O-6.2 QUINO REVIEW

Comment Letter O-6.2

EXHIBIT 2

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April 9, 2018

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Subject: Draft Environmental Impact Report, General Plan Amendment, and Specific Plan Amendment for Otay Ranch Village 14 and Planning Areas 16/19 Impacts on the Federally Endangered Quino Checkerspot Butterfly.

Dear Dr. Silver,

We appreciate the opportunity to review and comment on the DEIR for the Otay Ranch Village 14 and Planning Areas 16/19 development in Proctor Valley, San Diego County, with special consideration of impacts to the population of federally endangered *Euphydryas editha quino* (Quino Checkerspot Butterfly or "QCB") in the area. In conducting this review, we have also evaluated survey reports for the QCB conducted in support of the proposed development. O-6.2-1

We both have several decades of scientific, consulting, field observation, collection, and conservation experience with the QCB throughout southern California (dating back to the 1970's) as well many other listed butterflies. We have previously provided commentary on a similar proposed development, which provided extensive background QCB biological and ecological information in San Diego County, including commentary on interpretation of QCB survey results, along with relevant literature references on QCB (Osborne 2015, Pratt and Ballmer 2015). O-6.2-2 These letters provided by ourselves and several other QCB ecologists wrote critical commentary warning of the significant deleterious impacts the development of the Otay Ranch Village 13 project to the same QCB metapopulation we are discussing in this case (Klein 2015, Longcore 2015, Osborne 2015, Pratt and Ballmer 2015, Weiss 2015.) O-6.2-3 The Otay Ranch Village 14 and Planning Areas 16/19 is merely geographically somewhat farther north on the same QCB metapopulation and complex of core populations we are discussing here. Although minor details differ (here, we do not contemplate any project alternative, some QCB were actually encountered in the course of project related surveys for Otay Ranch Village 13, and like a collection of inkblots the scattered pattern of hostplant resources and ridgeline distributions differ between the project sites) the basic mechanics of our concerns about impacts to this regional QCB population of southwestern San Diego County expressed with those comments regarding the Otay Ranch Village 13 project apply to this Otay Ranch Village 14 and Planning Areas 16/19 project. For that reason, the County should review and respond to the concerns raised in these prior reports, which are attached hereto and incorporated by reference. O-6.2-4

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In addition to the attached reports, we provide the following comments and observations regarding Otay Ranch Village 14 and Planning Areas 16/19 Impacts on the Federally Endangered Quino Checkerspot Butterfly: O-6.2-5

After thoroughly reviewing the DEIR, we have readily come to the conclusion that this project is not compatible with Quino conservation. Although this development would not likely, by itself, cause the global extinction of Quino, it would certainly significantly contribute to that end. It is our expectation, based on the facts below, that substantial development (as proposed) at this venue will cause the decline and extirpation of Quino in the larger landscape surrounding the project site. There are other examples of this process that can now be compared to the proposed project – where major Quino population complexes have declined or been extirpated by development. These are presented by Osborne (2015). O-6.2-6

Language in the DEIR and its Executive Summary of Quino findings diminishes the perceived significance of the project site to QCB metapopulation structure and stability in the area.

It relies on three consecutive years (2014, 2015, and 2016) of surveys with negative findings for QCB, notes that the project would impact one historic QCB sighting location (and be adjacent to incidental sightings made by a USFWS biologist on a single day in 2017). In fact, the first two years of surveys obtained invalid results because the surveys were undertaken during drought years when QCB flight is greatly diminished or absent. The surveys were further invalid because they failed to cover the full project site improperly excluding or characterizing chaparral with potential QCB habitat as too dense to represent QCB habitat (example of excluded area attached). The 2016 survey (accepted by USFWS likely out of political necessity after requiring repeated surveys due to survey invalidity) was conducted in a year following multiple drought years when QCB numbers on the project site could not have been expected to recover from their drought induced decline. After extended drought, more than one year of suitable rainfall is required for a QCB population to rebound – the first year merely bringing the few surviving multiple year diapause larvae out to finish development, and the second year to realize reproductive success from the previous year. Hence, in spring of 2017, a single USFWS biologist, in only a few hours of observation was able to find several QCB in close proximity to the project site, in a year when the project proponent should have been conducting surveys on the site. Had surveys been conducted in 2017, it is likely that large numbers of QCB would have been found on the project site. Had surveys (with the man-power and intensity applied for the site in 2016) been applied annually since federal listing of QCB, it is likely that hundreds or thousands of adult QCB would have been found on the project site, just as they have been found on other well monitored core population sites through the years. We are personally aware of QCB collection records for Proctor Valley dating from the early 1980's (specifically specimens of March 30, 1982 collected by L. Shoemaker from a low ridgeline on the southwestern portion of Proctor Valley) representing historic records not listed with the CNDDB, and further demonstrating the long-term QCB population presence in the area. O-6.2-7

The DEIR incorrectly diminishes the significance of the extent of QCB habitat on the project site by stating that habitat is " . . . limited to scattered patches throughout the valley . . . ." In fact, virtually the entire project area (including areas excluded as habitat based on the assertion that shrub was too dense) represents QCB habitat. All regions supporting QCB in southern California and Mexico have hostplants distributed in scattered patches, just as they are in the Proctor Valley region. Scattered hostplant distribution is a definitive trait of core QCB habitat. After stating that the ". . . Proctor Valley O-6.2-8

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region is not considered a core area for QCB in the QCB Recovery Plan" (which is irrelevant because the QCB Recovery Plan does not represent the existing on-the-ground QCB population), and begrudgingly acknowledging that the " . . . region does contain documented historical sightings and the region is included in the metapopulation structure for the species . . . " (an empty statement because any land within a few kilometers of a QCB observation would, by definition, be within the "metapopulation structure" simply by virtue of the way butterflies disperse through habitat), the executive summery states that "From a metapopulation context, the Proctor Valley region provides suitable habitat for the species to expand into during very good reproductive and flight years." This statement suggests that the habitat is used only in good years and that it may be of marginal importance to QCB population dynamics. Again, this position is a "straw man" comprised of a series of weak and invalid survey results, the incorrect assumption that a scattered distribution of hostplant patches equates to diminished habitat quality. O-6.2-8 Cont.

These statements suggest that the preparers of the DEIR have little to no understanding of QCB ecology because they fail to apprehend that the distribution and quantities of QCB hostplants as documented by their own hostplant surveys actually represents a profoundly high quality environment for QCB metapopulation dynamics. They further fail to understand the real significance to regional QCB metapopulation function of the Proctor Valley (and the proposed project area) in its geographic situation through a terrain bottleneck and habitat bridge between the San Miguel Mountain area and Otay Mountains. Thus, rather than habitat into which QCB might venture during very good reproductive years, Proctor Valley, and the proposed project area, represents core habitat from which QCB might expand into other areas during years of high reproductive success. O-6.2-9

From our perspective as leading experts on QCB biology, ecology, and population dynamics, a QCB core area (even if not officially defined by the QCB Recovery Plan) exists through the Miguel Mountain area, through the Proctor Valley Region (including the project site) and south continuously through the Otay Mountains down at least to the Mexican border. The Dictionary Hill area to the north of this complex, where QCB has been absent for decades, would be one of those areas of (using language that the DEIR attempts to apply to the Proctor Valley region) "suitable habitat for the species to expand into during very good reproductive and flight years" and where QCB might then persist for a while (and incidentally while persisting may actually reciprocally supply metapopulation support back to the core areas southeast of Dictionary Hill including Proctor Valley). O-6.2-10

In our opinion:

1) Edge effects, deleterious to QCB population ecology and habitat quality (Preston et al. 2012), created by the disjointed, segmented distribution of the proposed development are greater than would have been realized had the development been concentrated near existing development. The DEIR fails to address far reaching edge effects (both direct and indirect) and on QCB population function in the vicinity of the project. O-6.2-11

2) The DEIR fails to address project impacts on QCB resulting from substantial separation (by development, see Preston et al. 2012) of the Otay Mt. critical habitat area from the existing metapopulation extension over the San Miguel Mountain area. O-6.2-12

3) The DEIR does not disclose or even reference how a significant segment of the regional QCB population, occupying approximately 18 square miles of habitat (northwest of the proposed

project, will be substantially separated by the proposed development from the Core population of the Otay Mountains (to the south of the project).

4) Because Proctor Valley is a key habitat bridge between the two core areas of San Miguel Mountain and Otay Mountain, development and its extended edge effects would sever connectivity, isolate populations, and significantly diminish the viability of both parts of the metapopulation.

O-6.2-12 Cont.

5) Proposed mitigation does not compensate for these significant regional impacts to QCB metapopulation function.

6) All proposed mitigation areas fall within the project sphere of deleterious influence from the development areas. Within the overarching Project Area, all lands of the Otay Ranch RMP Preserve, and all Conserved Open Space, fall within a short distance of less than two thousand feet from the Development Footprint – rendering these areas as inadequate and ineffectual for QCB conservation (Preston et al. 2012). Further damage to QCB habitat quality will occur because habitat areas adjacent to proposed development footprint (outside of the project sphere) that will be compromised by these edge effects are many times more extensive than the project development alone, lie. These impacts are not mitigated by the project.

7) Proposed habitat conservation areas will be directly adjacent to the development and be affected indirectly by invasive species, human disturbance, loss of nearby breeding habitat, and other factors, and the prognosis for continued occupancy of QCB in these areas will significantly diminish (Preston et al. 2012).

8) Due to the compromised environmental context of 560.9 acres of Conserved Footprint claimed for mitigation of the project, the developed plus environmentally-compromised habitat for QCB encompasses the entire project area and beyond. The additional 350.1 acres of land off site within the Otay Ranch RMP cannot adequately mitigate the overwhelming impacts the project would impose within Proctor Valley and upon the larger regional QCB metapopulation.

9) Effective mitigation of this level of impact, either onsite or offsite, is likely not possible. Trading known core habitat that has been occupied over decades for promises of habitat restoration and management elsewhere is not an effective conservation strategy, especially given the current tenuous status of QCB populations.

O-6.2-13

10) The development area has been occupied for decades, and is of critical importance to the continued regional persistence of the butterfly.

O-6.2-14

11) The nature and extent of the failed Quino population experiences at other QCB population sites (Osborne 2015) closely parallel the nature and extent of impacts that would be experienced due to a Village 14 and Planning Areas 16/19 development on the Quino populations existing in a metapopulation dynamic through the San Miguel Mountain – Proctor Valley – Otay Mountains areas around the proposed project.

O-6.2-15

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12) QCB Protocol surveys improperly excluded from survey extensive areas of habitat suitable for QCB, thereby rendering the surveys largely invalid. Such areas with "dense vegetation" were putatively excluded on the basis of a condition within guidelines (SUFWS 2014) that state in part "Closed-canopy woody vegetation including forests, riparian areas, shrub-lands, and chaparral. 'Closed-canopy woody vegetation' describes shrubs or trees growing closely together in which the upper portions of the vegetation converge (are touching) to the point that the open space between two or more plants is not significantly different than the open space within a single plant. Closed canopy shrub-land and chaparral are defined as vegetation so thick that it is inaccessible to humans except by destruction of woody vegetation (branches)." Examination of satellite imagery of the areas excluded from surveys clearly shows that there are open areas between shrubs. This open habitat amongst shrubs in the excluded areas is suitable habitat for QCB that must be surveyed. O-6.2-16

These comments and notes are Respectfully Submitted,

Ken H. Osborne and Gregory R. Ballmer

References:

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Longcore, T. 2015. *Re: Otay Ranch Village 13 Resort Village Draft Environmental Impact Report, General Plan Amendement and Specific Plan.* Letter submitted to County of San Diego, Planning and Development Services.

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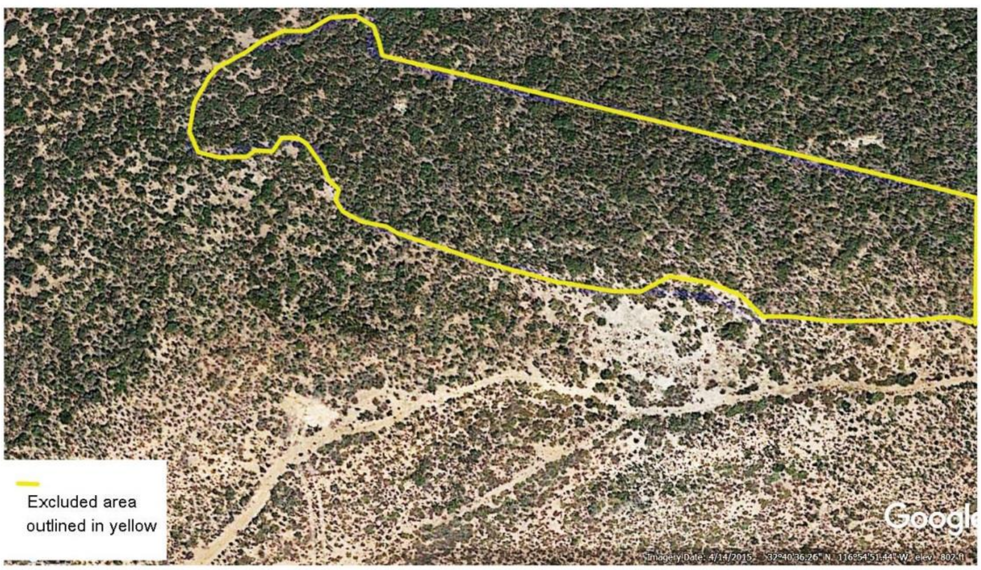
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Biological Conservation 152 (2012) 280–290

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Changing distribution patterns of an endangered butterfly: Linking local extinction patterns and variable habitat relationships

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ARTICLE INFO

Article history:
Received 11 September 2011
Received in revised form 2 March 2012
Accepted 11 March 2012
Available online 23 June 2012

Keywords:
Agricultural intensification
Euphydryas editha quino
Extinction
Grazing
Precipitation
Urbanization

ABSTRACT

Multiple processes are increasingly recognized as being responsible for species' extinctions. We evaluated population extinctions between 1930 and 1998 for the endangered Quino checkerspot (*Euphydryas editha quino*) butterfly relative to agricultural history, human population growth, climate variability, topographical diversity, and wildflower abundance. Overall agricultural land use was calculated for extinct and extant populations based upon cultivation and grazing intensities averaged across five time periods reflecting distinct agricultural practices from 1769 to present. Extinct populations were associated with a history of more intensive agriculture and greater human population growth at time of extinction. A long history of intensive livestock grazing was the strongest agricultural predictor of extinction. Based upon historic vegetation maps, extinct butterfly populations were typically isolated from other known populations by 1930, and in landscapes fragmented by cultivation and development. Precipitation and topographical variability were not important predictors of extinction. Wildflower host plants and nectar sources have declined across the butterfly's range because of invasive plants and habitat loss. The proportion of years considered average or abundant in wildflowers declined significantly during extinction periods. The Quino checkerspot has shifted in distribution from the coast into foothills and mountains. Newly discovered higher elevation populations experience more precipitation and are buffered from drought. Efforts to conserve Quino checkerspot are enhanced by understanding that the butterfly's decline and shifting distribution is a complex multi-scale process related to agricultural history, human population growth, climate variability, and wildflower decline.

1. Introduction

Multiple interacting stressors are driving species to extinction (Brook et al., 2008). Butterflies are especially sensitive to environmental change and accelerating extinction rates are leading to a global decline in butterfly diversity (Forister et al., 2010; Potts et al., 2010; Warren and Bourn, 2010). These declines are associated with urban and agricultural expansion and changing agricultural practices (Maes and Van Dyck, 2001; Stefanescu et al., 2004; Norris et al., 2010; Warren and Bourn, 2010; Fattorini, 2011). Agricultural intensification employing large-scale cultivation and use of pesticides and herbicides is reducing butterfly diversity (Schmitt and Rákosy, 2007; Marini et al., 2009; Ekroos et al., 2010; Warren and Bourn, 2010). Livestock grazing also affects butterfly populations, although the nature of the relationship depends on butterfly life history traits, plant community succession, grazing regimes, and invasive plant dynamics (Swengel, 2001; Pöyry et al., 2005; Schtickzelle et al., 2007; Vogel et al., 2007). In some species, lack of grazing leads to population extinction, whereas in others over-grazing causes extinction. Invasive species are another threat to butterfly populations (Moroń et al., 2009; Potts et al., 2010; Wagner and Van Driesche, 2010).

Climate change may cause future large-scale extinctions and interact with other drivers to accelerate extinction and biodiversity loss (Purvis et al., 2000; Brook et al., 2008). Insects are especially vulnerable to global warming as ambient temperature controls body temperature influencing metabolic reaction rates and life history phenology (Parmesan, 2006; Memmott et al., 2007; Wilson and Maclean, 2011). Precipitation patterns are changing with extremes in precipitation increasing (Easterling et al., 2000; IPCC, 2007; Seager et al., 2007). Increasing climate variability can lead to phenological mismatches between butterflies and host plants

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0006-3207/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biocon.2012.03.011

causing population extinctions (Ehrlich et al., 1980; McLaughlin et al., 2002; Parmesan, 2006; Hegland et al., 2009; Singer and Parmesan, 2010).

