Recovery Plan for Quino checkerspot butterfly (*Euphydryas editha quino*)
[Click here to view document]

Original Approved: August 11, 2003
Original Prepared by: Alison Williams-Anderson

DRAFT AMENDMENT 1

We have identified best available information that indicates the need to amend recovery criteria for the Quino checkerspot butterfly (Quino) since the recovery plan was completed. In this proposed modification we add delisting criteria and recovery actions. The proposed modification is shown as an appendix that supplements the recovery plan, superseding only the following sections: **EXECUTIVE SUMMARY** (pp. v–vii), Recovery Criteria (pp. 92–95), and select definitions in Appendix IV (see below; pp. 21, 22, 35) of the recovery plan (Service 2003).

For
U.S. Fish and Wildlife Service
Region 8
Carlsbad, California

March 2019

METHODOLOGY USED TO COMPLETE THE RECOVERY PLAN AMENDMENT

The original recovery plan (Service 2003) was authored by Service staff (Alison Williams-Anderson) and an official Technical Recovery Team of seven scientific experts. At the time the Recovery Plan was developed, the Technical Recovery Team found that there was insufficient information about the biology of the species to establish criteria and timeframes for delisting. Research activities needed to establish delisting criteria were identified as: "…survey areas between and around occurrence complexes to determine where there is intervening and/or additional landscape connectivity; map habitat patch distributions; monitor habitat loss; conduct preliminary modeling of metapopulation dynamics; investigate key natural history questions and threats." Through Service partnership activities such as the San Diego National Wildlife Refuge Quino Augmentation Project, and research funded through mitigation projects and grant programs, we have made strides toward meeting the research needs for delisting criteria development, especially in the Southwest San Diego Recovery Unit (Figure 2). For example, areas within and among occurrence complexes are being surveyed on a project-by project basis, and areas where intervening and/or additional landscape connectivity is needed are being identified. We are mapping habitat patch distributions, tracking habitat loss through GIS databases, developing a preliminary metapopulation model, and investigating key natural history questions and threats through a rearing and population augmentation program.

This document presents updated distribution information and provides quantitative delisting criteria. The document will be made available for public comment to ensure the best possible scientific and commercial data are used to support the criteria described herein. This amendment will also undergo peer review. These coordinated efforts helped to develop new quantitative criteria for the recovery plan that will better serve us as we work to recover the Quino checkerspot butterfly.

ADEQUACY OF RECOVERY CRITERIA

Section 4(f)(1)(B)(ii) of the Endangered Species Act (Act) requires that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list." Legal challenges to recovery plans (see Fund for Animals v. Babbitt, 903 F. Supp. 96 (D.D.C. 1995)) and a Government Accountability Audit (GAO 2006) also have affirmed the need to frame recovery criteria in terms of threats assessed under the five delisting factors.

Synthesis

New Scientific Information and Changed Circumstances

Below is a summary list of new scientific information and changed circumstances, which will help inform amended criteria and actions.

- New Quino observation data resulting in new and merged occurrence complexes, and permanent loss of occurrences due to development and isolation. Compare Service 2003 (Figure 3) to Figure 1.

- Recent extended drought resulting in low adult numbers across the species' range (starting in 2012, interrupted in 2017, continuing in 2018).
- San Diego National Wildlife Refuge Quino Augmentation project: The objective of this project is to augment occurrence complexes on the San Diego National Wildlife Refuge and to identify methods needed to monitor and manage Quino populations in San Diego County and to reintroduce populations across the range in the future. To date, there have been three releases on the refuge, with apparent establishment and reproduction at one site at least (Strahm *et al.* 2018). The project has also been developing a metapopulation model to identify key population dynamic parameters and habitat patch configurations required to support resilient metapopulations.
- The conclusions of post-recovery plan peer-reviewed publications analyzing climate change effects and evidence of range shift specifically for Quino (Preston *et al.* 2008, entire; Preston *et. al* 2012, entire; Parmesan *et al.* 2014, entire) all support the "fundamental conservation message" that connectivity among habitats and protected areas connected to higher elevation habitats is required for species climate change adaptation.
- Advances including: conservation achieved; knowledge gained, and partnerships and programs established and strengthened.

Since the 2003 Recovery Plan, additional occurrence complexes have been discovered and some expanded, while others have been lost (Table 1), or have significantly reduced footprints. As was the concern at the time of recovery plan publication (Service 2003, pp. 28–30), the former Northwest Riverside subsequently hit an extirpation threshold, where resilience was irretrievably lost and all occurrence complexes within the unit were extirpated (including the Harford Springs Core Occurrence Complex). The entire Northwest Riverside Recovery Unit is now believed to be unoccupied, and not likely to be recolonized without assistance. Furthermore, one of the two core occurrence complexes in the Southwest Riverside Recovery Unit (Warm Springs Creek) may be extirpated. Despite planning efforts to enhance resilience such as the soon-to-be constructed Quino habitat bridge that will enhance landscape connectivity, recovery unit viability is compromised due to loss of landscape and ecological connectivity (Table 1; Figure 2). These two recovery units are not only highly affected by climate change and drought, but habitat loss has been concentrated in these areas. In western Riverside County approximately a dozen populations are believed to have been permanently extirpated by habitat loss, isolation, or both since recovery plan publication.

The recovery plan hypothesized that in 2003 the species may have reached the latest 10- to 20-year population density and distribution peak, and discussed that Quino densities remained far below what they were in the late 1970s. It states "It is likely that there will be yet another drought-induced [Quino] crash during the next 5 to 10 years, such as the ones that occurred in the 1980's and …the 1960's." (Service 2003, p. 31). Not surprisingly, the current drought that has much reduced Quino abundance and detectability through most of the species range (Service unpublished data) started in approximately 2012, 10 years after that prediction was made. Therefore it is likely the species will need assistance to reestablish or maintain population resilience across its post-listing range and achieve recovery.

