Initial Investigation of Critical Biological Uncertainties for Harbison's dun skipper (*Euphyes vestris harbisoni*) on Conserved Lands in San Diego County

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Executive Summary

The Harbison's dun skipper (*Euphyes vestris harbisoni*) is a rare subspecies with a restricted distribution, known only from San Diego County and southern Orange County. Larvae are host-specialists, feeding only on the San Diego sedge (*Carex spissa*) that is often associated with riparian oak woodlands. Entomologists have expressed concern that the Harbison's dun skipper may be threatened due to habitat loss and degradation. The skipper was once considered a Category 2 species by the United States Fish and Wildlife Service and petitioned to be listed under the federal Endangered Species Act. Currently, it is a covered species in some HCP/NCCP plans in San Diego County.

Little is known about this skipper, as the few papers written are limited to describing the general life history and providing a vague distribution. This project is the first phase of a planned comprehensive monitoring program for the Harbison's dun skipper, designed to assist in the development of effective management and conservation practices. We focused on describing the distribution of the skipper, estimating population status and trend, describing habitat requirements of the larvae and adults, and identifying potential threats to the long-term persistence of the species as well as recommendations for monitoring and management.

Using herbarium records, information from biologists, and historical Harbison's dun skipper locations, we were able to find San Diego sedge at 38 general locations, primarily on conserved lands. All sedge plants were found in or immediately adjacent to a riparian oak woodland except two small patches. However, both of these locations also had oak woodlands with San Diego sedge present. In many cases, oak woodlands were patchily distributed along a creek and the sedge was only found in those woodlands. We did not find San Diego sedge in or along pools of still/standing water, only in areas with moving water or a dry ravine.

We were able to identify 26 historic Harbison's dun skipper localities from museum specimens, peer-reviewed literature, technical reports, and notes from local biologists. Most often, these locality data provided a general description rather than a specific point. Therefore, it can be difficult to know if we were revisiting the same location. Of the 34 locations with San Diego sedge that we surveyed for the skipper, 18 (53%) were occupied which is well below the occupancy rate described by Brown (1982).

Based on surveys for larvae and adults in 2013-2014, the current Harbison's dun skipper distribution includes the foothills in the northern and southern parts of San Diego County, extreme western Riverside County, and southern Orange County. In San Diego County, there appears to be a significant gap around the Poway area due to local extirpations likely resulting from wildfires. It is unclear whether the skipper currently occupies Silverado Canyon, its northernmost location, following the 1987 Silverado Fire. Extirpation from Silverado Canyon would represent a substantial range contraction. To the south, the Harbison's dun skipper has been documented in northern Baja California, Mexico. Skipper observations from Riverside County and Mexico are not represented in the published literature.

In 2013, a pilot study detected adults from 23 May to 16 July and had the largest daily counts of 8 adults at Loveland Reservoir, 6 to 10 at Hollenbeck Canyon Wildlife Area, and 6 to 8 at Barrett Lake. In 2014,

repeated sampling at selected sites provided a more robust description of the flight season phenology as well as reliable population size indices (daily maximum adult counts). Adults were present from 15 May to 18 June and the largest daily count was 5 to 6 adult skippers at Hollenbeck Canyon Wildlife Area. The shorter flight season and fewer individuals in 2014 were likely due to the preceding winter being extremely dry.

Larvae (and hibernacula) can be relatively easy to locate on San Diego sedge plants for several months so we suggest conducting larval surveys to document presence/absence of the Harbison's dun skipper at specific locations. If adult surveys are conducted, they should occur mid-May to early July, with temperatures 75-85°F (24-29°C) for maximum detection, and focusing on flowering plants near patches of San Diego sedge.

There are a number of threats to the Harbison's dun skipper, including recent extirpations further reducing its distribution, habitat alteration/loss, wildfires, drought, the goldspotted oak borer (*Agrilus auroguttatus*), and grazing. Additional surveys are warranted to better understand the skipper's distribution, assess annual variation in population size, quantify habitat use, further investigate threats, and collect genetic samples to describe gene-flow from which we can infer dispersal.