To effectively conserve declining species, it is important to understand the multiple processes leading to extinction. The endangered Quino checkerspot butterfly (*Euphydryas editha quino*) provides an opportunity to evaluate the association between population extinction and global change processes, including changing climate and land use. Quino checkerspot is the southernmost subspecies of Edith's checkerspot (*E. editha*), which is broadly distributed throughout western North America. The range of Edith's checkerspot has shifted northward and upwards in elevation, consistent with global warming predictions (Parmesan, 1996). Quino checkerspot populations exhibited the highest extinction rates, as expected for southerly populations in a warming and drying climate. Currently, this butterfly may be undergoing a range shift into higher elevations (USFWS, 2009), consistent with climate change predictions for the species (Parmesan, 1996; Preston et al., 2008). However, local extinctions and changes in historic distribution are also attributed to extensive habitat loss and degradation resulting from urban and agricultural land uses (Mattoni et al., 1997; USFWS, 1997, 2003).

In this paper, we evaluate spatial and temporal patterns of extinction in southern California populations of Quino checkerspot relative to agricultural history, human population growth, climate and topographic variability, and wildflower abundance. We also assess distributional changes and differences in environmental conditions across the United States (US) portion of the subspecies' historic and current range. Insights derived from these analyses will help us understand those environmental conditions under which Quino checkerspot populations may be more resilient or susceptible to global change processes. Such knowledge is important in prioritizing lands for conservation and informing management of this endangered subspecies.

2. Methods

2.1. Study system

Quino checkerspot was formerly distributed throughout cismontane southern California, US and northern Baja California, Mexico. Our southern California study area extends from the Pacific Ocean east through valleys, foothills, and mountains to the desert edge (Fig. 1). Climate, vegetation, and topography vary substantially. This once widespread and abundant butterfly currently occupies open coastal sage scrub and chaparral shrublands with native forbs. In early studies, Quino checkerspot primarily used *Plantago erecta* as a larval host plant with secondary use of *Plantago ovata* (Singer, 1971, 1982; White, 1974). More recently, butterflies have been observed using other host plants, particularly at higher elevation sites. These include *Castilleja exserta*, *Plantago patagonica*, *Antirrhinum coulterianum*, *Collinsia concolor*, and *Cordylanthus rigidus* (Mattoni et al., 1997; Pratt and Pierce, 2008; USFWS, 2003, 2009). Adult Quino checkerspot use multiple nectar sources, including species in the *Cryptantha*, *Eriodictyon*, *Gilia*, *Lasthenia*, *Lomatium*, *Muilla*, and *Plagiobothrys* genera. More than 75% of the butterfly's former range has been converted to agriculture and urban development, prompting listing as a federally-endangered species in 1997 (USFWS, 1997).

Quino checkerspot likely have a complex metapopulation structure with large (20–100 fold) fluctuations over 10–20 year periods (Mattoni et al., 1997; USFWS, 2009). Under certain environmental conditions, Quino checkerspot populations can explode in size and defoliate larval host plants leading to massive dispersal events (Murphy and White, 1984; White and Levin, 1981). Large populations tend to persist in more extensive, diverse habitats, whereas smaller, lower quality habitats are temporarily colonized by butterflies following massive dispersal events and sufficient rainfall for larval host plant growth. Extirpation of large, source populations is likely to lead to long term extinction in an area. In Edith's checkerspot, the annual timing and amount of precipitation drives population fluctuations by determining larval survival; 99% of pre-diapause larvae can die from starvation when host plants senesce after winter rains (Ehrlich et al., 1980).

2.2. Temporal and spatial patterns of the butterfly's distribution

To assess the spatial and temporal distribution of Quino checkerspot occurrences in the study area, we combined current butterfly locations with historic records and mapped observations by decade.

2.3. Environmental databases for modeling

To compare land use and climate differences at extinct and extant Quino checkerspot populations, we developed a database characterizing agricultural history, human population size, and precipitation and topographical variability. These data were derived from many sources and linked spatially to each population (Appendix Table 1). We developed a second environmental dataset using Geographic Information Systems (GISs) software and digital data to calculate variables reflecting current environmental conditions across the historic and present range of Quino checkerspot.

2.3.1. Environmental conditions at extinct and extant butterfly populations

For our analysis of environmental factors associated with extinction, we identified extinct populations and selected comparable extant populations for the purposes of calculating environmental variables during equivalent time periods. Extant populations were undeveloped locations where Quino checkerspot have been recorded since 1998. Extinct populations were those where a butterfly was detected historically (1905–1982) but has not been recorded since 1998. We defined the extinction period as the 20-year window centered on the last recorded butterfly observation. This period corresponds to the 10–20 year cycle in which butterfly populations can fluctuate exponentially and during which environmental conditions likely influence population dynamics leading to extinction (Mattoni et al., 1997; USFWS, 2003, 2009).

We calculated environmental variables during relevant time periods for each extinct population and then selected the closest extant population to calculate environmental variables during the same time periods. If there were no nearby extant populations, we selected an extant population in similar proximity to the coast as the extinct population. The intent was to select extinct and extant populations comparable in environmental conditions so that factors most strongly associated with extinction could be distinguished.

2.3.1.1. Human population. We used the size of the human population near a Quino checkerspot population as a proxy for the relative amount of historic habitat loss to urbanization (Forister et al., 2010). We used 1930 Wieslander Vegetation Type Maps (VTMs) to assess the level of development versus natural habitat in the vicinity of each butterfly population prior to the period of documented population extinctions (Wieslander, 1935; VTM, 2011). We aggregated decadal US Census Bureau human population data for counties, cities, and towns (Forstall, 1995; CSDF, 2000) in the vicinity of Quino checkerspot populations. We defined "vicinity" as a distance of ⩽5 km between the butterfly population and a town or city, which is within Quino checkerspot's dispersal

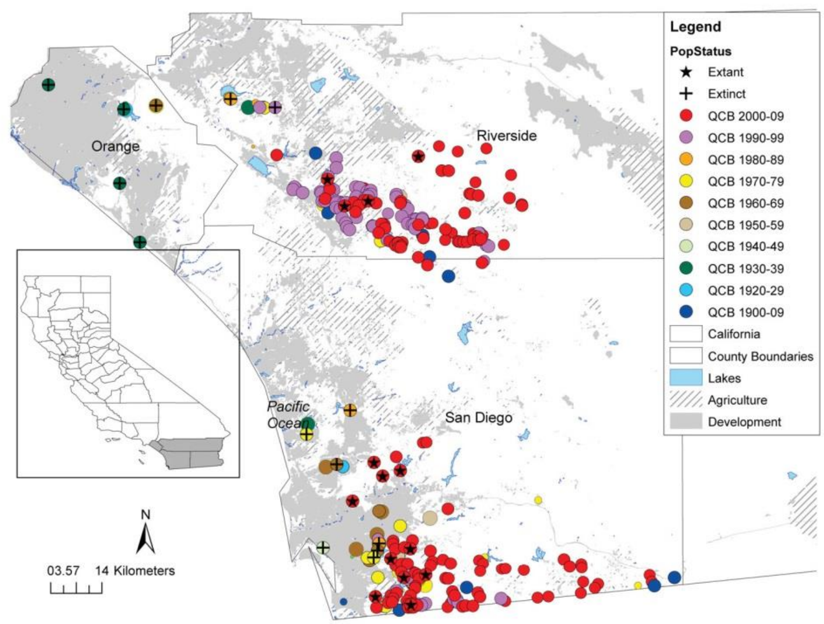

Fig. 1. Quino checkerspot butterfly (QCB) study area and butterfly locations classified by colored circles according to the most recent decade in which an observation was reported. Also shown are locations of extinct (triangle) and extant (circle) populations used in modeling.

capabilities (Harrison, 1989; Parmesan, 1996). We used maps with jurisdictional boundaries (Rand McNally, 2004, 2008) and a GIS layer of cities (ESRI, 2005) to determine towns and cities ⩽5 km from butterfly populations. Growth in human population was calculated as the difference in population density between the decade prior to the last butterfly observation for an extinct population and the decade following that observation. Human population growth was calculated for the same time period for the comparable extant population.

2.3.1.2. Agricultural history. To categorize land use change associated with agricultural practices, a score was developed for each population reflecting the relative intensity of grazing and cultivation over five discrete time periods between 1769 and present. These time periods represent different patterns of agricultural production in this region (Johnston and McCalla, 2004). Agriculture was introduced into California by Spanish missionaries in 1769. During the Spanish Mission/early Mexican (1769–1834) and Mexican rancho (1835–1848) periods, livestock grazing was the predominant form of agriculture. The early California statehood period (1849–1889) is characterized by cattle production, with a switch in the 1870s to sheep production and dry farming of wheat and barley. The agricultural intensification period (1890–1930) includes expansion of dry farming and rapid growth of intensive irrigated crops, such as fruits and vegetables. After 1930, there was further growth of agriculture, although following World War II a population boom converted large areas of farmland to urban/suburban development.

We compiled historical records from many sources (Appendix Table 1) to estimate relative livestock grazing intensities ⩽5 km from extinct and extant Quino checkerspot populations. We used historic Wieslander Vegetation Type Maps (VTMs) to assess spatial patterns of agriculture and natural vegetation near butterfly populations in 1930 (Wieslander, 1935; VTM, 2011). Lands used for livestock grazing were assigned a grazing intensity score based upon categories of livestock stocking rates (number of hectares/head of cattle/horse; Appendix Table 2). Cut-offs for stocking rates within each grazing category were based upon historic livestock grazing intensities in California (Minnich, 2008). Extinct and extant butterfly populations were given numeric scores for each time period based upon average livestock production records or upon typical stocking rates for that area. We used descriptions of historic land use (Appendix Table 1) to identify whether there was significant livestock grazing near populations or whether land was used for farming, urban/suburban development or left undisturbed. We categorized intensity of livestock grazing before 1930 to reflect grazing history before extinction and after 1890 to represent the period before and during extinction episodes. We also quantified grazing for only the decades prior to (1890–1930) and during (post-1930) documented butterfly extinctions.

In a similar manner, we compiled cultivation information from different sources (Appendix Table 1). We scored each extinct and extant population for relative intensity of cultivation during the five time periods (Appendix Table 2). We used historic Wieslander VTMs to categorize the amount of cultivated land ⩽5 km of butterfly populations in 1930, the start of the period of extinctions examined in this study. Cultivation included dry farming (grains) and irrigated crops (orchards, vineyards, vegetables, and hay). We calculated cultivation intensity from 1890 through 1930 to reflect conditions preceding extinctions and after 1930 to characterize extinction episodes.

To quantify overall agricultural land use for each population, we calculated an average score representing combined grazing and cultivation scores across the five time periods.

2.3.1.3. Climate. We obtained weather station records closest to extinct and extant Quino checkerspot populations and calculated climate parameters (WRCC, 2012). Since precipitation and temperature are highly correlated, we focused on precipitation variables, which are important in Edith's checkerspot population dynamics (Ehrlich et al., 1980; McLaughlin et al., 2002). We calculated mean and standard deviation annual rainfall (August 1–July 31) for the entire weather station record and for the 20-year extinction period at each population. Extremely low precipitation years experienced less precipitation than one standard deviation below the mean precipitation for the butterfly population with the lowest average rainfall. Similarly, extremely high precipitation years were those receiving more precipitation than one standard above the mean precipitation of the population with the highest average rainfall. Thresholds defining extreme rainfall years were ⩽140 mm and ⩾566 mm of precipitation.

We summarized precipitation from December to June of the rainfall year, the period of time most relevant to the Quino checkerspot life-cycle. We determined the proportion of extreme rainfall years for the entire weather station record for each population. For each extinct population, we calculated the difference between the proportion of extreme December to June rainfall years for the 20 year extinction window and preceding years of the weather station record. We also calculated this for the comparable extant population during the same time period. To further assess whether extreme precipitation was associated with extinction, we conducted a two sample paired *t*-test with extinct populations testing the null hypothesis that the proportion of extreme precipitation years was higher during the extinction period than in preceding years. We conducted the same analysis for extant populations.

2.3.1.4. Topography. Topography plays a strong role in sister subspecies Bay checkerspot (*E. editha bayensis*) larval development and survival and the timing of adult emergence (Weiss et al., 1988, 1993). We used a vector ruggedness measure (VRM) calculated in GIS to quantify local variation in terrain, this measure is less dependent on slope than other methods (Sappington et al., 2007). Vector analysis is used with a raster-based digital elevation model to decompose each grid cell into x, y, and z components using trigonometry and the slope and aspect of the cell. We calculated terrain ruggedness for a 3×3 neighborhood of 90 m cells at each population location.

2.3.1.5. Wildflower abundance. Minnich (2008) compiled newspaper records categorizing annual wildflower abundance for Los Angeles County from 1886 to 2007 and Riverside County from 1918 to 2007. Orange County was originally part of Los Angeles County and was included in the analysis. We had no wildflower records for San Diego County. For each extinct population in Los Angeles, Orange and Riverside counties, we calculated the proportion of years that wildflowers were average or high in abundance during the extinction period. We then calculated the proportion of average and high wildflower years for the period prior to extinction. We used a two sample paired *t*-test to test the null hypothesis that for extinct populations, wildflower abundance was lower during the extinction period than the preceding period.

2.3.2. GIS-based environmental dataset to compare butterfly habitats

For a larger-scale analysis of habitat relationships across the current distribution of Quino checkerspot, we used ARCGIS 9.1 software (ESRI, 2005) to calculate environmental variables from various digital source layers for a 1 km^2 grid across the study area. For each Quino checkerspot location we extracted values for environmental variables at the grid cell encompassing the location. Climate variables included average annual precipitation and minimum January temperature (OSU, 2006). To characterize topography we used a 90-m resolution Digital Elevation Model (USGS, 2006) to calculate median values for elevation, slope, and aspect within a 1 km^2 cell. Land cover variables included percent of coastal sage scrub and chaparral habitats and agricultural and developed lands within 1 km^2, as calculated from a vegetation map for the region (CDF, 2006).

2.4. Modeling methods

2.4.1. Model construction

2.4.1.1. Comparing extinct versus extant populations. We constructed and compared alternative logistic regression models to distinguish between environmental conditions associated with extinct versus extant populations. These models represented different *a priori* hypotheses regarding the importance of land use and climate in association with population extinction. We used an information-theoretic comparative approach to evaluate alternative models (Burnham and Anderson, 2002).

2.4.1.1.1. Butterfly extinctions, agriculture, human population, precipitation and terrain ruggedness. To explore the relationship of local-scale butterfly extinctions and land use change, climate variability, and topographic heterogeneity, we developed models comparing average intensity of agriculture (grazing and cultivation) since 1769 with human population growth, the difference in proportion of extreme precipitation during December through June rainfall years before and during the extinction period, and terrain ruggedness. We created a global model incorporating all four variables and alternative models with land use versus climate/topographic variables and interaction terms. We avoided multicollinearity by examining correlations among pairs of variables and for $r > 0.7$ we retained only one of the independent variables in the model (Tabachnick and Fidell, 1996).

2.4.1.1.2. Butterfly extinctions, grazing, and cultivation intensity over different time periods. We ran a second series of models to explore the association between butterfly population extinction and livestock grazing and crop cultivation during different time periods. We calculated intensity of grazing and cultivation, for the entire period preceding extinction (1769–1930) and several decades prior (1890–1930), during extinction (post-1930), and for the entire history of agriculture from 1769.

2.4.1.2. Environmental conditions across the Quino checkerspot's distribution. To determine if there were environmental differences within the current distribution of Quino checkerspot populations, we characterized environmental attributes for locations where Quino checkerspot populations were historically documented and still persist with areas where populations have only recently been detected. "Established" populations included both historical (<1998) and current locations, whereas "newly discovered" included a distinct region with no spatially explicit location records before 1998. We calculated mean ± standard deviation values for environmental variables. We used the comparative logistic regression modeling approach to evaluate differences in climate, vegetation, and land use at established versus newly discovered locations. As there were more records for established populations, we randomly selected a subset of these records to obtain equivalent sample sizes for modeling.

2.4.2. Model evaluation

To select the best approximating model(s), we used Akaike's information criterion adjusted for small samples (AIC; Burnham and Anderson, 2002). We selected the model with the lowest AIC_c value and calculated a difference in AIC_c (Δ_i) for each model. We computed Akaike weights (ω_i) representing the probability that a model was the best approximating model for the dataset. We also calculated an evidence ratio representing the probability that the model with the highest ω_i was likely to be correct compared to another model. Based upon cumulative Akaike weights, we identified a $\geqslant$95% confidence subset of best approximating models. To evaluate the relative importance of each variable, we calculated model averaged parameter estimates (MAPEs) and cumulative variables weights (CVWs).