Finally, we have noticed that most of the largest and apparently most resilient Quino populations are associated with relatively large, long-established reservoirs mostly surrounded by hills. Specifically: Lake Skinner (established in 1973; Skinner/Johnson Core Occurrence Complex); Vail Lake (established in 1948; Oak Mountain Core occurrence complex); and Lower Otay Lake (established in 1934; Otay Core Occurrence Complex). This is not likely a coincidence, as such water bodies ameliorate the effects of drought on Quino habitat in the immediate vicinity due to the "lake effect," a well-documented climate phenomenon where bodies of fresh water, especially those with hilly surroundings, increase humidity and decrease temperatures of surrounding land areas (e.g. Condi and Webster 1997, entire; Mohamed Degu *et al.* 2011, entire, Ekhtiari *et al*. 2017, entire; Theeuwes *et al*. 2013, entire). As described in the recovery plan (Service 2003, pp. 25, 50, 55, 86, 87, 89), through its large thermal mass, the ocean buffers coastal habitat from high temperature and low humidity extremes. On a smaller scale lakes have a similar effect, retaining heat and cold, and re-releasing them when temperature changes occur. Therefore we believe it is essential to focus conservation and management efforts first on those habitat patches within core occurrence complexes proximal to large water bodies, which likely contribute to population resilience.

Although Tribal lands occur within recovery unit boundaries and may harbor core populations, in accordance with the President's memorandum of April 29, 1994, Government-to-Government Relations with Native American Tribal Governments (59 FR 22951), E.O. 13175, the Department of the Interior's manual at 512 DM 2, Secretarial Order 3206 of June 5, 1997 (American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act), and S.O. 3335 of August 20, 2014 (Reaffirmation of the Federal Trust Responsibility to Federally Recognized Indian Tribes and Individual Indian Beneficiaries), we acknowledge that Tribal lands are not subject to the same controls as Federal public lands, are not part of the public domain, and are not subject to Federal public land laws. We recognize our responsibilities to work directly with Tribes in developing programs for healthy ecosystems, including recovery planning, and our responsibility to consult with federally recognized tribes on a government-to-government basis. In recognition of Tribal rights, we will coordinate recovery planning with non-Tribal stakeholders and cooperate with tribes to implement this recovery plan in a manner that minimizes, or if possible, avoids social, cultural, and economic impacts to Tribal communities.

Table 1. Quino checkerspot butterfly occurrence complexes within and outside of existing Recovery Units, 1970-present, associated with remaining habitat

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
1. Lake Mathews	1982	South of Lake Mathews: *NW Riverside*	Climate change effects, habitat destruction, degradation, isolation, fragmentation, nonnative plant invasion, drought, and fire. (Extirpated)
2. Harford Springs (core)	1998	SW of Lake Mathews: *NW Riverside and outside*	Same as above (Extirpated)
3. Canyon Lake	2002	W of Canyon Lake: *NW Riverside*	Same as above. (Extirpated)
4. N Warm Springs Creek	2003	N of the City of Murrieta: *SW Riverside*	Same as above. (Extirpated)
5. Warm Springs Creek (Core)	2010	N of the City of Murrieta: *SW Riverside*	Same as above. (Extirpated)
6. W Domenigoni Valley	2001	SW of Domenigini Valley Reservoir: *SW Riverside*	Climate change effects, habitat destruction, degradation, nonnative plant invasion, drought, and fire. (Extant)
7. E Domenigoni Valley	2011	SE of Domenigini Valley Reservoir: *SW Riverside*	Same as above. (Extant)
8. Skinner/ Johnson (Core)	2013	N, E, and S of Lake Skinner: *SW Riverside and outside*	Same as above. (Extant)
9. Pauba Valley	1998	W of Oak Mountain: *S Riverside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, drought, and fire. (Extirpated)
10. Black Hills	1992	N of Oak Mountain: *S Riverside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, drought, and fire. (Extant)

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
11. Oak Mountain/ Vail Lake (Core)	2017	Surrounding Vail Lake: *S Riverside*	Same as above. (Extant)
12. Sage (Core)	2004	Surrounding the community of Sage: *S Riverside*	Same as above. (Extant)
13. Rocky Ridge	1997	S of community of Sage: *S Riverside*	Same as above. (Extant)
14. Wilson Valley (Core)	2013	NW of Wilson Valley: *S Riverside*	Same as above. (Extant)
15. Aguanga/ Dameron Valley (Core)	2010	Near community of Aguanga: *S Riverside*	Same as above. (Extant)
16. Oak Grove	1992	Community of Oak Grove: *S Riverside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
17. Brown Canyon	1999	SE of the community of Hemet: *S Riverside*	Habitat degradation, nonnative plant invasion, drought, and fire. (Extant)
18. N Rouse Ridge	2005	Rouse Ridge: *S Riverside and S Riverside/N San Diego*	Nonnative plant invasion, grazing, and fire. (Extant)
19. S Fork Trail	2009	S of State Route 78, NW of Lake Hemet: *S Riverside/N San Diego and outside*	Same as above. (Extant)
20. Hurkey Creek	2009	East of community of Mountain Center: *Outside*	Nonnative plant invasion and fire. (Extant)
21. Horse Creek	2012	SE of Bautista Spring: *S Riverside and S Riverside/N San Diego*	Same as above. (Extant)

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
22. Garner Valley (Core)	2011	Vicinity of and NE of Garner Valley: *S Riverside/N San Diego and outside*	Habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
23. Bautista Road (Core)	2008	N of the community of Anza: *S Riverside/N San Diego*	Habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
24. Table Mountain Truck Trail	2011	East of Ramona Tribal reservation: *S Riverside/N San Diego*	Same as above. (Extant)
25. Thomas Mountain	2009	S slope Thomas Mt.: *S Riverside/N San Diego*	Nonnative plant invasion, grazing, and fire. (Extant)
26. Lookout Mountain	2003	S Garner Valley: *S Riverside/N San Diego*	Habitat destruction, degradation, and fragmentation, grazing nonnative plant invasion, and fire. (Extant)
27. Cave Rocks	2016	The community of Anza: *S Riverside/N San Diego*	Same as above. (Extant)
28. Cahuilla Creek	2003	Near Cahuilla Tribal Offices and Casino[3]: *S Riverside/N San Diego*	Habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
29. Barbara Trail	2008	SW of the community of Anza: *S Riverside and S Riverside/N San Diego*	Same as above. (Extant)
30. Tule Peak (Core)	2016	S of the community of Anza: *S Riverside/N San Diego*	Same as above. (Extant)
31. Terwilliger Valley (Core)	2009	S E of the community of Anza: *S Riverside/N San Diego*	Same as above. (Extant)
32. Holcomb	2018	NE of the community of Holcomb Village:	Climate change effects; nonnative plant invasion, and fire. (Extant)