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Introduction

The Harbison's dun skipper is restricted to southern Orange County and San Diego County (Brown and McGuire 1983), with no published records from Mexico. While this subspecies is restricted in distribution, three other subspecies are more widespread: *Euphyes v. metacomet* is found throughout the eastern United States and southeastern Canada; *Eupheys. v. vestris* occupies portions of the western coastal states and southern British Columbia; and *Euphyes v. kiowah* is found in the Rocky Mountains (Ferris and Brown 1981, McCabe and Post 1977, Pyle 2002, Warren 2005).

Entomologists have expressed concern that the Harbison's dun skipper (*Euphyes vestris harbisoni*) is a rare subspecies and may be negatively impacted by habitat loss and degradation (Brown 1991, Glassberg 2001, Faulkner and Klein 2012). In 1989, the United States Fish and Wildlife Service (USFWS) issued a notice of review, on which Harbison's dun skipper was listed as a Category 2 species:

> "Category 2 comprises taxa for which information now in possession of the Service indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules." (USFWS 1989)

Additional factors that pose a threat to the Harbison's dun skipper include habitat loss associated with urbanization, pollution, the recent wildfires of 2003 and 2007, and the prolonged dry conditions over the last decade.

Previous Harbison's Dun Skipper Research

Only two papers have been published that focus on Harbison's dun skipper. Brown and McGuire (1983) identified this subspecies as morphologically different from the other subspecies and describe its biology (life history and nectaring sources) and distribution. Brown (1982) describes the research leading to the Brown and McGuire (1983) paper and indicates that the Harbison's dun skipper was present in nearly all areas that contain considerable numbers of San Diego sedge (*Carex spissa*) plants in San Diego County. Brown and McGuire (1983) also recorded a local extirpation at Adobe Falls in San Diego due to development, pollution, and invasion by non-native plants.

Non peer-reviewed papers also provide useful information, often written by interested local biologists that are very familiar with the skipper. Brown (1991) primarily updates Brown and McGuire (1983) but includes a note about the reduction of a large local population caused by the development of Flinn Springs County Park. He describes the Harbison's dun skipper as an "exceptionally rare insect that occurs in small isolated colonies," and that at least some of these local populations are threatened by urban development. Faulkner and Klein (2012) also provide a species profile and updates the information in Brown and McGuire (1983) and Brown (1991).

Although the USFWS discontinued the Category 2 designation (USFWS 1996), the 1989 categorization is a reminder of long-standing concerns about status of the subspecies and the general lack of knowledge about the Harbison's dun skipper. In 1991, a petition to list the skipper was submitted. The petition

included three other species, the Laguna Mountains skipper (*Pyrgus ruralis lagunae*), Hermes copper (*Lycaena hermes*), and Thorne's hairstreak (*Callophrys* [*Mitoura*] *grynea thornei*) (USFWS 1991). The 90-day finding stated that the petition did not contain substantial information for listing, but substantial information existed elsewhere and the U.S. Fish and Wildlife Service would continue a formal status review (USFWS 2006).

The Harbison's dun skipper has been included in the development of HCP/NCCP plans in San Diego. It is a covered species in the MHCP, Carlsbad, and SDCWA NCCPs, and is proposed as a covered species in two additional NCCPs that are in the planning stage (San Diego North County and East County MSCPs). Biologists on SANDAG's Transnet Environmental Mitigation Program Working Group also identified this skipper as a taxon warranting attention because of its rarity. The skipper was not originally listed on the 2013 Western San Diego County Management Strategic Plan (MSP, SDMMP 2013) due to the lack of current observations, but will be incorporated into this plan with the 2015 revision. It will also be addressed in the update of the Connectivity Strategic Plan (Preston pers. comm.).

Harbison's Dun Skipper Biology

Harbison's dun skipper adults are medium-sized skippers with a wingspan of 25-35mm, plain brown to dark brown with golden hairs on the top of their head (Garth and Tilden 1986, Opler et al. 2013). The Harbison's dun skipper is larger than the other western subspecies (Brown and McGuire 1983) so the wingspan of most individuals are likely to be closer to 30-35mm. Males have a black stigma on the upperside of the forewings bordered by varying amounts of a rusty to orange color (Figure 1A) while females have two light spots on the forewing and sometimes very light discal band spots on the underside of the hindwing (Figure 1B).