3. Results

3.1. Temporal and spatial patterns of the Quino checkerspot's distribution

Quino checkerspot butterflies were historically recorded from the coast to the foothills of southern California (Fig. 1). Between the 1930s and 1970s the butterfly disappeared from most coastal areas. Current populations are distributed in the central and eastern portions of the butterfly's historic range. Most recent observations are clustered in southwestern Riverside County, particularly in the foothills, and in southern San Diego County. The most easterly distributed newly discovered locations in Riverside County were first documented in 1998 and are at higher elevations in the Peninsular Mountains.

3.1.1. Patterns of extinction relative to 1930 land use

Inspection of the VTMs reveals that in 1930 southern California was largely agrarian with human population centers in the major cities of Los Angeles, Riverside, and San Diego. There was extensive cultivation along the coast in northern Orange and San Diego counties and in large interior valleys. Native shrublands along the coast were fragmented by grassland, cultivated fields, and rural residences. Extensive native shrublands, particularly chaparral, were located away from the coast at higher elevations in the Santa Ana Mountains and Peninsular foothills. Only a few areas with large expanses of potential habitat lack historic butterfly observations, such as foothills/mountains in southern Orange County and northern San Diego County. In 1930 only 18% of butterfly populations that later went extinct had shrublands encompassing more than 50% of the area within 5 km of their location, compared with 58% of extant populations. Extinct populations were also more isolated in 1930, with only 9% having a known butterfly population within 5 km compared with 92% of extant populations.

3.2. Environmental conditions at extinct versus extant populations

We classified 14 local Quino checkerspot populations as extinct and selected 14 comparable extant populations within the historically established range (Fig. 1).

3.2.1. Butterfly extinctions, agriculture, human population, and precipitation

In distinguishing between extinct and extant Quino checkerspot populations three candidate models comprised a 97% confidence subset of best approximating models (Table 1). The top-ranked model included average agricultural intensity since 1769 and growth in human population during the extinction period. All three candidate models included these two variables. Difference in proportion of extreme precipitation years during the extinction period, terrain ruggedness, and interaction between agricultural intensity and human population growth did not improve performance of the other two candidate models.

There was a positive relationship between extinction and average agricultural intensity (Fig. 2a; MAPE: 0.10; 90% C.I.: 0.01–0.18). Agricultural intensity was an important predictor of extinction (CVW = 0.99). Extinct populations showed variable levels of human population growth (Fig. 2b), but there was a positive association between human population growth and extinction (MAPE: 0.0001; 95% C.I.: 0.0000–0.0003). Human population growth was as important as agriculture in predicting extinction (CVW of 0.97). Average annual rainfall (Fig. 2c) and minimum January temperature did not differ between extinct and extant populations. The difference in proportion of extreme December to June rainfall years during the 20-year extinction window compared with previous years did not show a trend relative to extinction (Fig. 2d, MAPE: 0.07; 95% C.I.: −0.07 to 0.21). Terrain ruggedness also did not show a trend in association with extinction (Fig. 2e, MAPE: −0.14; 95% C.I.: −0.37 to 0.09). CVWs of 0.42 indicate extreme precipitation and terrain ruggedness were substantially less important than land use in distinguishing between extinct and extant butterfly populations.

There was a subtle difference in extreme precipitation for extinct and extant populations that was detected only with paired sample comparisons. For extinct populations, the proportion of extreme rainfall years was significantly higher during the extinction period (mean ± standard deviation: 0.10 ± 0.06) compared with the prior period (0.06 ± 0.06; Paired two-sample t test, $t = 2.49$, $p = 0.01$). Similarly, for extant populations extreme rainfall was greater in the extinction period (0.13 ± 0.06) compared with the prior period (0.08 ± 0.05; Paired two-sample t test, $t = 2.50$, $p = 0.01$).

3.2.2. Butterfly extinctions, grazing, and cultivation

Three models comprised a 98% confidence subset of models relating livestock grazing and cultivation intensities over different time periods to butterfly extinction (Appendix Table 3). Average grazing intensity from 1769 to 1930 was the most important predictor of extinction. The best approximating model with a weight of 0.75 included only pre-1930 grazing, which had a positive association with extinction (Fig. 2f; MAPE: 1.36; 95% C.I.: 0.14–2.58; CVW = 0.98).

The second ranked model included pre-1930 grazing and post-1930 cultivation ($\Delta_i = 2.74$; $\omega_i = 0.19$; $\omega_i/\omega_1 = 3.9$), while the third ranked model included these two variables and an interaction term ($\Delta_i = 5.66$; $\omega_i = 0.05$; $\omega_i/\omega_1 = 13.8$). Post-1930 cultivation intensity showed no trend in relation to extinction (Fig. 2g; MAPE: 0.01; 95% C.I.: −0.13 to 0.15; CVW = 0.24). Other measures of grazing and cultivation were unimportant predictors of extinction.

3.2.3. Butterfly extinctions and wildflower abundance

Based upon newspaper accounts (Minnich, 2008), thirteen extinct Quino checkerspot populations in Los Angeles, Orange, and Riverside Counties had significantly fewer average or high abundance wildflower years (mean ± standard deviation: 0.18 ± 0.16; Paired two-sample t-test, $t = -5.795$, $p = <.0001$) during the extinction period than prior to extinction (0.51 ± 0.16). Between 1886 and 1918, 73% of years with records in Los Angeles County were classified as average or high abundance wildflower years. However,

Table 1
Performance of logistic regression models[a] in distinguishing between extinct and extant populations of Quino checkerspot relative to human population, precipitation extremes, terrain ruggedness and cumulative agricultural land use scores from first European settlement to present. K represents the number of model parameters, Δ_i is the difference in AIC_c values for each model relative to the model with the lowest AIC_c, ω_i is the model weight, and ω_i/ω_1 is the evidence ratio.

Model parameters	K	Δ_i	ω_i	ω_i/ω_1
Agriculture and human population	**4**	**0.000**	**0.444**	
Agriculture, human population, terrain ruggedness and December–June extreme precipitation	**6**	**0.147**	**0.413**	**1.1**
Agriculture, human population and interaction	**5**	**2.796**	**0.110**	**4.0**
Agriculture	3	6.353	0.019	23.9
Terrain ruggedness	4	8.256	0.007	61.7
Human population	3	9.614	0.004	123.3
Terrain ruggedness and December–June extreme precipitation	5	10.508	0.002	191.4
Terrain ruggedness, December–June extreme precipitation and interaction	5	13.09	0.001	191.4
December–January extreme precipitation	3	13.686	0.001	888.0

[a] Models highlighted in bold form 96% confidence subset of best approximating models. Variables are defined in the methods.

between 1918 and 2007, only 9% of years were average with no high abundance years. This trend in declining wildflower populations proceeded inland with increasing low abundance years beginning in the 1940s in Riverside County. However, wildflower fields have persisted in areas of western Riverside County with high abundances recorded as late as 1952 and average abundances as late as 2003. Populations remaining extant during the period of wildflower decline are located in eastern portions of the butterfly's range where wildflowers have remained more abundant.

3.3. Environmental variation across the historic and current range

In characterizing differences in environmental attributes across the historic range of Quino checkerspot, the butterfly's current distribution is shifted toward higher elevations (Fig. 3a). This is caused by the extinction of low elevation coastal populations and occurrence of newly discovered populations in the Peninsular Mountains. These latter populations receive substantially more rainfall than extinct or established populations (Fig. 3b). The proportion of extreme rainfall years calculated from long-term weather station records varies by region and tends to be lower for newly discovered populations (Fig. 3c). Average minimum January Temperature between 1970 and 2000 was much lower for newly discovered populations (Fig. 3d). There was little difference in the amount of current urban and agricultural development for established populations (Fig. 3e and f). Newly discovered populations occur in landscapes with more chaparral and less coastal sage scrub (Fig. 3g and h).

3.3.1. Environmental conditions at established versus newly discovered populations

Three logistic regression models formed a 95% confidence subset in distinguishing between established and newly discovered populations and all three models included climate variables (Table 2). The single most important predictor was annual rainfall with a CVW of 1.0; annual rainfall was lower at established populations (MAPE: −0.11; 95% C.I.: −0.18 to −0.03). The proportion of extreme rainfall years at weather stations near populations did not show a trend (MAPE: 2.70; 95% C.I.: −25.75 to 31.16; CVW = 0.35). Minimum January temperature was highly correlated with precipitation ($r = -0.96$, $p < .0001$) and was not used in modeling. Land use and vegetation variables showed no trends in distinguishing between established and newly discovered populations and CVWs were less than 0.10.

4. Discussion

4.1. Environmental conditions at extinct versus extant populations

Quino checkerspot population extinctions in southern California were most strongly associated with agricultural intensity from 1769 to present and to human population growth during the extinction period. By the early 1930s agriculture and rural development had led to extensive habitat loss and fragmentation. Climate played a subtle and localized role; it was not an important predictor of extinction, although extinct populations had significantly more extreme rainfall years during the extinction period. Climate variability may have exacerbated the effects of habitat loss and degradation on Quino checkerspot population dynamics. An interaction between habitat loss, degradation, and climate variability contributed to Bay checkerspot population extinctions where extreme precipitation was associated with large population fluctuations (Ehrlich et al., 1980; McLaughlin et al., 2002). Habitat loss and degradation resulted in the inability of butterflies to recolonize isolated habitat patches after populations were extirpated as a result of climate variability.

Many Quino checkerspot populations in southern California likely disappeared prior to the extinction events examined in this study (Mattoni et al., 1997). The Wieslander VTMs indicate that by 1930 populations that went extinct over the next six decades occurred in relatively isolated natural habitats fragmented by agriculture. Temporal and spatial patterns of Quino checkerspot population extinctions mirror trends in agricultural intensity and human population growth. Thus, land use practices may have directly caused butterfly extinctions through habitat destruction as well as indirectly through loss of resilience. Fragmented habitats with butterfly extinction following stochastic events (e.g., fire, flood, drought) would likely remain unoccupied because of isolation from other butterfly populations.

4.1.1. Butterfly extinctions, grazing, invasive plants, and declining wildflowers

Quino checkerspot population extinctions were associated with a longer, more intensive history of grazing. Those areas with the longest history of grazing and highest livestock stocking rates comprised the best pasture (Minnich, 2008) and were where butterflies initially went extinct. Other studies have also documented relationships between livestock grazing, quantified at relatively coarse scales, and landscape-scale patterns of butterfly diversity, abundance, population dynamics, and extinction (Hoyle and James, 2005; Pöyry et al., 2005; Saarinen and Jantunen, 2005).

The causal relationship between livestock grazing and Quino checkerspot population extinction is unknown. Grazing can cause direct mortality of immobile larvae and pupae through trampling (Weiss, 1999; Swengel, 2001; Schtickzelle et al., 2007). Grazing can indirectly affect butterflies by reducing the richness and abundance of native larval host and nectar plants and by altering vegetation structure and microclimate, thereby impacting thermoregulatory environments for developing larvae (Swengel, 2001; Hoyle and James, 2005; Saarinen and Jantunen, 2005; Schtickzelle et al., 2007). It is conceivable that over-grazing led to Quino checkerspot population extinctions in the 1800s when stocking rates

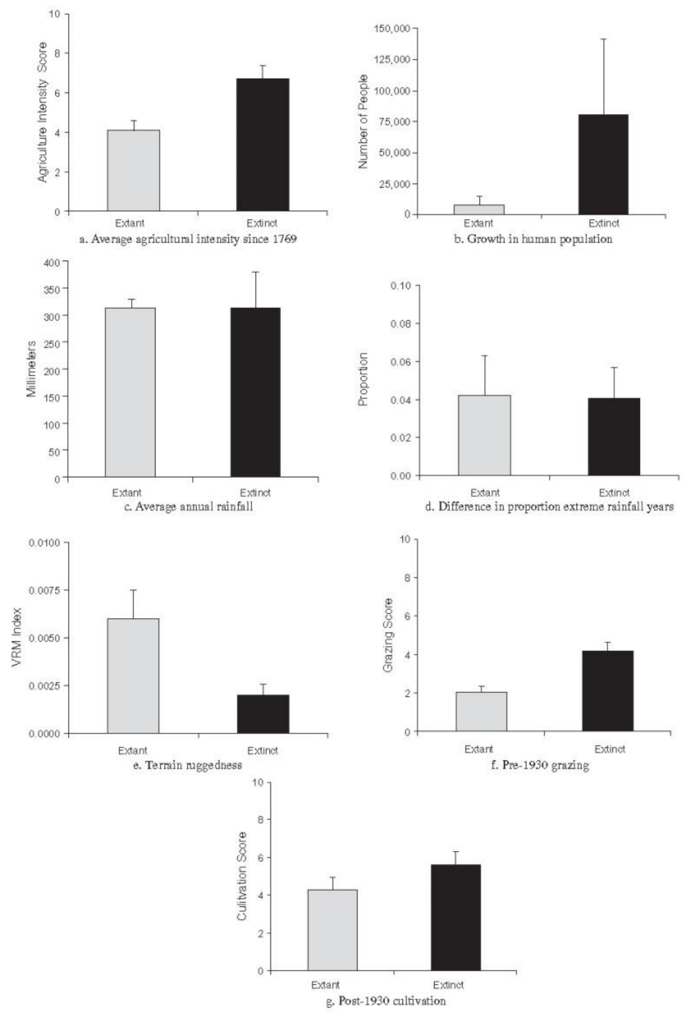

Fig. 2. Environmental attributes at 14 extinct and 14 extant Quino checkerspot populations.

were at their highest and that populations remaining in the 1930s were remnants of a previously more abundant distribution.

Based upon descriptions of Spanish Explorers, missionaries, and early settlers, the best pasture lands supported diverse and

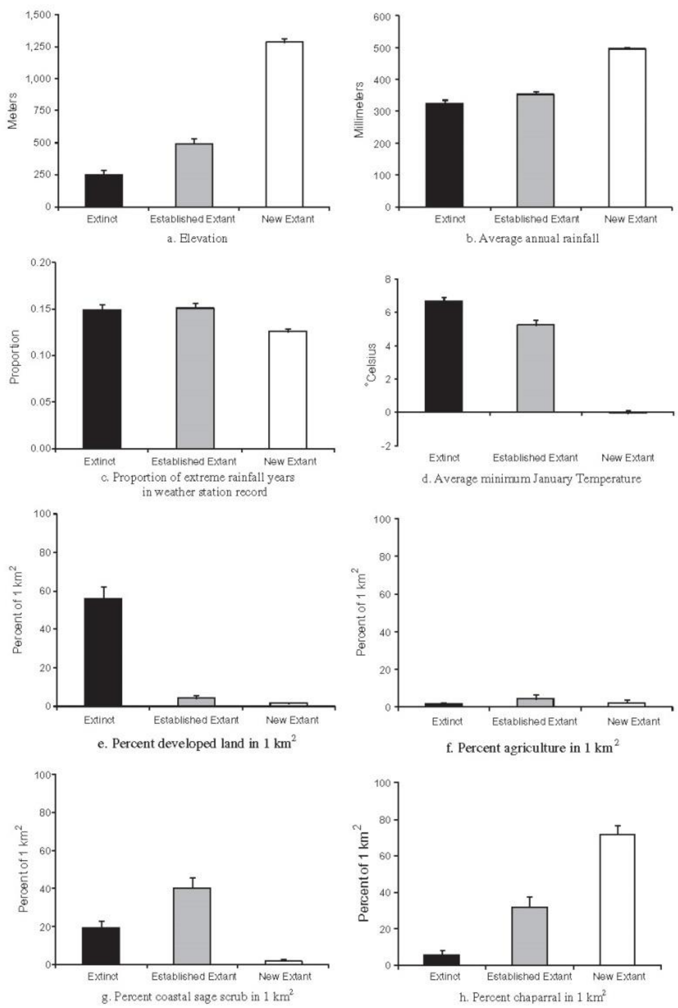

Fig. 3. Environmental attributes at regions currently occupied by Quino checkerspot compared with regions where the butterfly is extinct. "Extinct" indicates areas with no butterfly records since 1998, "established extant" indicates currently occupied areas where the butterfly was historically documented, and "new extant" indicates areas with no location records prior to 1998.

Table 2
Performance of logistic regression models[a] in distinguishing between newly discovered and established extant Quino checkerspot populations relative to current land use (percent agriculture and development in 1 km^2) and natural (climate, percent vegetation in 1 km^2) environmental factors. K represents the number of model parameters, Δ_i is the difference in AIC_c values for each model relative to the model with the lowest AIC_c, ω_i is the model weight, and ω_i/ω_1 is the evidence ratio.