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
		S Riverside/N San Diego	
33. Iron Spring Canyon	1998	S of the community of Anza: *S Riverside/N San Diego*	Habitat degradation, nonnative plant invasion, and fire. (Extant)
34. Palomar Divide	2015	E of Palomar Mt.: *S Riverside/N San Diego and outside*	Climate change effects; nonnative plant invasion, and fire. (Extant)
35. Fink Road	2011	SE of Palomar Mt.: *Outside*	Same as above. (Extant)
36. Cañada de San Vicente	2017	S of community of Ramona: *Outside*	Climate change effects, nonnative plant invasion, drought, and fire. (Extant)
37. San Vicente	2016	W of San Vicente Reservoir: *Outside*	Same as above. (Extant)
38. Sycamore Canyon	2005	Sycamore Canyon Open Space Preserve: *Outside*	Climate change effects, nonnative plant invasion, drought, and fire. (Extant)
39. Fanita Ranch	2018	N of the City of Santee: *Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, drought, and fire. (Extant)
40. Miramar (Core)	2018	Central Marine Corps Air Station, Miramar: *Outside*	Climate change effects, habitat degradation, nonnative plant invasion, drought, and fire. (Extant)
41. Mission Trails Park	2008	Mission Trails Regional Park: *Outside*	Climate change effects, habitat degradation, nonnative plant invasion, drought, and fire. (Extant)
42. Alpine	2010	Wright's field in the community of Alpine: *Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
43. Willits Rd	2004	SW of the community of Alpine: *Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, drought, and fire. (Extant)

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
44. Dehesa	2017	East of Sycuan Golf Resort: *Outside*	Same as above. (Extant)
45. Sycuan Peak	2018	Sycuan Peak: *Outside*	Climate change effects, nonnative plant invasion, drought, and fire. (Extant)
46. Dictionary Hill	2017	Dictionary Hill between the communities of La Presa and Spring Valley *Outside*	Climate change effects, habitat degradation and isolation, nonnative plant invasion, drought, and fire. (Extant)
47. Otay (Core)	2018	W and N Otay Mountain foothills, Otay Lakes, Jamul Mountains, E of Sweetwater Reservoir: *SW San Diego and Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, drought, and fire. (Extant)
48. W Otay Valley	2004	N of Otay Mesa: *SW San Diego*	Same as above. (Extant)
49. Jamul Butte	2004	N of Jamul Butte near community of Jamul: *Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
50. W Barrett Lake (Core)	2017	W of Barrett Lake: *Outside*	Same as above. (Extant)
51. Round Portrero	2010	SE of Barrett Lake: *Outside*	Same as above. (Extant)
52. SW Morena	2017	SW of Lake Morena and Morena Butte: *Outside*	Same as above. (Extant)
53. Marron Valley (Core)	2018	W of Otay Mountain, Marron Valley: *SW San Diego and Outside*	Climate change effects, habitat degradation, nonnative plant invasion, and fire. (Extant)
54. Barrett Junction	2006	NW of Tecate Peak: *SW San Diego*	Same as above. (Extant)
55. Tecate	2009	N of the City of Tecate:	Same as above. (Extant)

Occurrence Complex (core status)[1]	**Date last observed**	**Location: *RU***	**Current threats[2] (Estimated status)**
		SW San Diego and Outside	
56. Cottonwood	2010	N McCain Valley Rd E of Cottonwood Campground *Outside*	Climate change effects, habitat degradation, nonnative plant invasion, and fire. (Extant)
57. Manzanita	2010	Manzanita Tribal Reservation: *Outside*	Climate change effects, habitat destruction, degradation, and fragmentation, nonnative plant invasion, and fire. (Extant)
58. La Posta	2010	La Posta Tribal Reservation: *Outside*	Same as above. (Extant)
59. NE Morena	2004	E of the community of Morena Village: *Outside*	Same as above. (Extant)
60. SE Morena	2004	E of the community of Morena Village: *Outside*	Same as above. (Extant)
61. Clover Flat	2018	E of the community of Morena Village, NE of the Community of Campo: *Outside*	Same as above. (Extant)
62. Campo (Core)	2010	Campo Tribal Reservation: *SE San Diego and outside*	Same as above. (Extant)
63. E Campo	2010	E of Campo Tribal Reservation: *Outside*	Same as above. (Extant)
64. S Campo	2009	SW of Campo Tribal Reservation: *Outside*	Same as above. (Extant)
65. Jacumba (Core)	2011	W of the community of Jacumba Springs: *SE San Diego*	Habitat degradation, destruction, and fragmentation, nonnative plant invasion, drought, and fire. (Extant)
66. SW Jacumba	1973	Three miles W of the community of Jacumba Springs *SE San Diego*	Same as above. (Extant)

Occurrence Complex (core status)[1]	Date last observed	Location: *RU*	Current threats[2] (Estimated status)
67. Canyon City	2009	Vicinity of the community of Canyon City: *Outside*	Same as above. (Extant)
68. E Canyon City	2009	E of the community of Canyon City: *Outside*	Same as above. (Extant)

Abbreviations: E- east; I- Interstate; N- north; N/A- not applicable; ND- not documented, no historical records; RU –recovery unit; S- south; Unk- unknown; W- west.

[1]The area within overlapping one km radii of observation locations (or close to overlapping, but not including developed lands). Core status in recovery units is based on the size of the occurrence complex prior to habitat loss (area within overlapping 1 km radii).

[2]Climate-change effects are listed as a threat for all lower elevation occurrence complexes that are likely to experience decreasing habitat suitability (Preston *et al*. 2008, p. 2508); we used a break point of 2,500 feet (762 meters). Non-climate change-related drought is listed as a threat for all occurrence complexes with a 1961-1990 annual average precipitation below 15 inches (38 centimeters) (Oregon Climate Service 1995, p. 1).

[3]One adult in casino parking lot, may have been associated with nearby habitat or dispersing.

