority	Description	Responsible Parties[1]	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)					Total cost of action for recovery
					FY1	FY2	FY3	FY4	FY5	
3.1.5	**1**	Develop a release plan for Laguna Mountains skipper.	USFWS, USFS, UNIV, PVTC, PVT	TBD						**TBD**
3.1.6.1	**1**	Implement reintroduction to Laguna Meadow.	USFWS, USFS, UNIV, PVTC, PVT	5	75	75	50	50	50	**300**
3.1.6.2	**2**	Implement reintroduction or augmentation to other suitable sites.	USFWS, USFS, UNIV, PVTC, PVT	TBD						**TBD**
3.2	**1**	Monitor the Laguna Mountains skipper for population persistence and resilience within all occupied areas.	USFWS, USFS, PVTC, PVT, UNIV	30	20	20	20	30	30	**870**
									Total	**$3,090,000 +TBD**

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V. APPENDICES

Appendix I. Population Abundance and Growth Analyses

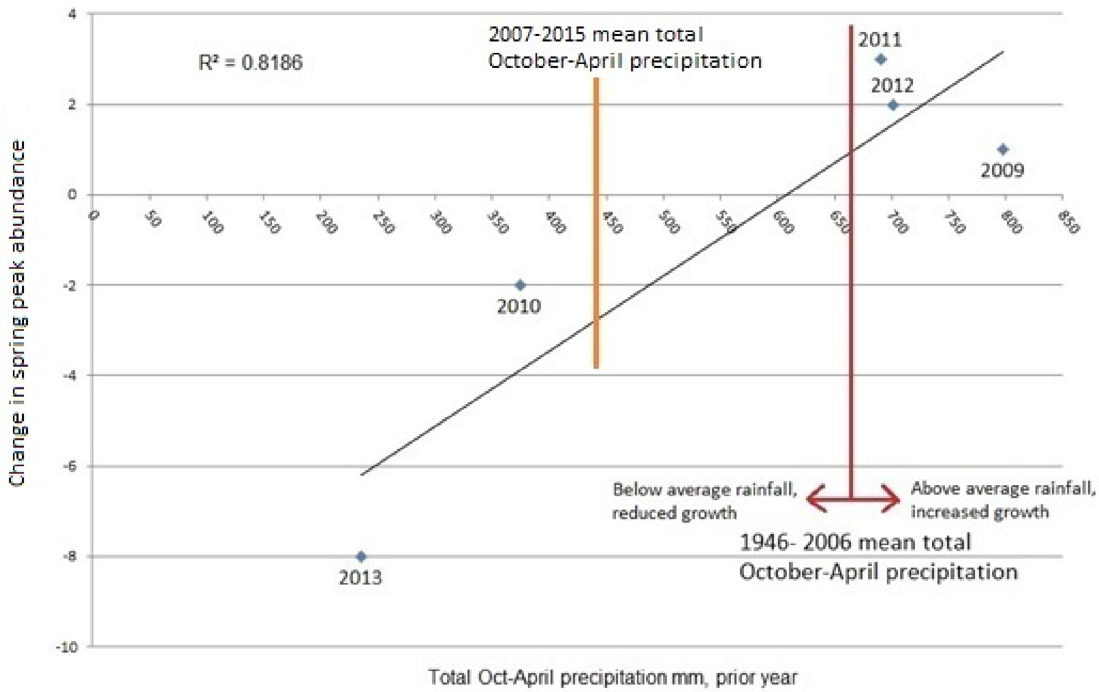

Figure 1. Monitoring data from Mendenhall Valley from 2009–2013 (Faulkner 2008, p. 2; 2009, pp. 2 and 3; 2010, p. 2; 2011, p. 2; 2012a, p. 2; 2013, p. 2) support the hypothesis that population growth increases when rainfall totals (October through April) from the previous year are above average and decreases when rainfall totals are below average (relationship illustrated by trendline). When rainfall totals approach the historical average (660 mm), population growth should occur at a replacement rate, that is no increase or decrease in size (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); incidental mortality due to grazing (east 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 Campground)	Private and USFS	Incidental mortality due to grazing, 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.