Model type	Model parameters	K	Δ_i	ω_i	ω_i/ω_1
Climate	**Annual rainfall**	**3**	**0.000**	**0.654**	
Climate	**Annual rainfall, proportion extreme rainfall**	**4**	**2.044**	**0.235**	**2.8**
Climate and land use	**Annual rainfall, proportion extreme rainfall, % agriculture, % development**	**6**	**4.638**	**0.064**	**10.2**
Climate and vegetation	Annual rainfall, proportion extreme rainfall, % chaparral, % coastal sage scrub	6	5.834	0.035	18.5
Climate, vegetation and land use	Annual rainfall, proportion extreme rainfall, % chaparral, % coastal sage scrub, % agriculture, % development	8	8.257	0.011	62.3
Vegetation	% Coastal sage scrub	3	48.451	0.000	6540000000.0
Vegetation	% Chaparral, % coastal	4	50.514	0.000	>6540000000.0
Vegetation and land use	% Chaparral, % coastal sage scrub, % agriculture, % development	6	54.084	0.000	>6540000000.0
Vegetation	% Chaparral	3	71.341	0.000	>6540000000.0
Climate	Proportion extreme rainfall	3	81.394	0.000	>6540000000.0
Land use	% Development	3	90.508	0.000	>6540000000.0
Land use	% Agriculture	3	92.007	0.000	>6540000000.0
Land use	% Agriculture, % development	4	92.027	0.000	>6540000000.0

[a] Models highlighted in bold form 95% confidence subset of best approximating models. Variables are defined in the methods.

abundant wildflower communities. These areas were also where exotic Mediterranean plants were first introduced and established (Mattoni et al., 1997; Minnich, 2008). Open forb lands with patches of shrubs are characteristic of high quality Quino checkerspot habitat. As late as the early 1900s, primary host and nectar plants for this butterfly were still common. However, southern California wildflowers started a precipitous decline in abundance around 1920 (Minnich, 2008). The trend in decreasing wildflower abundance began at the coast and spread inland, although in some years wildflowers are still average abundance in Riverside County, especially in areas with poor soils. The pattern and timing of wildflower decline corresponds with patterns of Quino checkerspot population extinctions.

Invasive annual grasses in combination with urban development and agricultural expansion contributed to the collapse of extensive native wildflower fields (Minnich, 2008). A suite of Mediterranean annual grasses first invaded coastal areas in the late 1800s, became well established by the 1930s, and then expanded into inland valleys (Wieslander, 1935; Minnich, 2008). This wave of invaders included red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), and slender wild oat (*Avena barbata*). The rapid decline of Quino checkerspot in the 20th century is likely caused in part by invasive plants and the collapse of native wildflower fields. Invasive grasses reduce the abundance of native larval host and nectar plants and bare ground available for optimal larval development (Weiss, 1999; Osborne and Redak, 2000). Invasive annual grasses have also contributed to population extinctions in other Edith's checkerspot subspecies (Weiss, 1999; Severns and Warren, 2008).

Intensive grazing can facilitate invasion of exotic plants and likely played a role in the spread and dominance of exotic grasses in California's native plant communities (Leiva et al., 1997; Weiss, 1999; Hayes and Holl, 2003; Seabloom et al., 2003; HilleRisLambers et al., 2010). Although livestock grazing may have contributed to the spread of invasive grasses and forbs, it can also be used to control these species and aid in the return of native species. Butterfly species, including the Bay checkerspot, have benefited from low intensity, managed grazing that reduces exotic grass cover and increases nectar and larval host plant cover (Weiss, 1999; Pöyry et al., 2005; Vogel et al., 2007; Thomas et al., 2010). Intensity and duration of livestock grazing, in relation to other factors determines the magnitude and type of impact grazing has on butterfly populations.

4.1.2. Extinction and cultivation intensity

Cultivation intensity and crop types varied across the study area. There was no clear association between cultivation intensity and extinction. Cultivation was localized and of low intensity from 1769 until the late 1800s. By 1930, the most intensively cultivated areas were coastal plains and river valleys with access to water for irrigating crops. Inland areas were used for dry farming barley and wheat. Extinct Quino checkerspot populations were located near irrigated orchards and crops, whereas extant populations near cultivation tended to be in dry farming regions.

4.1.3. Extinction and human population growth

Human population growth was associated with extinction; although, there was considerable variability. A number of extinctions occurred when the surrounding human population was relatively small. Human population was used as an indicator of urbanization driving habitat loss and fragmentation; we assumed that the larger the population the greater the area impacted by urban activities. This measure is an approximation of impacts and does not provide an actual overlay of converted land relative to butterfly populations. It also underestimates the impact of rural and semi-rural development. It is clear that urban development has fundamentally changed the southern California landscape and areas in which butterfly populations have gone extinct in Orange and San Diego counties currently support substantially higher levels of development compared with extant populations.

4.2. Historic distribution or range shift in response to changing climate?

Parmesan (1996) documented a northward and upward elevation shift in the overall range of Edith's checkerspot associated with changing climate. While habitat degradation and isolation could increase extinction rates, these factors were not thought to contribute to the latitudinal range shift in Edith's checkerspot. Quino checkerspot has not demonstrated a northward shift; rather, extant populations are occurring at higher elevations as predicted by climate change modeling (Parmesan, 1996; Preston et al., 2008). Quino checkerspot populations may have historically occurred, but were unrecorded, at higher elevations along their eastern range margin. High elevation populations are not unprecedented, as populations of Edith's checkerspot occur in the Sierra Nevada and San Bernardino Mountains (Thomas et al., 1996; Mattoni et al., 1997).

Alternatively, newly discovered populations may represent a range shift in response to changing climate, as these high elevation areas are buffered against drought compared with established areas within the historic distribution. Future climate projections for southern California predict temperatures will increase;

precipitation may decrease and is expected to be more variable, with longer, more severe droughts and more intense floods (Seager et al., 2007). The eastern edge of Quino checkerspot's range supports large and robust butterfly populations, abundant and diverse larval host plants and nectar sources, and relatively low levels of development and intensive agriculture. These areas may provide climate refugia that Quino checkerspot will require under future predicted scenarios of climate change (Preston et al., 2008).

5. Conclusion

Local-scale extinctions of Quino checkerspot butterfly populations in southern California were related to agricultural history, human population growth, and wildflower decline. The association of extreme precipitation with extinction was outweighed by the effects of land use. Butterfly population extinctions coincided with spatial and temporal patterns of habitat loss, high intensity grazing, invasion by exotic annual grasses, and wildflower decline. At a larger scale, differences within the distribution of extant Quino checkerspot populations were best predicted by climate variables. Higher elevation populations are buffered from drought. To develop conservation plans and management actions that result in successful long-term conservation of Quino checkerspot, it is important to recognize that multiple stressors operating at different scales influence population dynamics and changes in the butterfly's distribution.

Acknowledgements

Financial support was provided by the Center for Conservation Biology and Department of Entomology at the University of California, Riverside, the California State Department of Transportation, Waste Management, and the Shipley Skinner Reserve-Riverside County Endowment. The US Fish and Wildlife Service, Riverside County Regional Conservation Authority, and T. Scott supplied butterfly location data used in modeling. A. Anderson, E. Porter, and colleagues at the US Fish and Wildlife Service provided insight into historic and current butterfly distributions. R. Johnson, A. Hinojosa, C. Gonzalez-Abraham, and M. Davis provided Geographic Information Systems assistance. V. Rorive provided critical administrative support.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2012.03.011.

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May 22, 2015

Mr. Dennis Campbell
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5510 Overland Avenue, Suite 110
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Subject: Draft Environmental Impact Report, General Plan Amendment, and Specific Plan Amendment for Otay Ranch Village 13/Resort Village Impacts on the Federally Endangered Quino Checkerspot Butterfly.

Dear Mr. Campbell

Endangered Habitats League has asked that I review the proposed Otay Ranch Village 13/Resort Village project in its various alternative forms as described in the March 2015 draft Environmental Impact Report (DEIR), in light of any potential impacts that it (they) may have on the resident population of federally endangered Quino Checkerspot Butterfly (Quino) on the project site. I am a known biologist with some depth of understanding in the biology, ecology, and conservation of this endangered species (Appendix). To this end, I will begin by providing my overall prognosis of implications for Quino with this project and evidence supporting my prognosis including detailed explanation of mechanisms of impact and illustration of example populations extirpated in the wake of similar developments. Although briefed in my introductory comments, a detailed description of Quino biology and ecology will be provided in the appendix as foundational material.

After reviewing the DEIR, I have quickly and easily come to the conclusion that this project is not compatible with Quino conservation. Although I can't go so far to say that this development would, by itself, cause the global extinction of Quino, it would certainly significantly contribute to that end. Even with Alternative G, it's apparently minimal development footprint gives me concern. It is my understanding that a regulatory agency was willing to accept this proposed development in some incarnation on condition that mitigation in the form of habitat restoration or management was, or a County-wide conservation plan were assured. Even though I may consider weed control and habitat management measures as somewhat beneficial to Quino, I do not have any confidence that these measures have proven successful in the context of long-term Quino conservation, or that they are guaranteed success in perpetuity (due to unproven results with both this and previous projects, to limited funding, and to short-term attention span in the wake of a project's mitigation measures). An endorsement of the development even *with* such assurances as a County-wide plan are short-sighted. I observe that wildlife agencies are often too willing to opt for weed control, habitat "restoration", research endowments, and other similar make-work measures rather than the fundamental acquisition and protection of land.

It is my expectation, based on the facts below, that substantial development (as proposed) at this venue will cause the decline and extirpation of Quino in the larger surrounding landscape. There are other examples of this process that can now be compared to the proposed project – where major Quino population complexes (large sites or areas that consistently and reliably supported Quino in large

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numbers) – stopped supporting Quino (extirpations) *without* most of the actual land being developed. Areas previously supporting substantial Quino populations that were either surrounded by development or had extensive developments in close proximity or adjacent (Quino subsequently stopped on these areas) include the Warm Springs Creek and Murrieta Hogbacks area, Johnson Ranch, and possibly the Gavilan Hills in Riverside County. In the immediate vicinity of Otay Lake, these examples include Dictionary Hill (surrounded) and Otay Mesa (apparently too much scattered development and the various habitat restoration attempts for Quino have never produced Quino activity).

Like all butterflies, the basic biology of Quino is simple: adult butterflies lay eggs on their foodplants. The eggs hatch into caterpillars which grow and eventually pupate (to the chrysalis), and later hatch out as adult butterflies - but the similarities and simplicities end there. The complexities begin where the chosen foodplant dries up before the larvae can complete their development and where larvae that survive the late spring senescence of foodplants have evolved to enter into an obligatory dormant state, the diapause, for the summer and fall. The key foodplant for Quino at lower elevations of southern California, probably including the project site, is the ephemeral springtime annual plant, *Plantago erecta*. Ecological complexity and fragility are further driven by the fact that the persistence and availability of *P. erecta* for Quino larvae varies according to many microenvironmental factors – involving soils, biological soil crusts, shrub cover, slope and degree of solar insolation, just to name a few - which affect the longevity of the foodplants and mortality, by starvation, of butterfly larvae. Additional complexity comes to play in the site specific distribution of foodplant patches in the environment and their variable response over the year-to-year and decade-to-decade fluctuation in annual rainfall. In dry years, foodplants senesce earlier than normal, and though larvae may remain in diapause for more than one year, butterfly populations decline for a time. These factors finally impose the ultimate complexity, and simultaneously compound ecological fragility, as regional Quino populations persist only by virtue of a metapopulation structure and dynamic by which habitat patches provide variable and mutual support to the population, as a whole, over ecological time. Adult butterfly dispersal to new habitat patches, and specialized mating strategies intimately keyed to geographic features such as hilltops and ridgelines, are imposed by this precarious population structure and the tension between survival and extinction. What some may portray as simple, land-proportional, cumulative impacts of development on and adjacent to these population sites, are actually impacts greatly compounded and leveraged by their multitudinous domino effects on Quino metapopulation structure and metapopulation resources. Loss of a habitat patch here or a hilltop there, indirectly affects the fate of Quino on surrounding lands, and then, indirectly in turn on a regional basis. Whether, and at exactly what point the loss surpasses an extinction threshold for the metapopulation remains unknown but these thresholds have apparently been surpassed time and time again both before and after the federal listing of Quino as endangered, and these thresholds must vary from population to population, as each metapopulation is tied to its unique local geographical, topographical, geological and soil, microclimate, and biological conditions.

Interpreting survey results:

Butterfly surveys provide only a minimal understanding of distribution, abundance, and ecological integrity of a population. Even with the focus of such surveys, the Quino studies are designed merely to determine presence (or absence) by looking only for adult butterflies, and so biologists visit a site only once a week and cover nearly a hundred acres per biologist in a day. The biologists conducting these surveys are neither permitted (nor really capable) to survey for larvae (they are supposed to be able to identify a larva if they happen to come upon one) and even if they were competent to survey larvae, a thorough understanding of local distribution in any given season (such as Osborne 1998) could not be obtained. Clearly, a more accurate representation of butterfly distribution and habitat use on a site would be obtained by one biologist on every acre, every day, for the length of a season, for every season over the course of decades. Hostplants are not the focus of surveys and so (supposedly mapped as they are encountered – often with this mapping exercise detracting from time spent in the real objective of adult butterfly survey), though portrayed or interpreted in biological reports such as those used to evaluate impacts of the proposed project, the distributions and extents of hostplant presence is rather more a token representation of what might really be present on a site. With these considerations in mind, an interpretation of the biological reporting leads me to the conclusion that Quino effectively uses the entire site over the course of ecological time, even though local concentrations may shift from place to place across the site. Obviously some portions of the site are used considerably less (if at all) than others according to local presence of Quino resources such as hostplants, nectar flowers, hilltops, etc.

With respect to the Proposed Project Site:

Survey results show that the Proposed Project Site is occupied by Quino. This site is situated in a larger context with what was once a more broadly distributed metapopulation. Six miles to the northwest, Dictionary Hill (earlier discussed in light of its extirpation); four to five miles to the southwest Otay Mesa (also previously discussed); and within two to three miles to the northwest the Proctor Valley (western portions now developed) and ridgelines on southern portions of Miguel Mountain area (now much encroached by urban development) where Quino was still abundant in the 1980's, were all within easy dispersal distance to and from these hills north of Otay Reservoir. They were all part of the larger regional Quino metapopulation. Currently, a significant complex of Quino populations occurs in a rough arch extending from the Mexican border on the hills just east of the Otay Mesa, north up through the proposed project area (DEIR) and continuing north into the hills just south of Jamacha and northwest through Miguel Mountain up to the Jamacha area. The Otay Reservoir likely provides a soft buffer separating extensive developments to the west and the natural habitats supporting Quino north and east of the reservoir. This is all part of a larger metapopulation complex which extends farther east to such places as Marron Valley (Longcore et al. 2003, USFWS 2000).

Decades ago, Quino populations in these areas on the whole must have been broadly intertwined and interacting with Quino populations on a larger scale that spanned across the San Diego Basin. Quino populations in the San Diego region were declining in the face of urban expansion through the 1960's (Thorne 1070) but remained into the early 1980's around undeveloped rural sectors on the perimeter of San Diego, such as at Otay Mesa, Dictionary Hill where it had been for decades (Shields 1967), and western portions of Proctor Valley, as well as areas farther east. Eventually surrounded by development, although not developed itself, the Dictionary Hill site inevitably lost its Quino population. After Quino received federal protection, biological surveys for areas with negative results for Quino have been subject to development even though subject lands often represented suitable habitat likely part of the Quino metapopulation resource base (*ie* with hostplants, hilltops, nectar resources, open lands suitable for adult dispersal, etc.). As exemplified by my comments regarding such results on a site in Riverside County (Osborne 2004), "The series of QCB population sites around the Murrieta Hogbacks may have represented a robust, semiautonomous metapopulation unit, hierarchically nested within the broader regional metapopulation described above. Extensive, widespread, high density residential and commercial developments facing imminent approval across this region will likely permanently disrupt

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the extant QCB metapopulation structure and dynamic in this Hogbacks metapopulation unit". Although the subject lands (Hogbacks area) were likely subject to use by Quino over the course of ecological time (years), the butterfly was not found there *that* particular year in which the survey was undertaken. So, with the limited protections for suitable *habitat*, study by study, project by project, Quino metapopulations have been relentlessly eroded through much of its range.

The Quino population around the Murrieta Hogbacks in Riverside County was similar to the population on the Proposed Project site, and so it is instructive: It was similar in that *Plantago erecta* was widespread on open soils derived from volcanic geology. It was similar in that the population had survived with *some* development in the general vicinity (see figures in the appendix), and it was similar in that it was broadly connected with other Quino population sites located farther east, with open, undeveloped lands intervening. One of the important components of this site was known as the Hunter Road site, important for its large numbers of observed larval and adult Quino associated with especially dense stands of *Plantago erecta* – again, very similar to the Proposed site (Otay SRP DEIR). A partial development of the site was authorized and realized while remaining portions were set aside and managed for conservation of Quino. Other small developments and associated set aside conservation lands were acquired in the area, and over the years, additional residential developments expanded through the open areas outside of conservation lands. The result has been that Quino has failed throughout all of the Hogbacks metapopulation area, and is not likely to be reestablished by dispersing founders from other population sites due to the distances and extents of intervening urban developments involved. Blocks of habitat were lost here and there, blocks of open land through which the butterflies could disperse, but one cannot identify the precise final cause of the population collapse. We will never know exactly what was the last straw. However, it was a failure that I predicted a decade earlier (Osborne 2004). With a more recent analysis, proximity to urban population centers and growth is strongly correlated with Quino extinction events (Preston, *et al* 2012).