Figure 1. Adult Harbison's dun skipper (*Euphyes vestris harbisoni*). A) male identified by the black stigma on the forewing, B) female identified by the light spots on the forewing.

Brown and McGuire (1983) provide the most complete description of the Harbison's dun skipper biology. Historically, this subspecies has been found from Silverado Canyon in Orange County, south into San Diego County to the U.S.-Mexico border. While one of these locations is in the city of San Diego, the remaining 13 described locations are in the inland-foothill region. There are no published records from

Mexico. Adult Harbison's dun skippers emerge in the late spring/early summer, with specimens recorded from 15 May to 12 July. They remain close to their only known larval food plant San Diego sedge (*Carex spissa*) (Figure 2) and will often visit nearby nectar sources. Previously published nectar sources are: morning glory (*Calystegia macrostegia tenuifolia*), red thistle (*Cirsium occidentale*), loosestrife (*Lythrum californicum*), and rarely golden yarrow (*Eriophyllum confertiflorum*) and black mustard (*Brassica nigra*). Opler et al. (2013) indicate that dun skippers nectar on white, pink, and purple flowers.

Females deposit pale yellow-green eggs with a red ring and red dot singly on the underside of host plant leaves. Shortly after, larvae emerge and feed near the base of the plant. Second and third instar larvae construct a shelter (hibernaculum) by attaching two to four leaves together (Figure 3) where they can be found when not foraging. The head will be oriented away from the base of the leaves (Figure 4). Fourth, but occasionally third, instar larvae overwinter in these hibernacula. Pupation also occurs in these hibernacula, although larvae will construct more than one shelter. Immediately prior to pupation, the upper end is filled with a white, cotton-like substance (Figure 5), with pupation lasting 18-21 days. Brown and McGuire (1983) collected a larva, pupa, and adult at one location on the same day indicating that development is not tightly synchronized among individuals at a single site.

Goals and Objectives

This research is the first phase of a planned comprehensive monitoring program for the Harbison's dun skipper, designed to assist in the development of effective management and conservation practices. In general, an effective monitoring program for Lepidoptera needs to provide information on the distribution of the species, estimate population status and trend, describe habitat requirements of the larvae and adults, and identify potential threats to the long-term persistence of the species. This information is used to develop data-driven recommendations for monitoring and management. Our previous work with Hermes copper provides a successful template for initial investigations into biological studies of rare insects (Marschalek 2004; Marschalek and Deutschman 2008; Marschalek and Klein 2010; Deutschman et al. 2010, 2011; Strahm et al. 2012).

This initial project focuses on describing the distribution of the Harbison's dun skipper (identifying suitable habitat followed by field surveys) as well as providing a baseline for preliminary work on both population status (i.e. landscape genetic study) and habitat requirements (initial description of occupancy).

Specifically, we wanted to address the following in this first phase:

1) Identify known San Diego sedge locations
2) Identify additional areas with a high probability of having San Diego sedge
3) Conduct field surveys to assess reported patches of San Diego sedge
4) Conduct field surveys to identify unrecorded patched of San Diego sedge
5) Inspect San Diego sedge plants for Harbison's dun skipper larvae and hibernacula
6) Survey San Diego sedge patches for adult Harbison's dun skippers

Figure 2. San Diego sedge (*Carex spissa*). A) Several San Diego sedge plants in riparian oak woodland, B) close up of San Diego sedge flowers.