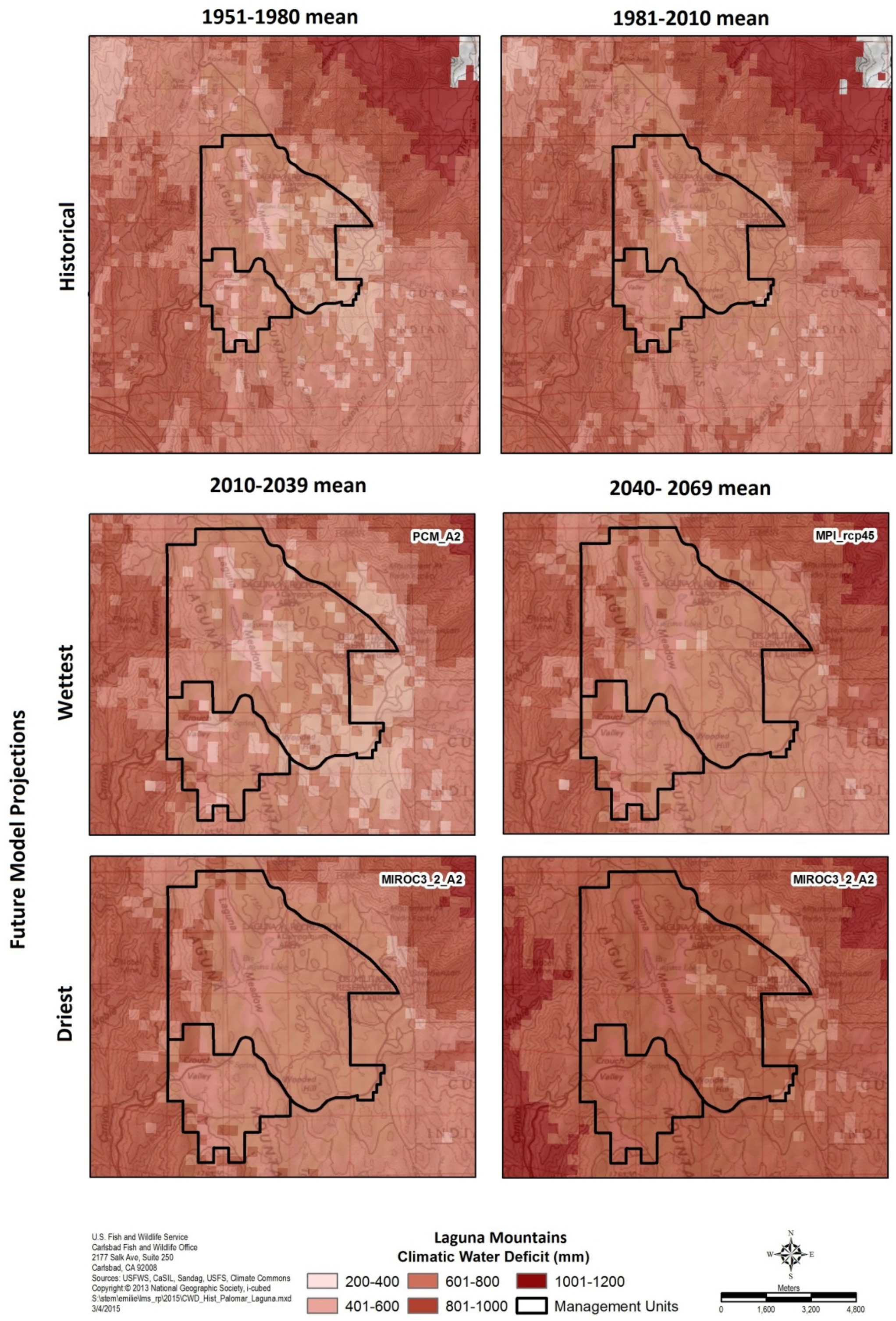

Figure 1. Historical 30 year mean modeled climatic water deficit (CWD) and future CWD projections for the Laguna Mountains, formerly occupied by Laguna Mountains skippers. Lower CWD values indicate higher soil moisture levels. Climatic water deficit can serve as an indicator of plant drought stress and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