Evidently (per continued Quino Presence north of Otay Reservoir) the expanded development along with the extirpations and declines of Quino in these other adjacent areas has not yet been sufficient to cause the collapse of Quino on the hills north of Otay Reservoir. As it stands now, some fifteen years after the listing of Quino as an endangered species, this rather extensive population site on the hills north of Otay Reservoir, represents an increasingly rare phenomenon – an endangered relict – a functioning Quino population not yet knocked out by developments on its western flanks and still continuously linked with other habitats located farther to the east, north and south.

The proximal impacts of the Proposed Project would include loss of habitat values such as hilltops and ridgelines important to mating success (Shields 1967, USFWS 2000), nectar sources (Minnich 2008), larval hosts and the special site specific soil conditions which support them (Osborne 2014), shrub cover (Osborne and Redak 2000, Pratt & Emmel, 2010), and open space conducive of adult dispersal due to direct conversion of habitat to "developed" uses. In addition, invasion by exotic species, trampling of larvae by livestock, humans and domestic (or feral) pets, increased fire frequency, increased exogenous inputs of Nitrogen (Weiss 1999), and recreational activities (Preston, *et al* 2012) are indirectly promoted in proximity do development, and will serve to eliminate Quino in adjacent and nearby locations. The resultant local impacts, when they cause declines in Quino, are compounded by their dynamic effect on metapopulation function over a much broader area extending beyond the project limits.

Returning to the example failure of Quino at the Murrieta Hogbacks in Riverside County, as it compares to the proposed Village 13 project on the Otay Ranch, the conditions parallel each other specifically with respect to acreage of occupied Quino habitat involved. The Hogbacks Quino distribution covered some 2500 acres by the time Quino was listed in 1997. The Proposed project site – currently supporting

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a Quino population - covers some 1869 acres. Since federal listing of Quino, approximately 400 acres were developed to residential use on the southeastern portion of the Quino population distribution including development of areas with known Quino occurrences (see attached maps). An additional approximately 200 acres were developed to residential on the western portion of this distribution (since listing), as well as other smaller developments on the northern portions, including a high school. Developed portions of the Hogbacks area covered some 600 to 700 acres. This 700 acre impact at Hogbacks may be compared to the proposed 771 acres of proposed Village 13development (including 1,881 single-family residences, mixed uses, parklands, public safety facility, elementary school, a resort, manufactured slopes, and associated roadways). The Hogbacks, "Core 2:" Conservation area realized the protection of numerous important topographic features, including the main ridgeline of the Hogbacks (southern portions of which remain undeveloped), ridgelines and peaks west of the Hogbacks (attached map), and numerous hilltops southwest of the Hogbacks. In spite of this protected open space, the Quino population failed. Similarly, the proposed Village 13 project would protect some 1089 acres of Quno habitat with its ridgelines and peaks. Currently, the undeveloped land (both protected and not) over the failed Quino population area at the Hogbacks covers more than 2000 acres (and additional substantial open lands continue toward the north in this area). The Quino population at the Hogbacks population relied on an extensive, patchy distribution of *Plantago erecta* stands of highly variable densities – just as does the Quino population of the Otay Ranch, and proposed development for the Village 13 project will impact a portion of those *Plantago* stands just as developments at Hogbacks did after 1997. Lands south of Hunter Road at the southeastern portion of the Hogbacks Quino distribution likely previously represented a substantial additional portion of this Quino population area in the 1970's prior to the development of that area, just as lands to the west, northwest and southwest of the Otay Ranch previously represented a substantial additional portion of that Quino population area, including Dictionary Hill, in the 1970's prior to the development of those areas. In all of these ways then, the nature and extent the failed Quino population experience at the Hogbacks appears to closely parallel the nature and extent of impacts that would be experienced due to a Village 13 development north of Otay Reservoir.

Clearly the north of Otay Lake population is a core population that cannot be lost. The health and function of the regional Otay Mountain metapopulation relies significantly on the continued existence of the core population component present on the Village 13 site. There is no evidence that the surrounding lands on the periphery of this core could continue to support the Otay Mountain metapopulation if that portion of the population that is now functional on the Village 13 site is lost. If the DEIR chooses to rely upon lands surrounding Village 13 outside of the immediate project area, it would have to demonstrate one or more sufficient core "source" populations on these lands, yet it has not done so. No substantial information exists as to role and viability of redundant core population(s) in the area if the project site population is lost. Rather, it must be assumed that the known, robust population documented on site is essential to the health, function, and persistence of the Otay Mountain metapopulation.

In conclusion, collapse of the Otay population is likely and predictable, and no mitigation has been offered. No project alternative, except perhaps a better-configured Alternative G, poses a better scenario, as all involve substantial loss of core resources.

Some ecologists are, for lack of a better word – enthralled - with the concept of climate change and its implications for Quino. One argument would be that Quino will adapt and rapidly shift its distribution to higher elevations where it will become more and more reliant on the hosplants predominantly used in higher elevations, and that such forecasts might diminish the perceived long-term value of the lower elevation Quino population complexes, such as that now present on the proposed Project site. While

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climate change is well documented on the time scale of the last ten thousand years, is likely continuing, and has profound long-term implications both for humanity and ecology, the findings as they relate specifically to Quino are more problematic and overreaching. The Parmesan (1996) conclusion of a northward range shift (across western North America) in *Euphydryas editha*, relied statistically on negative findings (failure to find Quino) on several population sites in southern California in the years following extreme drought. Her conclusions have been soundly invalidated in light of recent discoveries: 1) of multiple year larval diapause (Pratt and Emmel 2010) confounding the use of negative results, 2) discovery of Quino ranging so far south of what was previously documented into Baja California Norte, Mexico, as to represent a ten percent *southward* expansion in known range (Wikle pers com 2013) confounding the Parmesan proposition that her study covered the entire butterfly range ,and 3) revelations about required efforts in conducting presence-absence surveys (USFWS 1999, 2014). Similarly, the recent suggestions that the newly discovered populations in the historically more remote, inaccessible, and under collected, higher elevation portions of southern California represent a recent climate-change-induced range shift for Quino (Preston 2014, Parmesan *et al*. 2014), fail to fully appreciate the profound bias structured into the historic *specimen* versus present environmental compliance *survey data* collection imperatives. Since the late 1990's listing of Quino and the advent of extensive survey efforts on undeveloped lands, often in remote areas, many Quino population localities have been located in a broad region of higher elevations and farther east than historically known (for Quino) both in Riverside and San Diego Counties. These new (since Quino federal listing in 1997) distribution records, funded by the many and varied public and private project proponents, far exceed the efforts exerted historically, over many decades past, by butterfly collectors, who once drove fifteen minutes out of San Diego, Laguna Beach, Riverside, and Anaheim to collect specimens of Quino. In any case, the coastal Quino metapopulation centered on Otay Mountain and the Village 13 site are critical to the species' genetic diversity and more eastern, montane populations with different ecology and hostplants are in no sense a substitute. Loss of the Otay population would clearly drive the species toward global extinction.

General Background on Quino Checkerspot Butterfly:

The Quino Checkerspot Butterfly (*Euphydryas editha*), also known as Edith's Checkerspot, is a small brush-footed butterfly (family Nymphalidae) that flies once a year. Like most *Euphydryas* sp., it has a small, approximately 2.5 to 4 cm wingspan and is checkered with black, red, and yellowish markings. This species is distributed in local colonies over much of western North America (Scott 1986, Parmesan 1996). Many subspecies have been described including 18 from California (Garth and Tilden 1986, Emmel et al. 1998).

QCB colonies are primarily associated with low elevation (sea level to 3,000 feet) open grasslands, vernal pools, and sunny openings within chaparral, coastal-sage scrub, and juniper woodlands. Colonies are found frequently near clay soils that possess cryptogamic crusts (crusts that are formed by the association of algae, mosses and fungi upon the surface of the soil). QCB distributions closely approximate the distributions of the primary larval host plant, *Plantago erecta* (dot-seed plantain, also known as dwarf plantain, family Plantaginaceae). Recently discovered, higher elevation Quino populations in chaparral habitats have been found to use various other hostplants (Pratt *et al* 2001 and Pratt & Pierce 2010) including *Plantago patigonica*, *Antirrhinum coulterianum*, *Collinsia concolor*, and *Cordylanthus rigidus*. Although *E. editha* are oligophagous (feed upon a limited range of plant species) and feed primarily upon plants contained within the Scrophulariaceae, Plantaginaceae, and Orobanchaceae, local populations tend to be monophagous (feed on only one plant species) (White 1974, Scott 1986).

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QCB mating activity occurs in or near the meadows, clearings, open areas on slopes and ridgelines inhabited by the host plants, where the larvae previously developed, and on open or sparsely vegetated hilltops, ridgelines, and occasionally rocky hilltops (with or without the host plant being present nearby). Inordinately large numbers of adult males are found on hilltops (usually only one or two per hilltop), where they exhibit "territorial behavior" – flying sorties from various perches to chase other butterflies, including conspecifics. QCB males often chase each other high into the air, only to return to different parts of the hilltop. Hill-topping, where male butterflies await the arrival of unmated females in order to secure mates, is common in many species of butterflies and the behavior in QCB is well known among experienced southern California lepidopterists and was well documented by Shields (1967) in a study of Dictionary Hill. When QCB adult densities are relatively low, mating success derived from facultative hilltoping behavior may be critical to long term population viability.

Females lay egg masses that contain approximately 20-75 eggs and may produce up to 1,200 eggs in several batches during their lifetime. The eggs hatch in about ten days under favorable conditions and the larvae immediately begin to feed. In coastal California, the early larval stages undergo an obligatory aestival diapause (dormant period from late spring through winter), which is broken after fall or winter rains (Murphy and White 1984, Osborne 1998). The larvae then quickly complete their development, usually on the native annual plant *Plantago erecta*, and emerge as adults during the same spring (Emmel and Emmel 1973, White 1974, Orsak 1977, Murphy and White 1984, Mattoni et al. 1997). Adult flight typically occurs between late January and mid-May, with peak activity generally in March and April. The flight period varies from year to year, depending upon the annual rainfall and other weather conditions. The timing and abundance of rainfall are important factors affecting the timing of host seed germination, growth, maturity and senescence of the host plant (Murphy and White 1984, Dobkin et al. 1987), which in turn affects the survivorship of the larvae (Singer 1972, Ehrlich et al. 1980). Solar insolation on hillsides (determined in part by topography), where the larvae live, affects both the rate of host development and that of the larvae (White 1974, Weiss et al. 1988). In the race against host senescence, post-diapause larvae seek microclimates with high solar insolation in order to bask (Osborne 1998, Osborne and Redak 1999). This behavior increases their rate of development (Weiss et al. 1987). During periods of extended drought, the butterfly's populations decline and individual butterflies may become difficult to find. Larvae are capable of multiple year diapause, enabling survival through periods of extended drought (Pratt & Emmel, 2010). It is hypothesized that extended periods of diapause, lasting up to five or six years, may occur during these droughts (based on rearing observations by Ballmer, Pratt and J. Emmel).

Populations of *Euphydryas editha quino*, which were once distributed through much of lowland coastal southern California from northern Baja California, Mexico to Point Dume, Los Angeles County, have been declining since the late 1960's (Thorne 1970, Emmel and Emmel 1973, Orsak 1977, 1988). It has been hypothesized that this decline is primarily due to habitat loss by urban and agricultural expansion (Thorne 1970, Emmel and Emmel 1973, Orsak 1988), and possibly because of global warming and drought (Parmeasan 1996, but the Parmeasan findings are invalid), fire and overgrazing (Orsak 1977, but see Orsak 1988). After an extended drought in the late 1980's and early 1990's, only one *known* population of QCB remained (at Oak Mountain in Riverside County). Populations are now known to exist only at a few sites, in small isolated colonies, in southwestern Riverside and southern San Diego Counties. The decline of QCB may have started long before these modern observations after the early Spanish explorers and settlers introduced exotic grasses and forbs. These plants are highly competitive with the native QCB host plants (Proctor and Woodwell 1975).

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These comments and Notes are Respectfully Submitted,

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10

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Education

University of California, Riverside, Department of Entomology, M.S. Entomology, 1998. Thesis research on arthropod community structure of Southern Californian Coastal Sage Scrub.

University of California, Berkeley, Department of Entomology, B.S. Entomology, 1985.

Experience/Employment

1985 Lab Assistant [for S. Welter, Univ. of California, Berkeley]

1985-1987 Academic Specialist [for W. W. Allen, Univ. of California, Berkeley]

1987-1990 Research Entomologist for Driscoll Strawberry Assoc. Inc. Watsonville, CA

1990-1991 Lab Assistant [for D. Letourneau, Univ. of California, Santa Cruz]

1991 Lab instructor for Entomology course, Univ. of California, Santa Cruz.

1992-1994 Teaching (High School, Middle School) Santa Cruz Co. School District.

1995-1997 Lab Assistant [for R. Redak, Univ. of California, Riverside]

1998 Staff Research Assistant [for H. Costa, Univ. of California, Riverside]

1997- 2015 Independent biological consulting (DBA Osborne Biological Consulting).

PUBLICATIONS

Osborne, K. H. 1998. A description of arthropod community structure in southern Californian Coastal Sage Scrub. Masters Thesis, Univ. California, Riverside, CA.

Refereed

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Naval Weapons Station Seal Beach and Naval Facilities Engineering Command Southwest, San Diego, California.

Tetra Tech, Inc. (Osborne Biological Consulting contributing Entomological Evaluations) 2013: Wetland Restoration Monitoring Report 2013, Naval Base Ventura County Point Mugu, California. Prepared for Naval Base Ventura County and Naval Facilities Engineering Command Southwest, San Diego, California. February.

Osborne Biological Consulting and AMEC Environment and Infrastructure Inc. 2013. Habitat Assessment and Focused Adult Survey for Quino Checkerspot Butterfly (*Euphyeryas editha quino*) on the Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County, California. Submitted to Naval Weapons Station Seal Beach Fallbrook Detachment and Naval Facilities Engineering Command Southwest, San Diego, California.

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Osborne Biological Consulting and ICF International. 2014. An Entomological Investigation of the Coronado Beach Naval Base, San Diego County, California. 201. Unpublished report submitted to Coronado Beach Naval Base and Naval Facilities Engineering Command Southwest, San Diego, California.

Osborne Biological Consulting and AMEC Environment and Infrastructure Inc. In Progress. Habitat Assessment and Focused Adult Survey for Harbison's Dun Skipper Butterfly (*Euphys vestris harbisoni*) on the Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County, California. Submitted to Naval Weapons Station Seal Beach Fallbrook Detachment and Naval Facilities Engineering Command Southwest, San Diego, California.

Osborne Biological Consulting and AMEC Environment and Infrastructure Inc. In Progress. Monitoring for Gold-spotted Oak Borer (*Agrilus auroguttatus*) on the Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County, California. Submitted to Naval Weapons Station Seal Beach Fallbrook Detachment and Naval Facilities Engineering Command Southwest, San Diego, California.

Tetra Tech, Inc. (Osborne Biological Consulting contributing Entomological Evaluations, Year 2014 In progress) Wetland Restoration Monitoring Report 2014, Naval Base Ventura County Point Mugu, California. Prepared for Naval Base Ventura County and Naval Facilities Engineering Command Southwest, San Diego, California.

Osborne Biological Consulting and HDR Inc. (In Progress). Naval Base Ventura County San Nicolas Island, California: Biosecurity Monitoring: General Entomology and Biosecurity Recommendations. Naval Base Ventura County and Naval Facilities Engineering Command Southwest, San Diego, California.

Reviews

Contributing Reviewer, C. G. Thelander and M. Crabtree eds. 1994. Life on the edge: a Guide to California's Endangered Natural Resources: wildlife.

Contributions and Independent Scientific Review, U. S. Fish and Wildlife Service. 2003. Recovery Plan for the Quino Checkerspot Butterfly (*Euphydryas editha quino*). Portland, Oregon. X + 179 pp.

Contributions and Independent Scientific Review, U. S. Fish and Wildlife Service. 2005. Recovery Plan for the Laguna Mountains Skipper (*Pyrgus ruralis lagunae*). Portland, Oregon.

Requested Scientific Review, U. S. Fish and Wildlife Service. 2006. Proposal to Designate Critical Habitat for the Laguna Mountains Skipper; Federal Register/Vol. 70, No. 238/ December 2005

Presentations

2014. Biology, Ecology, and Conservation of the *Euproserpinus* (Sphingidae) moths. The Wildlife Society, San Joaquin Valley Chapter Natural Communities Conference, Bakersfield, CA. March 27.

2014. Idiosyncratic Ecological, Biological, and Behavioral Aspects of the Quino Checkerspot (*Euphydryas editha quino*) Adapted to Diverse Environmental and Climatological Conditions within its Southern Range. Edith's Checkerspot Workshop. Alviso, CA. January 28. Sponsored by Center for Natural Lands Management, Creekside Science, Xerces Society, U. S. Fish and Wildlife Service, and others.