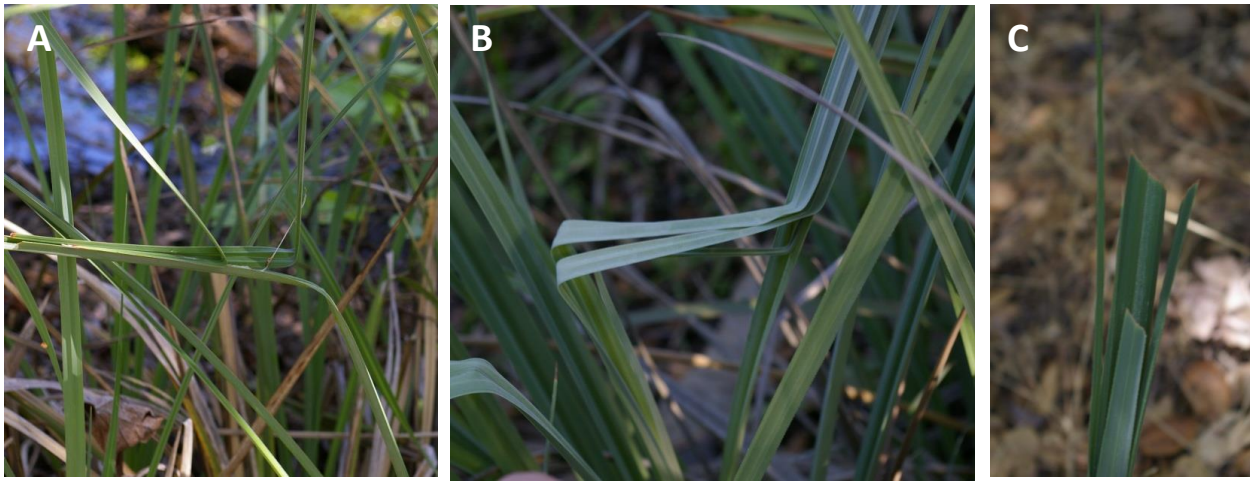

Figure 3. Harbison's dun skipper larval hibernacula. A) Horizontal orientation, B) vertical orientation, C) vertical orientation low in plant with leaf ends chewed off.

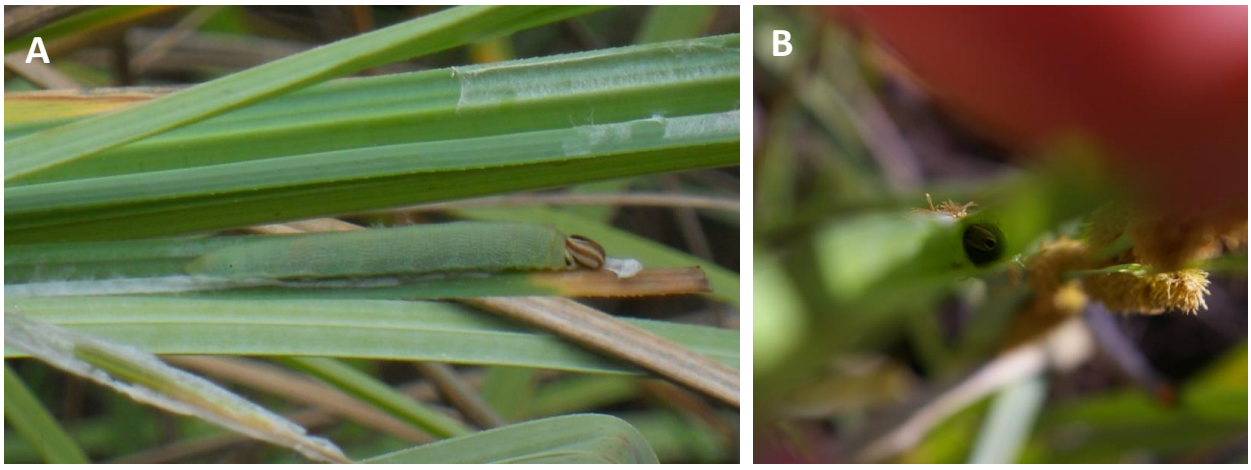

Figure 4. Harbison's dun skipper larva. A) Fourth instar larva after opening hibernacum, B) head of fourth instar larva evident when looking into hibernacum.