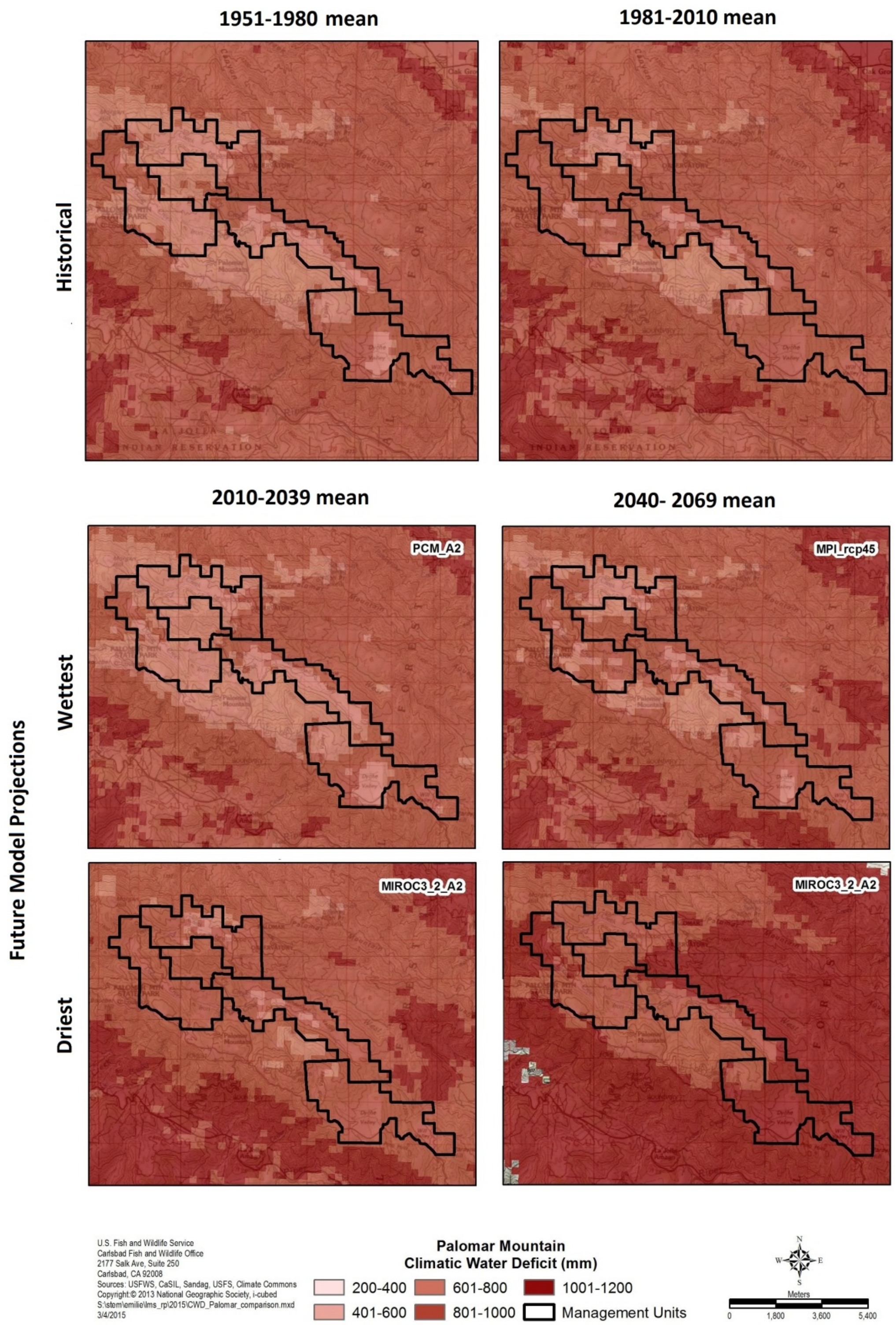

Figure 2. Historical 30 year mean modeled climatic water deficit (CWD) and future CWD projections for Palomar Mountain occupied by Laguna Mountains skippers. Lower CWD values indicate higher soil moisture levels. Climatic water deficit can serve as an indicator of plant drought stress and soil moisture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