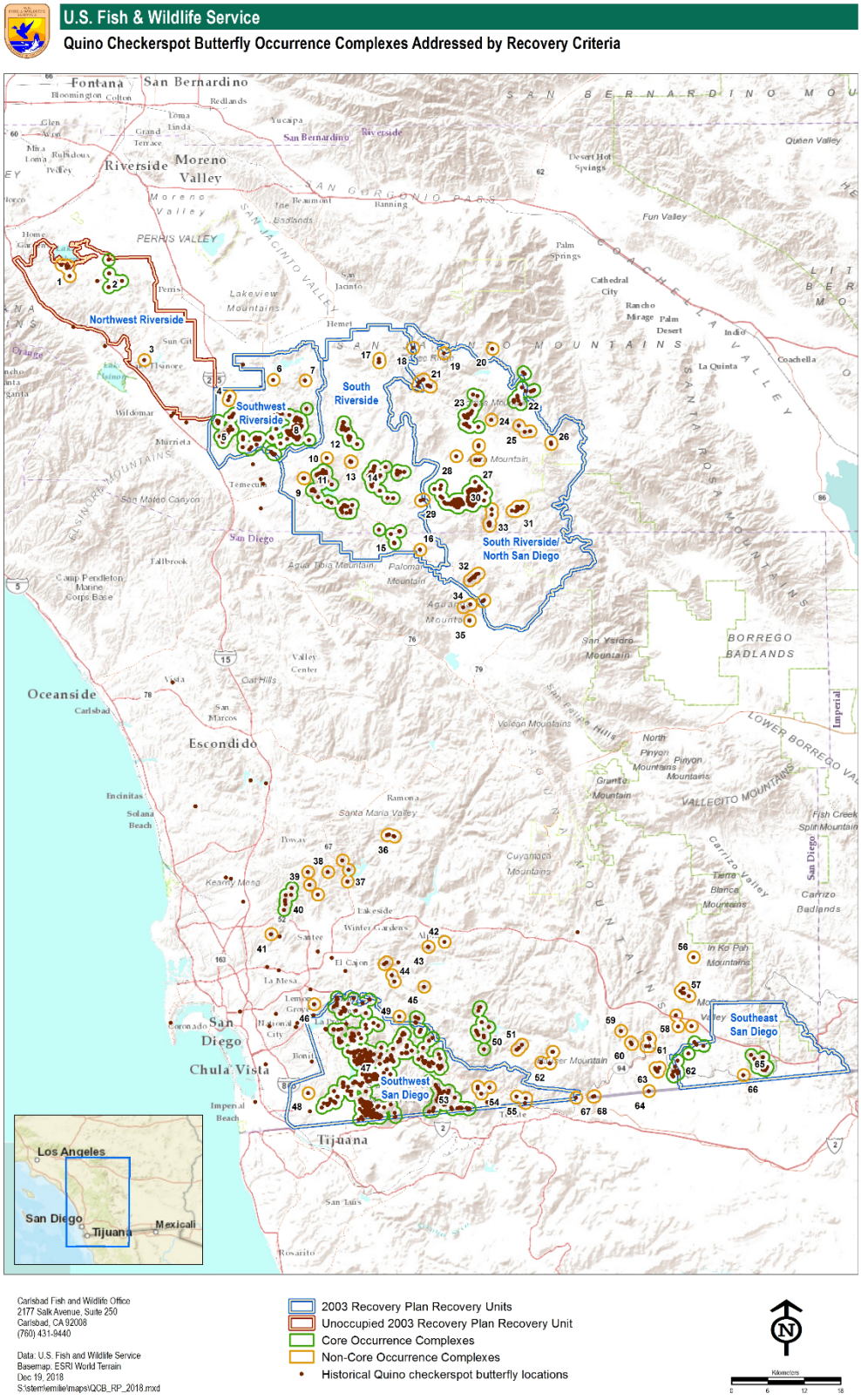

Figure 1. Quino checkerspot butterfly occurrence complexes and recovery units (mapped occurrence complexes areas are not all occupied at this time).