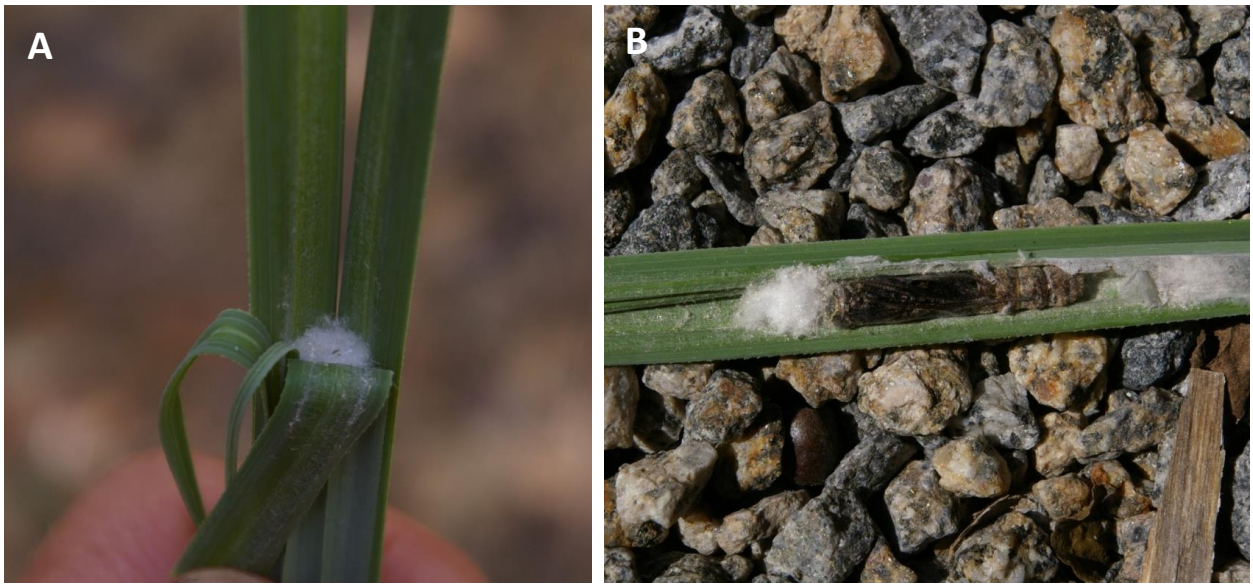

Figure 5. Harbison's dun skipper pupa. A) White, cotton-like substance superior to the pupa (two of four leaves pulled down for visibility), B) full hibernacum during pupation exposed by removing one leaf.

The primary goal was to search for previously unreported habitat patches occupied by Harbison's dun skipper on conserved lands throughout San Diego County. However, we also wanted to confirm the presence of the skipper at historic locations. First, potential habitat was identified using existing information on the distribution of the host plant, San Diego sedge. Patches of sedge were surveyed before the adult flight season to search for larvae and/or pupae as well as to prioritize sites for monitoring during the flight season. During the flight season, most sedge patches were visited several times and surveyed for Harbison's dun skipper adults. Adult surveys provided an opportunity to obtain an index of local population size of adults and note general behavior (e.g. intra- and inter-specific interactions, nectar sources).

San Diego Sedge and Larval Searches

Sedge and Larval Search Methods

Because the Harbison's dun skipper flight season is short (four to six weeks at any one site), our first task was to identify potential habitat prior to the flight season. We identified potential habitat in two phases. First we used existing information to select and prioritize places likely to contain suitable habitat defined by the presence of San Diego sedge. Second we conducted field reconnaissance to confirm the presence of San Diego sedge at those locations.

We used three sources of information to identify areas that might have potential habitat.

1) San Diego sedge locations as reported in the San Diego Natural History Museum (SDNHM) Plant Atlas (www.sdplantatlas.org), Calflora (http://www.calflora.org/), and the California Consortium of Herbaria (http://ucjeps.berkeley.edu/consortium/).
2) Locations of San Diego sedge and oak riparian woodlands as reported by other biologists.
3) Historical Harbison's dun skipper locations.