2011 Discovering the Biology of two "rare" *Schinia* (Noctuidae) from the American southwest. Annual meeting, Pacific Branch, The Lepidopterists' Society. Prescott, AZ

2009 On Continuing Researches into the Biology and Ecology of *Euproserpinus*. Annual meeting, Pacific Branch, The Lepidopterists' Society. Taft, CA

2007 Field Investigation of Hostplant Selection by Ovipositing *Pyrgus ruralis lagunae*, Captive Rearing and Propagation of nominate *P. ruralis*, and Hostplant Propagation. Laguna Mt. Skipper Workshop, U. S. Fish and Wildlife Service, Carlsbad, CA, March.

2006 New Resident Status of the Subtropical Butterfly *Phoebis agarithe* (Boisduval) in the lower Colorado Desert of Southern California. Annual meeting, Pacific Branch of the Lepidopterists' Society. Eframe, UT, July.

2004 Lepidoptera of Southern California – Threatened and Endangered, Potential Candidates. Lorquin Entomological Society, Los Angeles Museum of Natural History, June.

2000 Biology and Behavior of *Euproserpinus phaeton* (Sphingidae): Peculiar habits and Mass Rearing Methods with Relevance to Conservation of Endangered *E. euterpe*. Annual meeting, Pacific Branch, The Lepidopterists' Society. Ashland, OR

1999 Biology and Ecology of *Euphydryas editha quino*. Lecture given as part of a workshop on endangered Quino Checkerspot, at University of California, Riverside. December.

1998 Biology and Ecology of *Euphydryas editha quino*. Lecture given as part of a workshop on endangered Quino Checkerspot, at University of California, Riverside 12 December.

1997 Arthropod communities of two shrub species and the grass-forb understory in Southern Californian Coastal Sage Scrub. Departmental Seminal, Department of Entomology, University of California, Riverside, 27 October.

1997 Ecology of *Euphydryas editha quino*. Lecture given on behalf of "Friends of the U. C. R. Entomology Museum" at U.S. Fish and Wildlife Service field office, Carlsbad, CA. 10 December.

1997 Shrub stand composition effects on an arthropod community. Annual meeting, Ecological Society of America. Albuquerque, NM, 10 August.

1997 Arthropod communities on two dominant shrub species in Southern California Coastal Sage. Annual meeting, Pacific Branch, Entomological Society of America. San Jose, CA

1996 Plant community effects on larval densities of *Euphydryas editha quino*. Annual meeting, Pacific Branch, Entomological Society of America. Big Sky, MT, 24 June.

1996 Plant community effects on larval densities of *Euphydryas editha quino*. Annual meeting, Entomological Society of America. Louisville, KY, 9 December.

1995 Biology of *Euproserpinus, Proserpinus, and Arctonotus* – three closely related oddballs. Annual meeting, Pacific Branch, Lepidopterists' Society. Berkeley, CA, 24 June.

Service

2006 President, Lorquin Entomological Society, Los Angeles

2006 - 2007 President, Friends of the U. C. Riverside Entomology Research Museum

2005 - 2006 Vice President, Friends of the U. C. Riverside Entomology Research Museum

2004 - 2015 Vice President, Tri-County Conservation League

Awards

1995 Comstock Award for student presentation. Annual meeting, Pacific Branch, Lepidopterists Soc. of America, Berkeley, CA. June.

1996 Student presentation competition Entomological Soc. of America, Pacific Branch Meetings, Big Sky, Mont. 24 June.

1996 1st place, Linnaean Games, Entomological Soc. of America, Pacific Branch

Meetings, Big Sky, Mont. 24 June.

1996 2nd place, Linnaean Games, Annual meeting, Entomological Soc. of America, Louisville, KY. 9 December.

1997 1st place, Linnaean Games, Entomological Soc. of America, Pacific Branch, San Jose, CA. 24 June.

1997 2nd place, Student talks competition, annual student seminar day, Department of Entomology, University of California, Riverside, CA. 17 September.

Legal Declarations

Osborne K. H. 2011. Retained by SDG&E as an expert authority on the Quino Checkerspot Butterfly, working with LATHAM & WATKINS LLP on behalf of the SDG&E Sunrise Project. Prepared legal depositions and Declaration is support of SDG&E's opposition to a Motion for Preliminary Injunction (filed by conservation groups) CASE NO. 3:10-CV-001222-AJBBGS). Prepared Declaration, an ensuing Rebuttal Declaration (filed with the United States District Court, San Diego), and an additional Declaration as this matter was appealed to the 9th Circuit Court (No. 11-56121). My arguments and rebuttals consistently prevailed against those of Quino biologists retained by the plaintiffs.

Osborne, K. H. and G. R. Ballmer. 2014. A Petition to the United States Department of the Interior, Fish and Wildlife Service, for emergency action to list an endangered species pursuant to the conditions and regulations of the Federal Endangered Species Act: For the San Joaquin Valley Giant Flower-loving Fly (*Rhaphiomidas trochilus*). Submitted June, 2014.

References

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Personal Information

On behalf of private clients, conservation groups and resource agencies, I (as Osborne Biological Consulting) conduct general arthropod inventories; focused surveys, evaluations and assessments of habitat potential for all threatened and endangered insect species, undertake comprehensive arthropod inventories and diversity studies, provide consultations and advise on a variety of insect pest and nuisance problems. Accordingly, I have prepared, and continue to prepare dozens of technical reports on surveys, habitat assessments, biological opinions, restoration and mitigation plans, and habitat conservation plans dealing with a wide range of threatened, endangered and sensitive species. I do additional habitat evaluations and surveys for rare and narrow endemic plant species, and for other various sensitive wildlife species.

After more than forty-eight years with an avid interest in insects of California, I have an intimate familiarity with much of our fauna. My experience, (largely through collecting, rearing, and captive propagation) has been focused on California from 1964 to present. Through the 1980's and 90's, emphasized the employment, development, and improvement of diverse insect sampling methods for use in agricultural and wild land environments, and analysis of samples obtained from various trapping methods. In recent years, these methods have been and are being used in the undertaking of total arthropod inventories on various public and quasi public lands.

Since 1964, and on an annual basis, have reared and/or captive bread, dozens or hundreds of species of butterflies and moths (including many Lycaenidae, Riodinidae, Hesperiidae, Pieridae, Nymphalidae, Heliconiidae, Papilionidae, Noctuiidae, Lasiocampidae, Shphingidae, Saturniidae, Microlepidoptera) of the United States. For many years, my interest has been focused on lepidoptera, but generally includes all insects. Graduate studies involved sampling and sorting to species some twenty thousand arthropods from one ecological community.

My fifty years experience with Californian lepidoptera allows me to identify butterfly species in the field at a glance and easily recognize the habitats, and terrain peculiar to many species. I am intimately familiar with most described species of butterflies in the state, including their biology, having spent most of my life exploring California counties, often logging in excess of 80, 000 travel miles per year. I have assembled and maintain a collection of over 50,000 specimens of macrolepidoptera, specializing in butterflies, and moth families Noctuiidae, Arctiidae, Notodontidae, Lasiocampidae, Sphingidae, and Saturniidae. My collection has resulted in many county and state records. For several years, I have participated in annual "4th of July butterfly counts" at Big Creek, Monterey Co.: Berkeley; Mount Diablo, Contra Costa Co.; and Big Bear, San Bernardino Co.

I am currently certified and permitted by the USFWS (TE-837760-8) to survey for all endangered insect species of southern California (Quino checkerspot butterfly, El Segundo blue butterfly, Palos Verdes blue butterfly, and Laguna Mountains skipper, Delhi Sands Flower-loving fly, and Kern Primrose Sphinx moth [KPSM]); and for northern California permitted for work on the federally endangered Lange's Metalmark butterfly. I am a major contributor to the Quino Checkerspot Recovery Plan (QCB), and for several years, contracted with the USFWS to monitor reference populations of QCB, and conduct extensive surveys for endangered Laguna Mountain Skipper in San Diego County. 35 years experience observing, collecting, rearing, and researching *Euphydryas editha* from populations representing a large number of subspecies and localities, including the endangered QCB and Bay Checkerspot. I am the only individual to have conducted and published any quantitative field research on habitat use and characteristics for QCB. I have several years of contracted field surveys and studies on the Laguna Mountains Skipper, including investigation of methods for captive propagation of related *Pyrgus ruralis* in northern California (undertaken for the U. S. Forest Service and U. S. Fish and Wildlife Service). I am a major contributor to the Laguna Mountains Skipper Recovery Plan. I am currently investigating the biology, ecology, and parasitology of the federally threatened KPSM; here, making the first rearing to adult with documentation of various aspects of larval motility, hostplant selection, pupation depth and development, adult eclosion, and mate attraction via pheromone. In addition, I have undertaken laboratory investigations of the molecular phylogeny of the sphingids *Euproserpinus* (including federally threatened KPSM populations), and related genera. I have undertaken the first successful rearing of larval Giant Flower Loving Fly (a genus which includes endangered Delhi Sands Flower-loving fly), discovering the feeding habits in the process.

Traditionally, USFWS considered any land within the known range of Delhi Sands Flower-loving Fly (DSF) to have been mapped with Delhi Sands soils, as subject to formal survey for the DSF. Thus, my additional qualifications in this regard include thirty years experience with, research, and discoveries, in *Rhaphiomidas*, life history, biology, and ecology, such that I am now a leading expert in this narrow field of study. These qualifications are provided with more detail below as support for DSF habitat assessments I make on a grading system I developed (which is accepted by the USFWS).

My interest in the Giant flower-loving flies (*Rhaphiomidas*) is ongoing now for some thirty years, and for the last two decades I have focused research efforts on the biology and ecology of these dune inhabiting flies, with special attention to the Delhi sands flower-loving fly (DSF). I have been observing DSF in the field for over ten years, paying particular attention to DSF adult habits, including mating behavior. Extensive field observations of adult behavior for several other *Rhaphiomidas* species has further augmented and refined my understanding of *Rhaphiomidas* biology, ecology and habitat requirements. Until very recently, nothing was known of the larval biology for any species *Rhaphiomidas* (aside from their existence under the soil surface, and the adult female deposition of eggs a few centimeters under the soil surface). Colleagues (including Ballmer and Van Dam) and I recently recovered several live larvae of *R. trochilus* – for the first time demonstrating the great depth (up to two meters) at which the larvae dwell, their association with particular moisture horizons in the dune sands, and their gross morphology (fully grown larvae of *Rhaphiomidas* had not been previously documented for any species). While Ballmer and I are undertaking formal morphological studies of larvae, and M. Van Dam pursues systematics research using molecular/DNA methods (which confirmed the identity of our larvae as *Rhaphiomidas*), I have undertaken the task of making live observations, and in so doing, became the first and only biologist to document the feeding behavior of the larvae, their indeterminant development, the high motility of larvae through the soil column, and soil conditions precluding normal motility. Pupation biology, also long unknown, was finally elucidated when I undertook field studies on *R. acton* in the Mojave desert, demonstrating that it is the larva that migrates to the soil surface to pupate and then await impending emergence as an adult (larva themselves not pupating at depth and migrating to surface as a pupa as previously hypothesized). I am also the only biologist to excavate live *Rhaphiomidas* pupae in the field and achieve successful adult emergence in the laboratory. Ballmer and I have developed a DSF habitat rating system recognized by the USFWS.

Public Service

I have for a number of years, co-taught several workshops on the biology, ecology, and identification of QCB for consulting biologists. These workshops have been the source for the bulk of QCB understanding by many current consulting biologists. On behalf of conservation groups such as Endangered Habitats League and Center for Biodiversity, I have made critical review and suggestions for improvement of the Riverside County Multi-Species Habitat Conservation Plan, and frequently give critical review of Environmental Impact Reports and Habitat Conservation Plans.

CV for Gregory R. Ballmer

Born 21 August 1945, Toledo, Ohio, USA
Higher Education:
Bachelor of Science in Entomology 1967 - UC Riverside
Master of Science in Entomology 1973 - UC Riverside

Professional:
November 1967 - November 1970: US Peace Corps Volunteer/Entomologist in Thailand National Malaria Eradication Project
Sept. 1971-Sept. 1973 Research Assistant, Entomology Department, University of California, Riverside
May 1974 to June 2008: Staff Research Associate in Entomology Department, University of California, Riverside

Recent professional work
Experience in conducting research on economic control of insect pests of cotton, lettuce, tomato, pepper, strawberry, citrus, and grapes. Insect subjects of research include pink bollworm (*Pectinophora gossypiella*), cotton budworm (*Heliothis virescens*), tomato fruitworm (*Heliothis zea*), beet armyworm (*Spodoptera exigua*), cabbage looper (*Trichoplusia ni*), silverleaf whitefly (*Bemisia argentifolii*), greenhouse whitefly (*Trialeurodes vaporariorum*), glassywing sharpshooter (*Homalodisca vitripennis*) , and pepper psyllid (*Paratrioza cockerelli*).

Other professional and personal pursuits include research on systematics, ecology, and larval morphology of lycaenid butterflies (Lepidoptera), systematics of *Apiocera* and *Rhaphiomidas* (Diptera), and insect conservation.

Avocational interests include participation in resource conservation-oriented organizations: Tri-County Conservation League (current President and member of Board of Directors), Riverside Land Conservancy (past Secretary and current member of Board of Directors), insect photography, travel (especially Southeast Asia).

Other accomplishments:
Wrote petition to list Delhi Sands Giant Flower-loving Fly as Federal Endangered Species (1989); listed 1993. Co-wrote petition to list the Valley Giant Flower-loving Fly as Federal Endangered Species (2014).

Award for outstanding service to USDA as member of Cuckoo Bee Task Force, 1993

Presenter at South Coast Missing Linkages Workshop, University of Redlands, 7 August 2002: "The Role of Arthropods in Habitat Linkages".
Presenter at various professional seminars on agricultural and other entomological research.

Co-instructor (with David Hawks, Ken Osborne, and Gordon Pratt) for workshop on biology and ecology of the Endangered Quino Checkerspot Butterfly (*Euphydryas editha quino*) for professional surveyors and public trust agency biologists, December 1998 and January 1999, Riverside, CA.

Travel: Australia 1986, Brazil, Burma, Cambodia, England, Indonesia, Japan, Lao PDR, Malaysia, Mexico, Sweden, Thailand 1967-'71 (continuously) and 1986-2015 (1-2 months/year).

PUBLICATIONS

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1. Van Steenwyk, R.A., N. C. Toscano, G. R. Ballmer, K. Kido, H. T. Reynolds. 1975. Increases of Heliothis spp. In cotton under various insecticide treatment regimes. Environmental Entomology 4: 993-996.

2. Van Steenwyk, R.A., G.R. Ballmer. 1976. Relationship of cotton boll age, size and moisture content to pink bollworm attack. Journal of Economic Entomology 69 (5): 579-582.

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8. Pearson, A. C., V. Sevacherian, G. R. Ballmer, P. V. Vail, T. J. Henneberry. 1988. Spring annual hosts of five noctuid pests in the Imperial Valley of

California (Lepidoptera: Noctuidae). Journal of the Kansas Entomological Society 61: 464-470.

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11. Pearson, A. C., G. R. Ballmer, V. Sevacherian, P. V. Vail. 1989. Interpretation of rubidium marking levels in beet armyworm eggs (Lepidoptera: Noctuidae). Environmental Entomology 18: 844-848.

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13. Ballmer G.R. and G.F. Pratt. 1989. A survey of the last instar larvae of the Lycaenidae of California. The Journal of Research on the Lepidoptera 27 (1) (1990) 1988, 1-80.

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15. Ballmer, G.R. & G.F. Pratt. 1992. Quantification of ant attendance of lycaenid larvae. The Journal of Research on the Lepidoptera 30: 95-112.

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18. Ballmer, G.R. 1995. Nation's richest insect diversity in California [sidebar *in* Scott, T., R. Standiford, and N. Pratini: Private landowners critical to saving California biodiversity]. California Agriculture 49 (6): 50-57.

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21. Bi, J. L., N. C. Toscano, and G. R. Ballmer. 2002. Field evaluations of novel chloronicotinyls and insect growth regulators against the greenhouse whitefly on summer-planted strawberries. *Hort Science* 37: 914-918.

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24. Ballmer, G.R. 2003. Observations on resource partitioning among ants (Hymenoptera: Formicidae) and lycaenid larvae (Lepidoptera: Lycaenidae) associated with *Pueraria phaseoloides* in South Thailand. Science Asia 29 (3): 197-202.

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29. Ballmer, G.R. and D.M. Wright, 2014. Notes on the immature stages of *Setabis* sp., a myrmecophagous riodinid butterfly (Lepidoptera: Riodinidae). The Journal of Research on the Lepidoptera Vol.47: 11-15.

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Published:

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2. Van Steenwyk, R.A., N.C. Toscano, G.R. Ballmer, K. Kido and H.T. Reynolds. 1976. Increased insecticide use in cotton may cause secondary pest outbreaks. Calif. Agric. 30: 14-15.