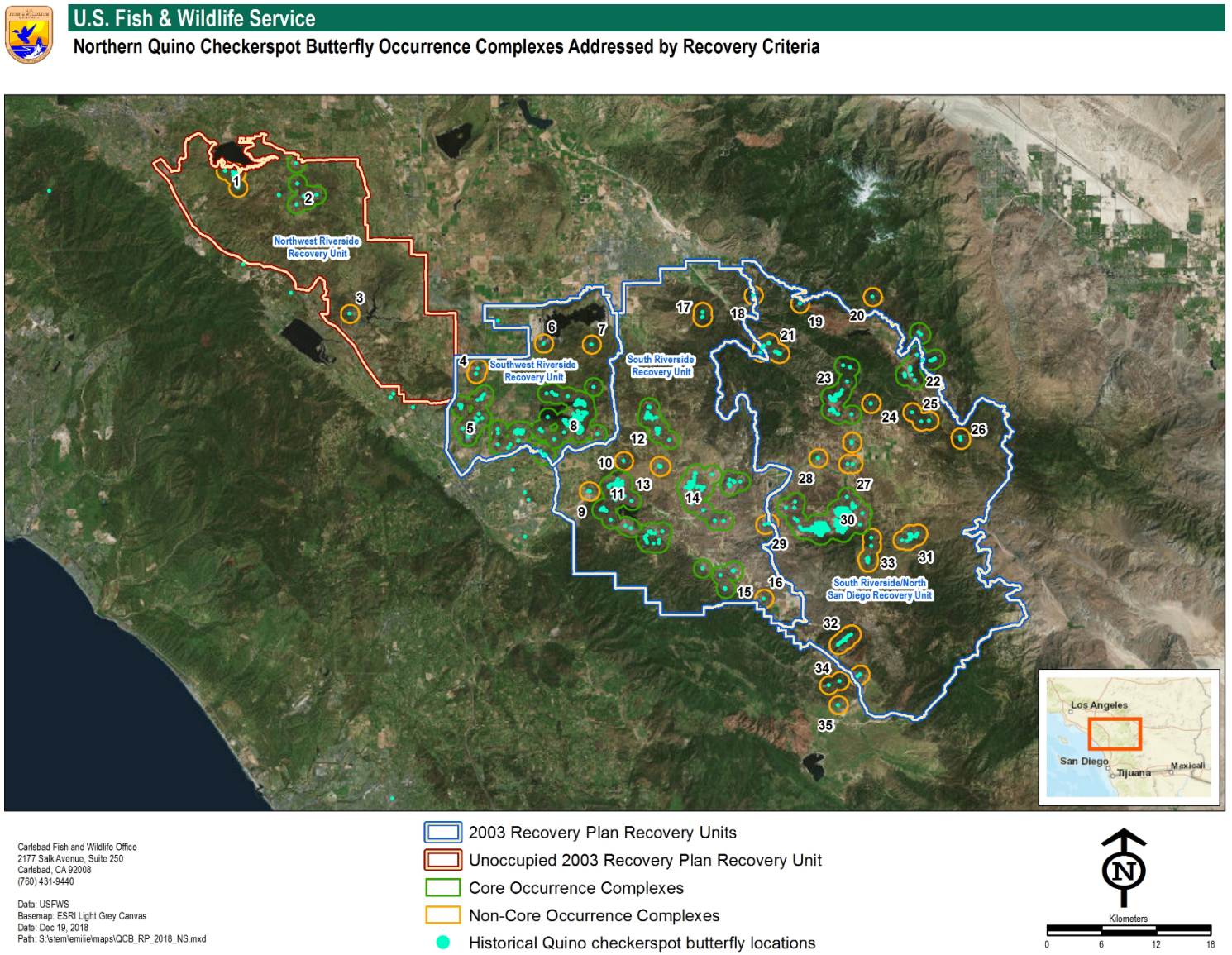

Figure 2. Quino checkerspot butterfly northern distribution and recovery units (mapped occurrence complex areas are not all occupied at this time).

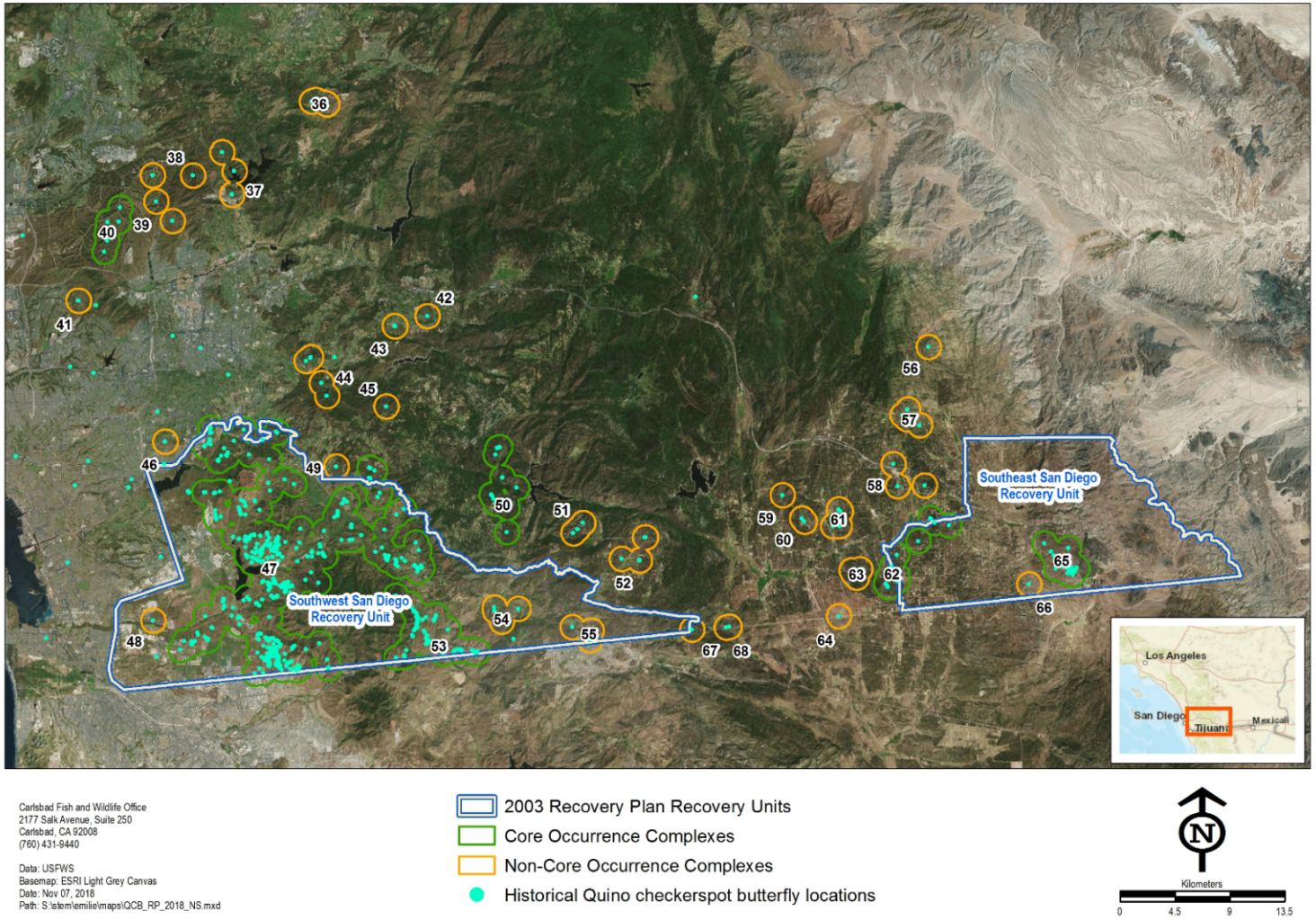

Figure 3. Quino checkerspot butterfly southern distribution and recovery units (mapped occurrence complex areas are not all occupied at this time).

AMENDED RECOVERY CRITERIA

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Act are no longer necessary and it may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from endangered to threatened. The term "endangered species" means any species (species, subspecies, or distinct population segment) which is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Definition of terms for recovery criteria (primarily from Service 2003, pp. 21, 22, 35, and Appendix IV; updated clarification in brackets):

- Ecological connectivity: Undeveloped wildlands between two areas [supports rare long-distance movement of adults and populations of other species associated with Quino habitat, such as nectar source plants]. May or may not include landscape connectivity (connected habitat patches). Habitat areas or populations lacking ecological connectivity are considered completely isolated.
- Habitat connectivity: The degree [or lack] of fragmentation within a habitat patch. If roads or other development occurs within a habitat patch to the point that adults cannot move freely among resources, then one habitat patch may effectively become two or more with intervening areas becoming dispersal areas that support limited exchange between habitat patches. Habitat patches with poor connectivity are considered fragmented, and are generally prone to higher levels of ongoing degradation.
- Habitat patch: a set of relatively discrete larval host plant "micro-patches" and other resources, including nectar source plants and hilltops, within the typical flight range of adult Quino (up to 200 m (660 feet)).
- Landscape connectivity: The degree of linkage among habitat patches joined by dispersal areas [within a metapopulation distribution; undeveloped wildlands among proximal habitat patches create landscape connectivity].
- Occurrence complex: Spatially clustered Quino observation records. The largest ones are termed "core occurrence complexes" and [are believed to] represent current [or former] population density centers. Occurrence complexes represent current short-term documented local occupancy, probably within the greater distribution of extant metapopulations. Occurrence complexes are mapped using 1 km (0.6 mi) movement radii. Occurrences within approximately 2 km (1.2 mi) of each other are considered part of the same complex. [Core designation is based on total polygon area equal to or greater than the minimum occurrence complex size in the set of the largest occurrence complexes in each recovery unit.]
- Population distribution: The maximum long-term "footprint" (geographic area occupied at any time over approximately 50 years) of a panmictic population or metapopulation, as delineated and verified by research and monitoring. This area may include more than one occurrence complex, and metapopulation distributions are likely to be greater than the distribution of most occurrence complexes. Further research is required to determine the