We knew that San Diego sedge is not restricted to oak woodlands. However, it was quickly evident that searching for oak woodlands in low lying areas was an efficient way to locate the sedge compared to searching all ravines and riparian areas. Brown (1991) also observed this subspecies typically inhabiting partially shaded riparian oak woodlands.

Sedge and Larval Search Results

Based on records contained in the SDNHM Plant Atlas, Calflora, and the California Consortium of Herbaria, San Diego sedge has a relatively restricted distribution but not as limited as the Harbison's dun skipper. San Diego sedge records extend from the United States-Mexico border north into extreme southern Monterey County (Figures 6 and 7). Most of these localities are in coastal San Diego and southern Orange County, extreme northern Los Angeles basin, and coastal San Luis Obispo County. These three regions are widely separated from one another.

We were able to identify 26 historic Harbison's dun skipper localities from museum specimens, peer-reviewed literature, technical reports, and notes from local biologists (Table 1). Most often, these locality data provided a general description rather than a specific point. Therefore, it was difficult to know if we were revisiting the same location.

Using Herbarium records, information from biologists, and historical Harbison's dun skipper locations, we were able to find San Diego sedge at 38 general locations, primarily on conserved lands (Figure 8, Appendix 1). All sedge plants were found in or immediately adjacent to riparian oak woodlands except for two small patches (Crestridge Ecological Reserve, Otay Mountain). However, both of these locations also had oak woodlands containing San Diego sedge. In many cases, oak woodlands were patchily distributed along a creek and the sedge was only found in those patches of woodlands (not in the openings between woodlands). Occasionally willows and sycamores were mixed in with these oaks. We did not find San Diego sedge in or along pools of still/standing water, only in areas with moving water or a dry ravine. It appears that *Arundo* and *Typha* are able to out compete the sedge, utilize a different niche, or both as the sedge was not present in close proximity to these other species. Published reports for San Diego sedge indicate a distribution up to 600 meters in elevation (Hickman 1993, Calflora 2013); however the plants on Otay Mountain were at 950 meters in elevation.

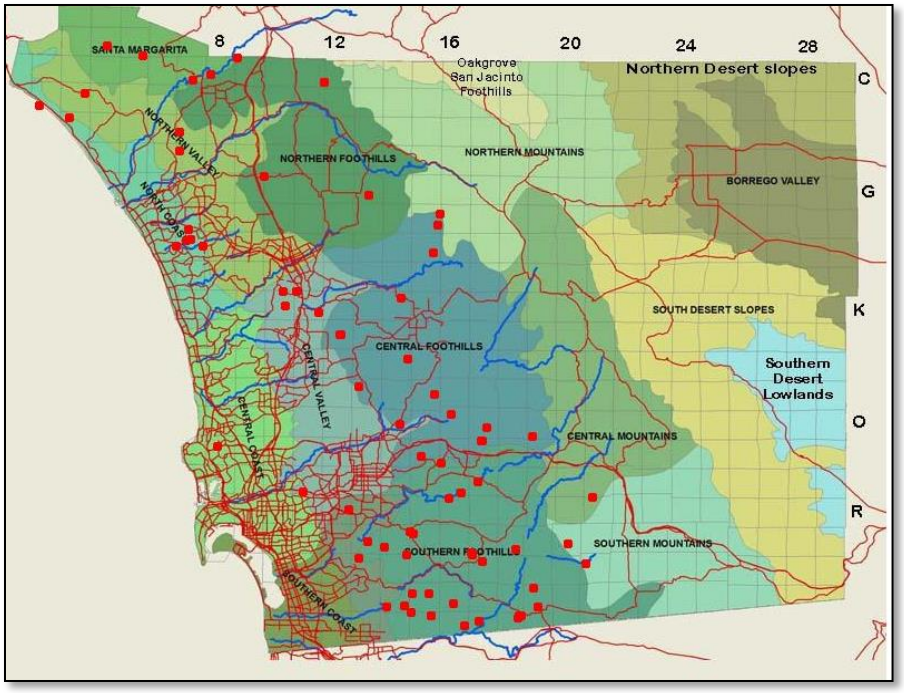

Figure 6. *Carex spissa* observations from the San Diego Natural History Museum Plant Atlas.