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11. Bi, J.L., S.J. Tuan, G.R. Ballmer and N.C. Toscano. 2003. Susceptibility of the Greenhouse Whitefly from Different Locations in Southern California to Insect Growth Regulators Esteem® and Applaud®. The Pink Sheet, California Strawberry Commission 03-05, Watsonville, CA 2pp.

12. Toscano, N. C., F. Zalom, J. Bi, G. Ballmer. 2005. Integrated pest management of insect pests of strawberries with emphasis on greenhouse whiteflies. *In* California Strawberry Commission Annual Production Research Report 2004 – 2005. p 21-29.

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14. Toscano, N. C., F. Zalom, J. Bi, G. Ballmer. 2007. Integrated pest management of arthropod pests of strawberries with emphasis on greenhouse whiteflies, sapider mites and lepidopterous pests. *In* California Strawberry Commission Annual Production Research Report 2006 – 2007. p 202-212

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16. Toscano, N. C., J. Bi, G. Ballmer, F. Zalom. 2008. Integrated pest management of arthropod pests of strawberries with emphasis on greenhouse whiteflies, sapider mites and lepidopterous pests. *In* California Strawberry Commission Annual Production Research Report 2007 – 2008. p 157-163.

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2. Toscano, N.C., N. Prabhaker, S. Zhou, and G. Ballmer. 1998. Toxicity of Applaud® and Knack® against silverleaf whiteflies from southern California: Implications for Susceptibility Monitoring. *In*: Proc. Beltwide Cotton Conference Vol. 2: 1093-1094.
3. Bi, J. L., G. R. Ballmer, N. C. Toscano, and M. A. Madore. 2000. Effect of nitrogen fertility on cotton-whitefly interactions, pp. 1135-1142. *In*: Proc. Belt-wide Cotton Conferences, 2000, National Cotton Council.
4. Bi, Jian-long, G.R. Ballmer and N.C. Toscano. 2004. Evaluation of Novel Insecticides Against the Greenhouse Whitefly on Strawberries. *In:* Proceedings of the 15th International Plant Protection Congress, Beijing, China, May 11-16, p. 169.

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Otay Lakes Quino Checkerspot Comments

Stuart B. Weiss, Ph.D.
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July 17, 2015

Dan Silver, Executive Director
Endangered Habitats League
8424 Santa Monica Blvd., Suite A 592
Los Angeles, CA 90069-4267

Dear Mr. Silver,

Thank you for the opportunity to review and comment on the DEIR for development in the Otay Lakes area in San Diego County, with a focus on the impacts to *Euphydryas editha quino*. I have also reviewed comment letters by Longcore, Klein, Osborne, Faulkner, Marshalek, Pratt-Ballmer, and USFWS, as well as relevant portions of the Quino checkerspot Recovery Plan. Many of my comments reinforce points made by these other *quino* experts.

I have several decades of scientific and conservation experience with the closely related Bay checkerspot butterfly (*E. editha bayensis*) and many other listed butterflies, as well as with landscape-scale conservation and Habitat Conservation Plans. Since 2008, I have visited numerous *quino* sites in San Diego and Riverside Counties, including a February 2013 site visit to Otay Lakes and other San Diego County *quino* sites with USFWS staff. I have the following comments and observations:

1) In the Quino Recovery Plan, the development site is identified as core *quino* habitat, has been occupied for decades, and is of critical importance to the continued regional persistence of the butterfly.
2) As other commenters have noted, the locations of adult butterflies are often far removed from key breeding areas (patches of hostplants, especially *Plantago erecta*), and are often clumped. This reflects the far-ranging hilltopping and searching behaviors of adult *quino* across the landscape, especially when butterfly densities are low and hostplants are patchy. Basing the magnitude of impacts on adult distribution, as was done in the DEIR, is inappropriate.
3) In February 2013, I visited the site with USFWS and other biologists and we detected several *quino* postdiapause larvae in two of the *Plantago* patches within the proposed development footprint. The rate of larval observations (1-3 larvae/10 person minutes) indicated that the

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patches were occupied at densities of low-hundreds per hectare, based on relationships established with *Plantago* feeding Bay checkerspot larvae.

4) In Figure 2.3-11 in the DEIR, the overlay of the development footprint on the *Plantago erecta* distribution shows that 3 out of 5 of the mapped multi-acre polygons of *Plantago* will be destroyed (including the 2 in which larvae were observed). Numerous mapped point occurrences of *Plantago* are within the footprint as well. *A quantitative analysis of the fraction of Plantago polygon area and fraction of point occurrences in the development footprint is a far more appropriate indicator of impact on this core population than the flawed adult observation analysis.*
5) The remaining two polygons will be directly adjacent to the development and be affected *indirectly* by invasive species, human disturbance, loss of nearby breeding habitat, and other factors, and the prognosis for continued occupancy will decline as indicated by other commenters and by Preston et al. (2012).
6) The impact based on *direct* loss of hostplants appears to be >50% of the breeding habitat, the exact value to be determined by a GIS analysis. Additional *indirect* impacts on the adjacent hostplant patches will raise this figure. This level of impact is incompatible with conservation of the core population, and would contribute to the collapse of the regional metapopulation.
7) Effective mitigation of this level of impact, either onsite or offsite, is doubtful. Trading known core habitat that has been occupied over decades for promises of habitat restoration and management elsewhere is not an effective conservation strategy, especially given the current status of *quino* populations.
8) For effective *quino* conservation, the only marginally acceptable alternative presented is Alternative G, which largely avoids direct impact on *Plantago* stands except for a few point occurrences.

If there are any questions about these comments, please do not hesitate to contact me. Thank you for your consideration,

Literature cited

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.

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2.3 Biological Resources

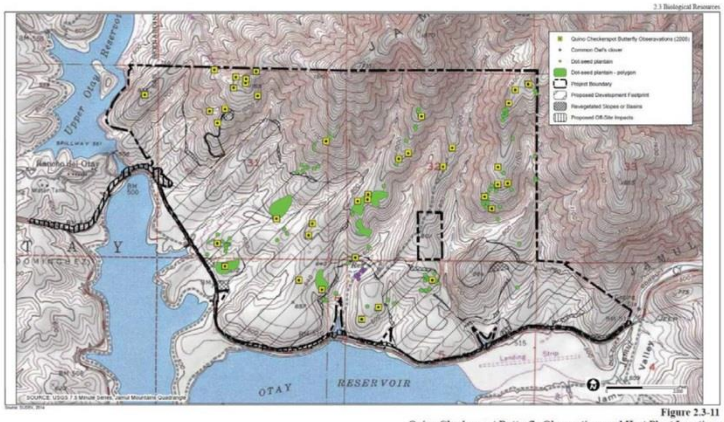

Figure 2.3-11
Quino Checkerspot Butterfly Observations and Host Plant Locations

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EDUCATION

Stanford University 1992 - 1996
Ph.D. in Biological Sciences. September 1996
Area of Specialization: Ecology and Conservation Biology
Dissertation: Weather, landscape structure and the population ecology of a threatened butterfly, *Euphydryas editha bayensis*.
Doctoral Committee: Profs. Paul R. Ehrlich, Peter M. Vitousek, Harold A. Mooney

Stanford University 1978 - 1982
B.S. with Honors Biological Sciences 1984
Area of Specialization: Population Biology and Ecology

Current position: Founder and Chief Scientist, Creekside Center for Earth Observation

Expertise: Conservation biology, landscape ecology, microclimatology, restoration ecology, GIS analysis, statistical analysis and experimental design, nitrogen deposition, policy development.

Creekside Center for Earth Observation, selected projects

- Sep 2006 – present: Science advisor to Bay Area Upland Habitat Goals, Bay Area Open Space Council
- Sep 2006 – present; Restoration of *Clarkia franciscana* and other rare plants in the San Francisco Presidio, National Park Service and Presidio Trust
- Sep 2007 – present: San Mateo Thornmint Restoration, USFWS funded
- Aug 2006 – Mar 2008: Stream temperature characterization of San Francisquito Creek, San Francisquito Watershed Council
- Oct 2004-Dec 2007: Adaptive management of serpentine soil species in Santa Clara County, funded by USFWS Central Valley Project Conservation Project.
- July 2004- July 2005: Recovery Plan for Tidal Marsh Species, population analysis of California Clapper Rail, Salt Marsh Harvest Mouse, and development of recovery criteria and strategies.
- 2004-2006: Habitat assessment of microclimate in Monarch Butterfly Biosphere Reserve, Mexico, funded by World Wildlife Fund, Mexico
- 1999-present: Calpine Metcalf Energy Center Project: N-deposition impact assessment, mitigation planning, and long-term monitoring, negotiations with CEC and USFWS.

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- 2001-present: Edgewood Preserve Habitat restoration for Bay checkerspot butterfly: assessed N-deposition and habitat impacts from I-280, planned the restoration of habitat and reintroduction of butterfly in 2007
- Continuing studies of Bay checkerspot butterfly ecology and conservation
- Vineyard microclimate studies with Robert Mondavi Winery, Woodbridge Winery, Etude Winery, Gallo of Sonoma, Opus One, J. Lohr, and other wineries
- Habitat assessment of over-wintering monarch butterflies California
- Regional biodiversity assessments in Oaxaca, Mexico and Podocarpus National Park, Ecuador
- Climate change research and mapping in White Mountains, CA

Postdoctoral Fellow, Center for Conservation Biology, Stanford University**:** 1996- 1999
Staff Biologist, Center for Conservation Biology, Stanford University: 1984-1992

SELECTED PUBLICATIONS **(From 29 peer reviewed, full list available on request)**

Fenn, M.E., E.B. Allen, **S.B. Weiss**, S. Jovan , L.H. Geiser , G.S. Tonnesen, R.F. Johnson, L.E. Rao, B.S. Gimeno, F. Yuan, T. Meixner, A. Bytnerowicz. 2010. Nitrogen critical loads and management alternatives for N-impacted ecosystems in California. Journal of Environmental Management 91:2402-2423.

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Galindo-Leal, C., J.P. Fay, **S.B.Weiss**, and B. Sandler. 2000. Conservation priorities in the greater Calakmul region, Mexico: Correcting the consequences of a congenital illness. Natural Areas Journal 20:376-380.

Weiss, S.B. 1999. Cars, cows, and checkerspot butterflies: nitrogen deposition and grassland management for a threatened species. Conservation Biology 13:1476-1486

Guisan, A., **S.B. Weiss**, A.D. Weiss.1999. GLM versus CCA spatial modeling of plant species distribution. Plant Ecology 143:107-122.

Human, K.G., **S.B. Weiss**, A.D. Weiss, B. Sandler, and D.M. Gordon. 1998. Effects of abiotic conditions on the distribution and activity of the invasive Argentine ant Environmental Entomology 27:822-833.

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Critique of Otay Mesa SRP EIR

CEQA compliance

Section 4.1.2.1 ostensibly discusses alternative project sites capable of achieving the project goals. Unfortunately, this section of the EIR does not identify any specific alternative location(s) and contains no specific discussion of impacts associated with alternative project locations. Instead, this section dismissively concludes that any such locations would likely have the same sort of environmental impacts. This does not meet the CEQA requirement to provide sufficient specific information to permit a reviewer to objectively assess the impacts associated with specific alternative locations and to compare those impacts with those identified for the proposed preferred project location. The key here is that CEQA requires that an EIR identify environmental impacts of a project and those of a range of reasonable alternatives. Absent such information, no objective comparison is possible and the EIR needs to be amended and resubmitted for public review to correct this deficiency.

Just as the environmental impacts of the various onsite alternatives are similar, but vary in specific impacts to resident biological resources, so would alternative project locations have their own unique suites of environmental impacts. Furthermore, there is no indication that the project objectives could not be achieved, substantially or entirely, by considering an alternative project location removed from the biologically sensitive Otay Mesa area. Here it is notable that CEQA requires consideration of project alternatives unconstrained by cost considerations. The goal is to identify an environmentally superior project alternative. In this instance, because impacts to sensitive biological resources are scattered throughout the project site, the best alternative may be that which has the smallest footprint (Alternative G), an unidentified alternative location, or no project at all.

As noted in other sections of the EIR, a range of onsite alternative designs with different mixes of housing and other land uses, each having different configurations and associated impacts, have been identified (Alternatives A, C-G). The varying degrees of environmental impacts associated with each alternative are ultimately related to the topography and distribution of biological resources scattered over the entire project site, as well as the proximity of conserved habitat to anticipated incompatible urban land uses.

As discussed below, the "preferred" project identified in the EIR would probably be the "kiss of death" for the resident Quino Checkerspot Butterfly (QCB) population. All proposed development alternatives are likely to result in QCB population decline and possible extirpation. The speed of population decline would likely be in direct proportion to the degree of interaction of the adjacent human population (see discussion below). In that regard, QCB population decline might be expected to decline slowest if the least amount of land adjacent to occupied QCB habitat were converted to urban uses, as in Alternative G; however, the best outcome for QCB, would be to avoid all human occupation of adjacent lands.

Impacts to Quino Checkerspot Butterfly (QCB)

[Biological resources] Fig. 2.3.-3 (Sensitive wildlife species map),

2.3-10 (Sensitive wildlife species map with proposed development footprint)

2.3.11 (QCB & host plants)

Figs. 2.3-3, 2.3.10, and 2.3-11 in the DEIR Biological Resources Section of the DEIR depict locations within the project area where QCB adults have been sighted, where two of its host plants, owls clover (*Castilleja exserta*) and dot seed plantain (*Plantago erecta*) were found, and where the proposed development footprint overlaps those sites. There is no indication of the distributions of other potential host plants, such as snapdragon (*Antirrhinum*), Chinese lanterns (*Collinsia*), and rigid bird's beak (*Cordylanthus*), which are important oviposition sites and larval food plants in some regions of southern California (Pratt *et al* 2001 and Pratt & Pierce 2010). Nor are there indications where other resources, such as nectar sources and shrub cover (for diapause larvae) in proximity to larval hosts, are distributed. At the time of its listing as Endangered, only two QCB larval host plant species were recognized (*C. exserta* and *P. erecta*), while others have been confirmed in the course of subsequent field surveys (Pratt, *et al* 2001; Pratt & Pierce 2010). Current USFWS survey guidelines for QCB (Dec. 2014) require mapping of six larval host plant species: *Antirrhinum coulterianum, Castilleja exserta, Collinsia heterophyllum, Cordylanthus rigidus, Plantago Erecta, P. patagonica*, and "other potential larval host plants". It is also notable that QCB larvae in lab colonies readily feed on *Antirrhinum nuttallianum*, and prefer *Collinsia concolor* over *Plantago erecta* (Pratt, personal observations). All field observations of QCB larvae using *Collinsia* refer to *C. concolor*. It is notable that, although not discussed in the DEIR, an earlier plant survey of Otay ranch (RECON 1989) included *A. nuttallianum*, but apparently overlooked *P. erecta* and *C. exserta*. Current QCB survey guidelines also require mapping of all observations of QCB larvae and nectar sources; but that information is also absent from the DEIR discussion of the various project alternatives (perhaps such observations were not recorded). The failure of the DEIR to identify the presence and distribution of all potential QCB larval host plants and adult nectar sources within the project area limits the utility of that document for the purpose of comparing project alternatives with respect to potential direct impacts to the QCB population. These issues are discussed further below.

Although the DEIR states that impacts to QCB can be mitigated to a level of "less than cumulatively considerable*", no convincing evidence of that determination is presented. While the DEIR indicates that four of five projects proposed for the same general area of SW San Diego County are believed to harbor QCB and are likely to be required to provide mitigation for impacts to that species, no specific impacts or mitigations related to those projects have been identified. Absent such information, it is not reasonable to conclude (as the DEIR does) that impacts to QCB can be mitigated to a level of "less than cumulatively considerable".

Perhaps more to the point, the DEIR does not present convincing evidence that any of the project alternatives would not lead to decline or extirpation of QCB within the project boundary (or regionally), regardless of putative cumulative impacts. The implicit assumption in the EIR is that the 966 acres to be conserved (2/3 of "critical habitat" within the project area), including four acres of restored habitat, constitute 2/3 of "suitable habitat" for QCB on site and is, therefore, sufficient to maintain the resident QCB population. But that does not necessarily equate to preserving 2/3 of the QCB population and its essential resources; nor is there any assurance that such a degree of habitat preservation would be sufficient. Such an assertion might be valid if all critical resources for QCB were evenly distributed and if their value to the QCB population did not also have a geographic component. However, the distribution maps for QCB adult sightings and larval host plants (Figs. 2.3-10 and 2.3-11) indicate their clumped, rather than evenly distributed, occurrences.