specific population distributions required for resilience. For some core occurrence complexes and associated non-core complexes, habitat-based population distributions that meet the definition of critical habitat have already been mapped and defined by the Service. These are the areas used to map critical habitat units (Service 2008, p. 28838), prior to removal of excluded areas. For example, the Campo habitat-based population distribution includes the Campo Core occurrence complex, and Northeast Morena, Southeast Morana, Clover Flats, and East Campo non-core occurrence complexes).

- Population Resilience: In general, the ability of a Quino checkerspot butterfly population or metapopulation to survive periodic extreme and unpredictable environmental circumstances and persist long-term (50+ years) in an ecosystem not [irreparably] compromised by human impacts. For recovery monitoring purposes, population resilience is demonstrated if: [1) it demonstrates (through monitoring data) parameters specified by a metapopulation model predicting 90% likelihood of persistence for 50 years. That is, the proportion of model runs over a time period of 50 years resulting in metapopulation survival (termed surviving replicates) is no less than 90% percent. The type of data and metapopulation model used will be peer-reviewed and supported by the majority of peer reviewers; or] 2) a decrease in the number of habitat patches supporting larval development (as demonstrated by adult detectability) within an occurrence complex or population (metapopulation or pan-mictic population) is followed by increases of approximately equal, or greater, magnitude over a 15-year period without augmentation to span varying environmental conditions, or over a 10-year period [following] augmentation. The period following augmentation is shorter because augmentation increases the population size and it would include habitat restoration as needed, so there should be higher confidence in population resilience. These numbers are given in lieu of species-specific model parameters; they reflect estimated periods of metapopulation persistence based on expert opinion and published studies (Service 2003, pp. 24 and 25). The percent of patches occupied should be estimated by surveys in a sample of no less than 50 percent of the total number of habitat patches identified within a population distribution. Occupancy for the purpose of population resilience monitoring should include adults (reproductive individuals) and pre-diapause larval clusters (their offspring). The surveyed sample of habitat patches should be distributed as equally as possible across a metapopulation distribution to avoid error from possible correlation of suitability among proximal patches.

We provide recovery criteria for the Quino checkerspot butterfly as follows:

Downlisting Recovery Criteria

Downlisting criteria will be incorporated and remain current as in the Recovery Plan for the Quino checkerspot butterfly (Service 2003, pp. 92–95) with slight modifications as indicated with updated occurrence complex distributions (Table 1; Figures 1 and 2), and term definitions (see above).

Delisting Recovery Criteria
Delisting criteria apply to all occurrences referred to in the criteria below and identified in Table 1. The Quino Checkerspot butterfly will be considered for delisting when downlisting criteria are met and:

1. Reproduction is documented at least 4 years after reintroduction or last augmentation for the populations established in the Northwest Riverside Recovery Unit and in the footprint of the Warm Springs Creek Core Occurrence complex.

2. A total of 15 core occurrence complexes (not including the former Harford Springs or Warm Springs Creek core occurrence complexes) are conserved (protected and managed) in perpetuity, support resilient populations or metapopulations, and are ecologically connected via conserved lands to other core occurrence complexes (this includes ecological connectivity among the northern and southern portions of the range).

Justification: Core occurrence complexes contribute the most to species viability. These are the largest geographically, and are therefore likely to belong to the most resilient metapopulations within the species range. Our conservation strategy is focused on preserving and maintaining all 15 known core occurrence complexes, thereby ensuring species representation across the species' range and habitat types. The largest core occurrence complexes are associated with large reservoirs and are considered crucial for species survival: Skinner/Johnson Core Occurrence Complex; Oak Mountain Core Occurrence Complex; and Otay Core Occurrence Complex. Core occurrence complexes should be ecologically connected in order to facilitate natural recolonization of extirpated populations and thereby maintain metapopulation resilience.

If two new core occurrence complexes are identified or established that do not include Tribal land, with ecological connectivity (that also does not include Tribal land) to other core occurrence complexes, these areas can substitute for incomplete conservation and ecological connectivity of the Campo and Jacumba core occurrence complexes (Table 1, Figure 2).

3. Adequate (80 percent or greater of known) non-core occurrence complexes are conserved, as defined by the following:

    a. The 40 non-core occurrence complexes within existing ecological connectivity areas among core occurrence complexes (Table 1, Figures 2 and 3) support populations that demonstrate reproduction in the field for at least 4 years prior to delisting.

    b. In addition to those non-core occurrence complexes that contribute to ecological connectivity, non-core occurrence complexes with high-elevation montane influence (above 4000 ft (1219 m) in elevation) are conserved and managed with reproduction in the field at least 4 years prior to delisting.

c. Occurrence complexes and areas of occurrence complex distribution with marine influence (Coastal Terraces and Coastal Hills California Ecological Subregions; Figure 4) are conserved and have landscape connectivity to habitat occupied by a resilient population.

Justification: Given the potential for loss of core occurrence complexes through extended drought, fire, and other impacts, it is important to maintain sufficient non-core occurrence complexes to connect core occurrence complexes and act as refugia for protection from catastrophic impacts. The 40 non-core occurrence complexes identified in this recovery strategy include those that fall within the existing corridors of ecological connectivity among metapopulations that increase metapopulation resilience, because their distributions encompass the highest known quality habitat within these corridors (include landscape and habitat connectivity). These non-core occurrence complexes also contribute to the relatively high level of species redundancy required to support a viable species distribution composed of resilient metapopulations. Meeting this criterion will demonstrate that the loss of ecological connectivity and fragmentation of habitat (Factor A) have been effectively curtailed and no longer pose a threat to the Quino checkerspot butterfly.