The EIR does not adequately evaluate the viability of the resident QCB colony with respect to the "edge effect" of future planned (and/or likely) adjacent land uses associated with the various project development alternatives. The project alternatives portray an array of alternative development footprints which seek to preserve some concentrations of QCB sightings and host plants, at the expense of losing others. However, in addition to variable direct loss of QCB habitat, all alternative development alternatives would increase the degree of exposure of the resident QCB population to potentially (or likely) incompatible anthropogenic land uses, including residential neighborhoods. This is most easily seen by comparing the convoluted lineal perimeters of the various alternatives; the greater the perimeter, the greater the exposure of the QCB population to "edge effect" impacts likely to cause QCB population decline. Here it should be noted that proximity to human populations is strongly correlated with prior QCB extinction events in Southern California (Preston, *et al*, 2012). Although the specific cause(s) of previous extinctions may vary with location, they likely include loss of habitat values, such as nectar sources (Minnich 2008), larval hosts, and shrub cover due to direct conversion of habitat to "developed" uses, invasion by exotic species, trampling of larvae by livestock, humans and domestic (or feral) pets, increased fire frequency, and recreational activities (Preston, *et al* 2012).

The past history of the decline and extirpation of QCB colonies in Southern California parallels human population growth and the spread of urbanization (Preston, *et al*, 2012). For example, a colony of QCB persisted on nearby Dictionary Hill in San Diego until it became surrounded by urban neighborhoods in the 1970s. Although the upper slopes of Dictionary Hill still maintain populations of QCB larval host plants, the butterfly no longer exists there. Likewise, QCB populations in Orange County, the Gavilan Hills and along Warm Springs Creek in Murrieta (both in Riverside county) have disappeared, although larval host plant populations persist there. What these and all other extirpated QCB population sites have in common is nearby human population growth and urban encroachment.

Inadvertent mortality of QCB larvae from trampling by recreationists is certainly a contributing factor in the decline of some QCB colonies. Numerous dead QCB larvae, apparently trampled by ORVs, foot, and equestrian traffic, were found along informal recreation trails within and adjacent to QCB colonies at Harford Springs County Park and the Warms Springs Creek QCB Preserve in Murrieta (Riverside County), shortly before those QCB colonies were extirpated (Ballmer & Pratt, personal observations). Because post-diapause QCB larvae spend much time on or near the soil surface to absorb solar energy and feed on low plants, they often occur on and adjacent to the bare soil of recreation and game trails, where they and their host plants are especially vulnerable to trampling by grazing animals and human traffic.

Some pertinent aspects of QCB biology/ecology

The old adage which cautions against 'putting all one's eggs in one basket' aptly describes QCB behavior. Adult QCB usually appear in late winter and early spring, but actual timing depends on variable weather patterns, which also affect the appearance, growth, and longevity of nectar sources and larval host plants. Mated females disperse to deposit eggs on suitable host plants which may be widely dispersed and located some distance away from the site of mating. Availability of appropriate nectar sources may prolong the longevity and increase the fecundity of female QCB. While adult male QCB use a wide variety of nectar sources, females use a narrower suite of nectar sources (*e.g. Chaenactis glabriuscula, Layia glandulosa,* and *Senecio californicus*) (Pratt, personal observations).

Mated females deposit clusters of eggs near the ground on larval host plants; young larvae feed for 2-4 weeks depending upon temperature and food plant quality and then disperse to find secluded sites where they remain dormant (diapause) for several months (or even years). Larvae break diapause with the onset of winter rains, when they leave their secluded diapause shelters and actively seek out and feed on young sprouts of their host plants (Osborne & Redak 2000). One factor that helps QCB colonies to persist through periodic drought is the proclivity of larvae to remain in diapause for multiple years (Pratt & Emmel, 2010). Even under ideal conditions for growth, a substantial percentage of post-diapause QCB larvae in lab colonies typically re-enter diapause for another year or more (*ibid*).

Dispersal of mated females can account for the historical distribution of QCB in widely scattered locations, and helps to ensure population viability by maintaining a distributed metapopulation structure and re-establishment of colonies at sites where QCB had previously died out. Metapopulations of QCB are characterized by subpopulations having different mixes of reproductive resources (larval host plants, shrub cover, and topographic features), which buffer the population against environmental stochasm (wild fires, drought, poor timing of rainfall, etc). While stochastic events may cause some subpopulations to decline during a given season, others may prosper.

In general, QCB reproductive success depends on presence of suitable host plants throughout the extended period from post-diapause larval emergence (late fall and winter), through adult maturation and oviposition (late winter and spring), and pre-diapause larval development (early to mid spring). Because larval host plants are mostly short-lived annuals whose longevity depends on fickle rainfall patterns, pre- and post-diapause larvae may feed on different plant species. Host plants used by post-diapause QCB larvae appear sooner and grow more quickly on exposed, south-facing slopes, but pre-diapause larvae use hosts which may appear later and persist longer on north-facing slopes and in the shade of shrubs.

Female QCB prefer to oviposit on plants in sunny locations, but as those plants senesce or become defoliated, young larvae may seek out more succulent host plants in partially shaded situations, such as those growing among shrubs. Shrub cover in proximity to larval food plants is also important in providing suitably sheltered sites for diapause larvae (Pratt & Emmel, 2010). While large expanses of larval host plants, as may occur in meadows, may maximize the production of larvae, the absence of shrub cover for diapause larvae maximizes their mortality (*ibid*). Thus, a mosaic of shrub cover and open sunny patches of larval host plants, along with topographic diversity, promote survival of QCB and should be critical components of a QCB habitat preserve. Another *sine qua non* is absence of substantial human population adjacent to the QCB habitat.

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References:

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Regional Environmental Consultants (RECON), 1989. Biological Resources Inventory Report for the Otay Ranch Poperty. [RECON number 2003b, 12 October 1989] Prepared for the Baldwin Company, 11973 El Camino Real, Suite 200, San Diego, CA

NOTES

^*CEQA Guidelines 15130: Cumulative Projects Description August 2011 3-1 ConocoPhillips Santa Maria Refinery Throughput Increase DEIR 3.0 Cumulative Projects Description Section 15130 of the California Environmental Quality Act (CEQA) Guidelines requires that an Environmental Impact Report (EIR) discuss cumulative impacts of a project when the project's incremental effect is cumulatively considerable, as defined in Section 15065(c). Section 15355 of the State CEQA Guidelines defines "cumulative impacts" as two or more individual effects that, when considered together, are either considerable or compound other environmental impacts. State CEQA Guidelines (14 CCR 15130) require a reasonable analysis of the significant cumulative impacts of a Proposed Project. Cumulative impacts are defined by CEQA as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts" (State CEQA Guidelines, Section 15355).

Cumulative impacts are further described as follows:
The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impacts from several projects are the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time (State CEQA Guidelines, Section 15355[b]).
Furthermore, according to State CEQA Guidelines Section 15130(a)(1): As defined in Section 15355, a "cumulative impact" consists of an impact that is created as a result of the combination of the project evaluated in the EIR together with other projects causing related impacts. An EIR should not discuss impacts which do not result in part from the project evaluated in the EIR.
In addition, as stated in the State CEQA Guidelines, Section 15064(i)(5): The mere existence of significant cumulative impacts caused by other projects alone shall not constitute substantial evidence that the proposed project's incremental effects are cumulatively considerable. A typical "project specific" cumulative analysis looks at the changes in the environment that result from the incremental impact of development of a Proposed Project and other reasonably foreseeable projects that have not been included in the environmental setting. For example, the air quality impacts of two projects in close proximity may prove to be insignificant when project emissions are analyzed separately, but could be significant when these emissions are combined and analyzed together. While these projects may be unrelated, their combined (*i.e.*, cumulative) air quality impacts would be significant.

Curriculum Vitae Gordon Pratt

NAME: Gordon F. Pratt

PLACE AND YEAR OF BIRTH: Toronto, Ontario, May 9 1953

CITIZENSHIP: Became a Naturalized Citizen of the United States on October 30, 1992 at Philadelphia, Pennsylvania: Naturalization No. A08 583 460.

EDUCATION: Northeastern University, 1971-1976, Boston, Mass., Bachelors Science in Biology with Honors.

Queen's University, 1976-1979, Kingston, Ont., Masters in Molecular Biology, Oct., 1979.

University of California, Riverside, Fall 1980 - Fall 1988, PhD. in Entomology (Insect Systematics), with an inside minor in insect/plant interactions and an outside minor in Population Biology.

HONORARY SOCIETIES: The Academy
Phi Sigma

AWARDS: Outstanding Teaching Assistant for Entomology at UCR in 1984 (for Insect Systematics).

John Adams Comstock Award that is given for outstanding student presentation at the June 1985 Lepidopterist Society Meetings of the Pacific Slope Branch in the San Bernardino Mts.

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Lepidopterists' Research Society
Friends of the Entomology Research Museum
Lepidopterists' Society
Entomological Society of Washington
Pacific Coast Entomological Society
High Country Garden Club

Previous Field Work on the Military Bases of Southern California that Relates to the Potential Contract

I have been studying and identifying insects in the Mojave Desert since the early 1980s. From 1994 to 1996 I studied the butterflies on three of the Mojave Desert Military Bases: China Lake Naval Air Weapons Station (CLNAWS), Fort Irwin National Training Center (FINTC), and Edwards Air Force Base (EAFB) (Pratt 1999a). From 1996-1998 I did an Invertebrate Survey of EAFB (Pratt 1998, 1999b, 2000). From 2001 to 2005 I did an Invertebrate Survey of Marine Corps Air Ground Combat Center in 29 Palms (Pratt 2005). In addition I did a terrestrial Arthropod survey outside of the Mojave Desert for Vandenberg AFB from 2004-2005 (Pratt 2006). I have been doing an invertebrate survey since 2000 through 2009 at various springs in CLNAWS and from 2009 to present I have been doing an endangered plant census along with an invertebrate survey (Pratt 2013).

From the work I did this summer I collected several thousand invertebrates to be identified this winter. Many of these have been mounted, labeled, and processed. The biologists that work for CLNAWS have collected the malaise trap contents at three different springs at least once a month which probably totals well over 20,000 invertebrates. The trap contents are presently stored in alcohol and will be examined through a dissecting microscope to determine species of interest to be mounted and labeled this winter. All of these invertebrates need to be processed and identified over the winter months.

Butterfly larvae have specific food plants, so during the butterfly survey from 1994-1996 I identified many different food plants on the different military bases. The herbarium at UCR helped in the identification of plants that I was not familiar with. During the arthropod and invertebrate surveys I used plant diversities to identify unique habitat. The endangered Lane Mountain Milkvetch (*Astragalus jaegerianus*) occurs on FINTC and while doing the butterfly survey in 1994 I a couple of days searching for the milkvetch in the Paradise Range. The reason I studied the milkvetch was it was hoped that I would find unique insects associated with the plant. While surveying for the milkvetch I took video recordings of the plant growing up through supporting plants (mostly *Ambrosia dumosa*).

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Pratt, G. F. 1999a. Butterflies and Moths of the Western Mojave Desert (China Lake Naval Air Weapons Station, Fort Irwin National Training Center, and Edwards Air Force Base), Entomology Department, University of California Riverside, CA 92521, 148 pp.

Pratt, G. F. 1999b. Terrestrial Invertebrates of Edwards Air Force Base, 1997. Technical Report EL-99-xx of the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180.

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Pratt, G. F. 2006. Terrestrial Arthropods of Vandenberg Air Force Base, Lompoc, California, Entom 2004-2005, Entomology Department at the University of California at Riverside, 30 pp.

Pratt G. F. 2013. Invertebrate Survey and Endangered Plant Census of China Lake Naval Air Weapons Station. 365 pp.

TEACHING

Demonstrator: Queen's University, Kingston Ontario, Canada

Introductory Cell Biology, 1976
Ecology, 1977
Entomology, 1977-1979

Teaching Assistant: University of California, Riverside, CA

Embryology, 1982
Biology 1B, 1983
Parasitology, 1983
Insect Systematics, 1983-1986
Immature Insect Taxonomy, 1984-1986
Field Entomology, 1985

Instructor: University of California Extension, Riverside, CA

Biology and Ecology of Southern California Butterflies, 1998-2001
Field Entomology, 2001

Instructor: Quino Checkerspot Butterfly Workshop, fall 1997, winter 1998, fall 1998, winter 1999, winter 2000

Academic Research

Queen's University, Masters Research: Isolation and Characterization of mRNA for the proteins Calliforin and Vitellogenin of the Blowfly *Calliphora erythrocephala*. Dr. B. N. White and Dr. G. R. Wyatt, Department of Biology, Sept. 1976- Oct. 1979.

University of California, Riverside, CA., Phd. Research: Evolution and Biology of *Euphilotes* biotypes (Lepidoptera: Lycaenidae) using electrophoretic, biological, and morphological characters. Dr. John D. Pinto, Dept. of Entomology and Dr. Clay Sassaman, Dept. of Biology, Sept. 1980- Dec. 1988.

University of Delaware, Newark, DE, Post-doc Research: Evolution and population structure of the *Enchenopa binotata* complex using morphological, biological, and electrophoretic characters. Dr. Tom Wood, Dept. of Entomology and Applied Ecology, July 1989- June 1991.

University of Delaware, Newark, DE., Post-doc Research: Evolution of various North American Groups of Insects to Identify various Vicariant Mechanisms using morphological, biological, and electrophoretic characters in association with biogeographical patterns of distribution. Dr. Tom Allen, Dept. of Entomology and Applied Ecology, September 1991- January 1993.

University of California, Riverside, CA, Post-doc Research:

1993-1994 Identification of electrophoretic markers of *Aphytis melinus* and *A. liganensis* (parasites of California red scale) for population studies and determining efficacy of biological control releases. Dr. Bob Luck, Dept. of Entomology, July 1993-1994.

1994-1998 Butterfly Survey of three military bases in the Mojave Desert. These bases are located at China Lake Naval Weapons Center, Fort Irwin Military Reservation, and Edwards Air Force Base and cover about 4,000 square miles of the Mojave Desert.

1996-1999 Invertebrate Survey of Edwards Air Force Base. This research was to determine areas of high species richness and endemics, for management purposes.

1997-1998 Invertebrate Survey of Fort Irwin Acquisition Areas to follow before and after military training.

1997-2002 Study of Invertebrates that indicate damage level of habitat out at Fort Irwin National Training Center. This is heavily trained area that has many local areas that differ in their damage level due to training.

1997-present Survey of endangered Quino Checkerspot through the California Fish and Game. This survey also involves rearing and studying the checkerspot under laboratory conditions.

1999 Survey of the endangered Laguna Skipper in the Palomar and Laguna Mts through the Cleveland National Forest. This study is to determine present condition of the skipper in the Laguna Mountains, survey for additional food plants, and to monitor the skipper in the Palomar Mts.

1998 An author of the Recovery Plan for the El Segundo Blue for USFWS.

1999-present Survey of invertebrates found around springs in China Lake Air Naval Weapons Station.

2001-present Survey for arthropods Installation Wide at Twentynine Palms Marine Base.

2000-2003 I was part of the Quino Technology Team, which was involved in the decision process of the endangered Quino Checkerspot butterfly.

2000-2001 survey for the Sacramento Mountains Blue, *Icaricia icarioides* subspecies.

2000-2001 survey for the Sacramento Mountains Green Hairstreak, *Callophrys affinis* subspecies.

2000-2001 survey for the butterflies found in the southwest corner of New Mexico.

2002-2005 survey for arthropods in Marine Corps Air Ground Combat Center (U.S. Navy).

2003-2004 survey for the Hunter Mountain Copper a subspecies which John Emmel and I named.

2003-2005 survey for the Lotis Blue in Mendocino and Sonoma Counties.

2004-2006 survey for arthropods in Vandenberg Air Force Base.

2003-2007 consult and monitor for the Palos Verdes Blue.

2003-2007 examine genetic differences in populations of members of the *Apodemia mormo* complex and populations of *Glaucopsyche lygdamus* in the western Mojave Desert (Cal State University at Dominguez Hills).

2007 surveyed for the El Segundo Blue Butterfly (ESBB) and trained biologists to survey for ESBB to Liz Bell, Morgan Ball, Alice Abela, and John Labonte.

2004-2008 perform field experiments on larval diapause in the Quino Checkerspot.

2007-2008 examined DNA of *Euphilotes* populations to determine the relationships of the Vandenberg Air Force Base population of the El Segundo Blue Butterfly to the populations at the El Segundo Dunes and neighboring Palos Verdes Peninsula.

2008 University of California, Riverside, CA, Research Assistant:

2008-2010 surveyed to collect larvae and adult Quino Checkerspot Butterflies to transfer them to restored habitat at the La Posta Mountain Warfare Training Facility.

2009-2010 determined the distance and depth that El Segundo Blue Butterfly larvae crawl on and into the ground to pupate.

2004-2010 captive breed the endangered Quino Checkerspot Butterfly.

2009-present survey for arthropods at springs and Lane Mountain Milkvetch on the south range of China Lake Naval Air Weapons Station.

2010-2014 University of California, Riverside, CA, Research Associate:

USFWS Permit – TE004939-10

This permit was recently updated in January 2011. The permit is for captive breeding of the endangered Palos Verdes Blue, and rear El Segundo Blue Butterfly larvae from females from Vandenberg Air Force Base. Included in the permit is to survey for and identify the Laguna Mountain Skipper, Palos Verdes Blue, El Segundo Blue, and Lotis Blue

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