4. A management plan is implemented for populations specified in delisting criteria 2 and 3 that effectively manages and ameliorates impacts from nonnative plants, enhanced nitrogen deposition effects, and increasing atmospheric carbon dioxide effects (Threat Factor A).

5. A management plan is implemented to effectively manage and ameliorate impacts from Off-road vehicle activity and grazing to the populations specified in criteria 2 and 3 (Threat Factors A and E).

6. The risk of permanent population extirpation due to wildfire and climate change (Factor E) is minimized across the species range by protection and management of populations specified in delisting criterion 2 and 3.

All classification decisions consider the following five factors: (1) is there a present or threatened destruction, modification, or curtailment of the species' habitat or range; (2) is the species subject to overutilization for commercial, recreational scientific or educational purposes; (3) is disease or predation a factor; (4) are there inadequate existing regulatory mechanisms in place outside the ESA (taking into account the efforts by states and other organizations to protect the species or habitat); and (5) are other natural or manmade factors affecting its continued existence. When delisting or downlisting a species, we first propose the action in the *Federal Register* and seek public comment and peer review. Our final decision is announced in the *Federal Register*.

Rationale for Recovery Criteria

Recovery criteria are designed as a benchmark against which to assess the amelioration of threats, along with population resilience, species redundancy (number and distribution of populations), and species representation (habitat and genetic diversity among populations). Core occurrence complexes within the species' current range must be protected, as they represent

resilient populations or metapopulations that are most likely to rebound from low population numbers after drought, fire, or other stochastic events. All threat factors must be addressed to achieve the population resilience required to maintain species redundancy before species viability can be restored. Protecting habitat and populations at higher elevations and retaining the current range of climate influences maximizes representation across diverse habitat types and ensures local genetic adaptation to climate extremes is not lost and/or habitat where climate change effects are ameliorated (coastal influence and higher elevation habitat) remains available to the species. Timeframes to demonstrate reproduction and a level of population establishment where resilience is uncertain are 2-4 years because of the potential for extended diapause in a drought year (breeding might not happen every year).

In particular, criteria are designed to conserve habitat and ensure management essential for maintenance of resilient metapopulations. Metapopulations require maintenance of habitat and landscape connectivity within metapopulation distributions, and ecological connectivity among them. Two fundamental tenets of the Recovery Plan are the need for amelioration of the impacts of climate change (e.g. downlisting criterion 5) and planning for adaptability. Based on their climate change niche model analysis, Preston *et al.* (2012, p. 289) concluded higher elevation habitats are important, stating "…differences within the distribution of extant [Quino] populations were best predicted by climate variables. Higher elevation populations are buffered from drought." Parmesan *et al.* (2014) found strong support for an ongoing shift of species' distribution upward in elevation, and their model predicted that eventually lands outside of the species historical range would be required for species survival. Parmesan *et al.* (2014, p. 17) concluded "The fundamental conservation message from this example is that we need to increase connectivity among habitats and protected areas and increase species' *in situ* resistance and resilience to climate change by improving the health of populations, species, and ecosystems." California Ecological Subunits identify areas with marine influence (Figure 4) from Goudey and Smith 1994 [2007]: "…ecological units are mapped based on associations of those biotic and environmental factors that directly affect or indirectly express energy, moisture, and nutrient gradients which regulate the structure and function of ecosystems. These factors include climate, physiography, water, soils, air, hydrology, and potential natural communities." Therefore, we focused criteria on population connectivity and well-documented areas of occupancy within coastal climate influence (defined by California Ecological Subunits) and/or proximity to large lakes, and areas with montane climate influence.

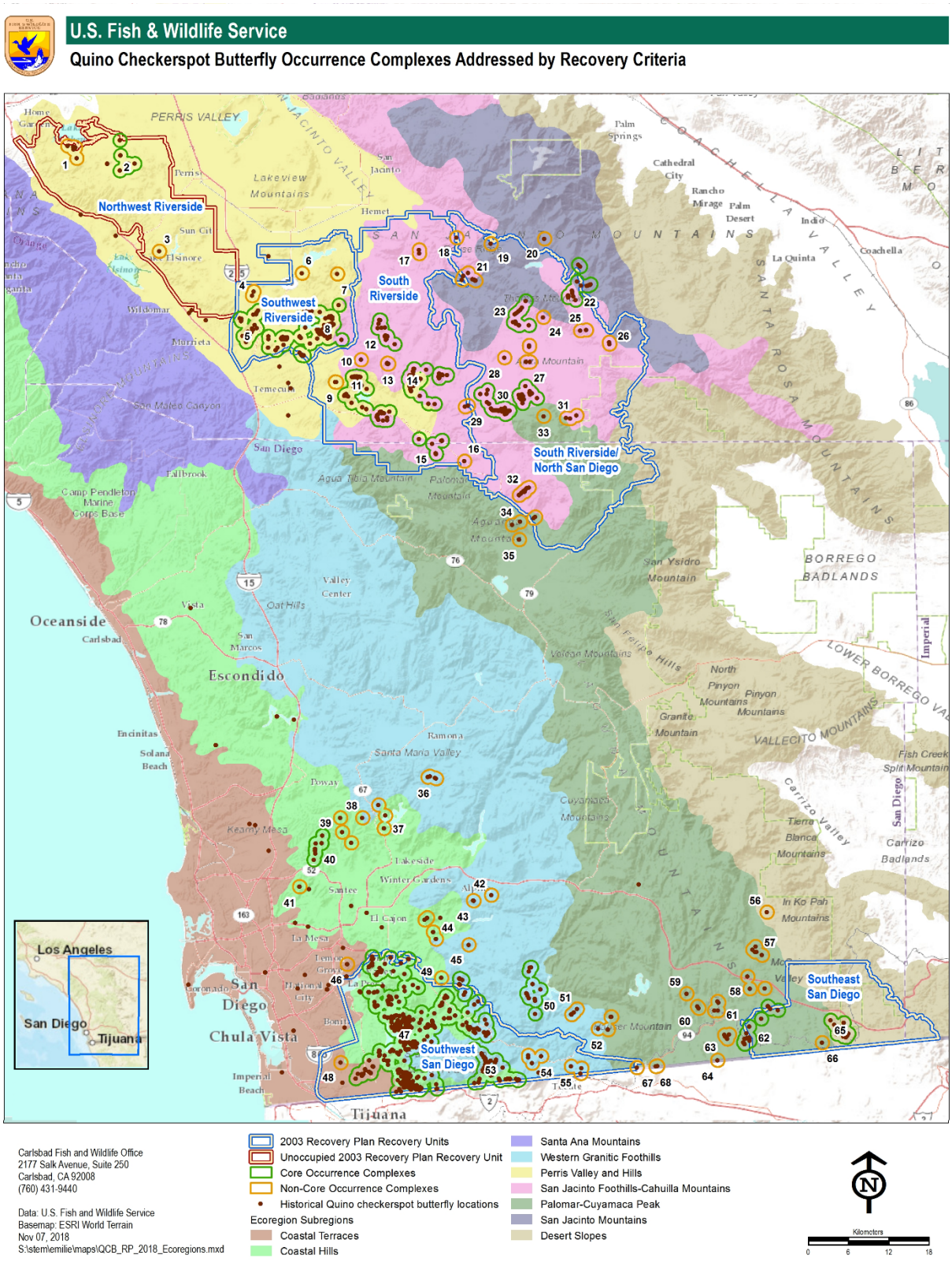

Figure 4. Quino checkerspot butterfly distribution map with California Ecological Subregions.

ADDITIONAL AND AMENDED RECOVERY ACTIONS

The goals of this recovery plan remain: (1) protecting habitat supporting known current population distributions (occurrence complexes) and connectivity among them; (2) maintaining or creating resilient populations; and (3) conducting research necessary to achieve recovery criteria. Recommendations made in the recovery action narrative required to achieve these goals (Service 2003, pp. 96–113) and meet the amended criteria should be generally the same, except with respect to site specificity (updated occurrence complexes as described in criteria, illustrated in Figures 1– 3, and listed in Table 1). Specific sites where actions are applicable should be clear in the recovery criteria. Below are new actions:

1) Seek funding for acquisition of habitat from willing sellers in areas described in delisting criteria (Priority 1).

2) In the South Riverside/North San Diego Recovery Unit, in the vicinity of the community of Anza, determine areas that would best provide ecological connectivity among core occurrence complexes that do not include Tribal lands (Cahuilla Band of Indians). Work with State, Federal, and local government agencies to conserve these areas, and to conserve habitat outside of Tribal lands (Ramona Band of Cahuilla, Santa Rosa Band of Cahuilla Indians) associated with the Bautista Road core, and Table Mountain Truck Trail and Lookout Mountain non-core occurrence complexes. Work with Tribal partners to plan for voluntary ecological connectivity and habitat conservation as appropriate (Priority 1).

3) Determine areas that would best provide ecological connectivity in southern San Diego County among core occurrence complexes that do not include Tribal lands (Barona Band of Mission Indians, Viejas Band of Kumeyaay Indians, Sycuan Band of the Kumeyaay Nation). Work with State, Federal, and local government agencies to conserve these areas. Secure remaining ecological connectivity in non-Tribal land bottleneck north of the Barona Band of Mission Indians' reservation (vicinity of San Vicente Road). Work with Tribal partners to determine recovery value and Tribal conservation status of ecological connectivity within the Capitan Grande Reservation. Work with Tribal partners to plan for voluntary ecological connectivity conservation as appropriate (Priority 1).

4) In Southeast San Diego County, in the vicinity of the communities of Campo and La Posta, determine areas that would best provide ecological connectivity among core occurrence complexes. Work with State, Federal, and local government agencies to conserve these areas. Work with Tribal partners to plan for voluntary ecological connectivity and habitat conservation as appropriate (Priority 2).

COSTS, TIMING, PRIORITY OF ADDITIONAL RECOVERY ACTIONS

The additional recovery actions are not anticipated to significantly affect estimates of cost and timing described in the recovery plan.

LITERATURE CITED

Condie, S.A. and I.T. Webster. 1997. The influence of wind stress, temperature, and humidity gradients on evaporation from reservoirs. Water Resources Research 33: 2813–2822.

Ekhtiari, N., S. Grossman-Clark, H. Koch, W. Meira de Souza, R.V. Donner, and J. Volkholz Effects of the Lake Sobradinho Reservoir (Northeastern Brazil) on the Regional Climate. Climate 5: 1–17.

Goudey, C.B., and D.W. Smith, eds. 1994 [2007]. Ecoregions of California 07_3. USDA Forest Service Pacific Southwest Region Remote Sensing Lab, McClellan, CA. Digital Geographic Information System data, updated 2007.

Mohamed Degu, A., F. Hossain, D. Niyogi, R. Pielke Sr., J. Marshall Shepherd, N. Voisin, and T. Chronis. 2011. The influence of large dams on surrounding climate and precipitation patterns. Geophysical Research Letters 38: 1–7.

Parmesan, C., A. Williams-Anderson, M. Moskwik, A.S. Mikheyev, and M.C. Singer. 2014. Endangered Quino checkerspot butterfly and climate change: Short-term success but long-term vulnerability? J. Insect Conserv. Online DOI 10.1007/s10841-014-9743-4.

Preston, K.L., R.A. Redak, M.F. Allen, and J.T. Rotenberry. 2012. Changing distribution patterns of an endangered butterfly: Linking local extinction patterns and variable habitat relationships. Biological Conservation 152: 280–290.

Preston, K.L., J.T. Rotenberry, R.A. Redak, and M. F. Allen. 2008. Habitat shifts of endangered species under altered climate conditions: importance of biotic interactions. Global Change Biology 14: 2501–2515.

Strahm, S. 2018. San Diego National Wildlife Refuge Quino Checkerspot Butterfly (*Euphydryas editha quino*) Augmentation Project: 2018 Annual Report. Prepared by Conservation Biology Institute for the United States Fish and Wildlife Service Cooperative Agreement Award F16AC00706. 50 pp.

Service [U.S. Fish and Wildlife Service]. 2003. Recovery Plan for the Quino Checkerspot Butterfly (*Euphydryas editha quino*). Portland, Oregon. x + 179 pp.

Service [U.S. Fish and Wildlife Service]. 2009. Quino Checkerspot Butterfly (*Euphydryas editha quino*) 5-Year Review: Summary and Evaluation. Carlsbad, California. 54 pp.

Theeuwes, N.E., A. Solcerová, and G.J. Steeneveld. 2013. Modeling the influence of open water surfaces on the summertime temperature and thermal comfort in the city. J. Geophysical Research: Atmospheres 118: 8881–8896.