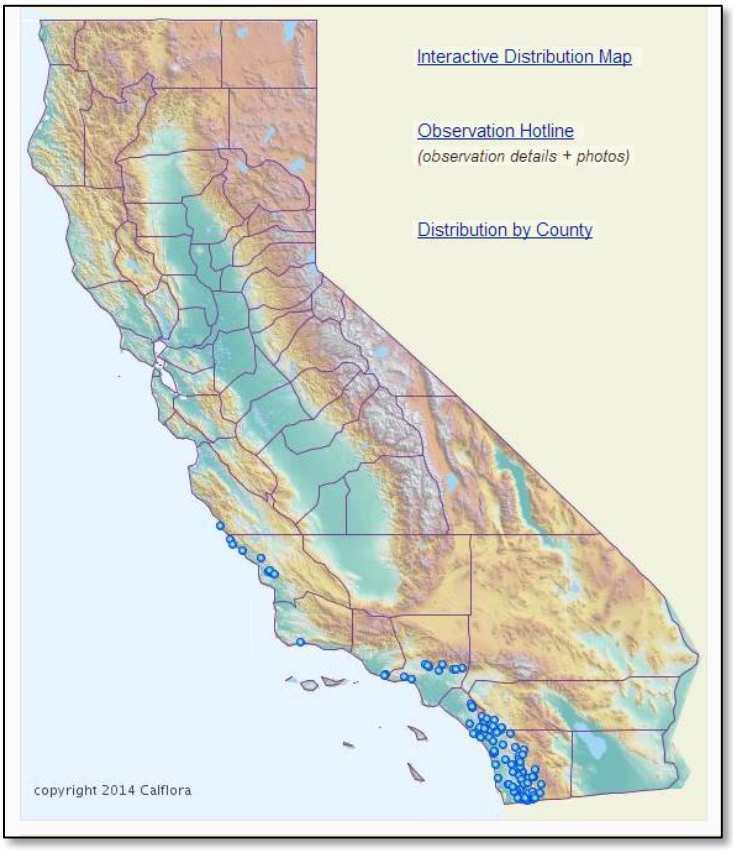

Figure 7. *Carex spissa* observations from Calflora (includes California Consortium of Herbaria).

Table 1. Historic Harbison's dun skipper localities.

Location	Citation
Adobe Falls	Brown and McGuire (1983)
Black Mountain (Ramona area)	Shiraiwa pers. com.
Blossom Valley	Brown and McGuire (1983)
Bottle Mountain	Osborne pers. com.
*Camp Pendleton (eastern)	Osborne pers. com.
Crestridge Ecological Reserve	Faulkner and Klein (2012)
Daley Ranch	USFWS email/map
Dulzura (vicinity)	Brown (1991)
El Monte Oaks	Brown and McGuire (1983)
Fallbrook area	Brown (1991), Brown and McGuire (1983)
Flinn Springs	Brown (1991), Brown and McGuire (1983)
Hellhole Canyon/Creek	Brown and McGuire (1983)
Lake Poway	Brown and McGuire (1983)
Old Viejas Grade, Poser Mountain	Brown (1991), Brown and McGuire (1983)
Otay Mountain	Brown (1991), Faulkner and Klein (2012)
Pechanga Indian Reservation	Osborne pers. com.
Poway	Brown and McGuire (1983)
Poway, Green Valley Truck Trail	Brown and McGuire (1983)
Ramona area	Brown (1991)
Red Mountain	Scheidt (2010)
Rios Canyon	Faulkner and Klein (2012)
San Pasqual Academy	Brown (1991), Brown and McGuire (1983)
Silverado Canyon (Orange County)	Brown and McGuire (1983)
Sycamore Canyon/Goodan Ranch	Faulkner and Klein (2012), Pratt pers. com.
Tecate Peak, north slope 13.3km E Dulzura	Brown (1991), Brown and McGuire (1983)
Valley Center (east of)	Brown (1991)

*General location unknown at this time

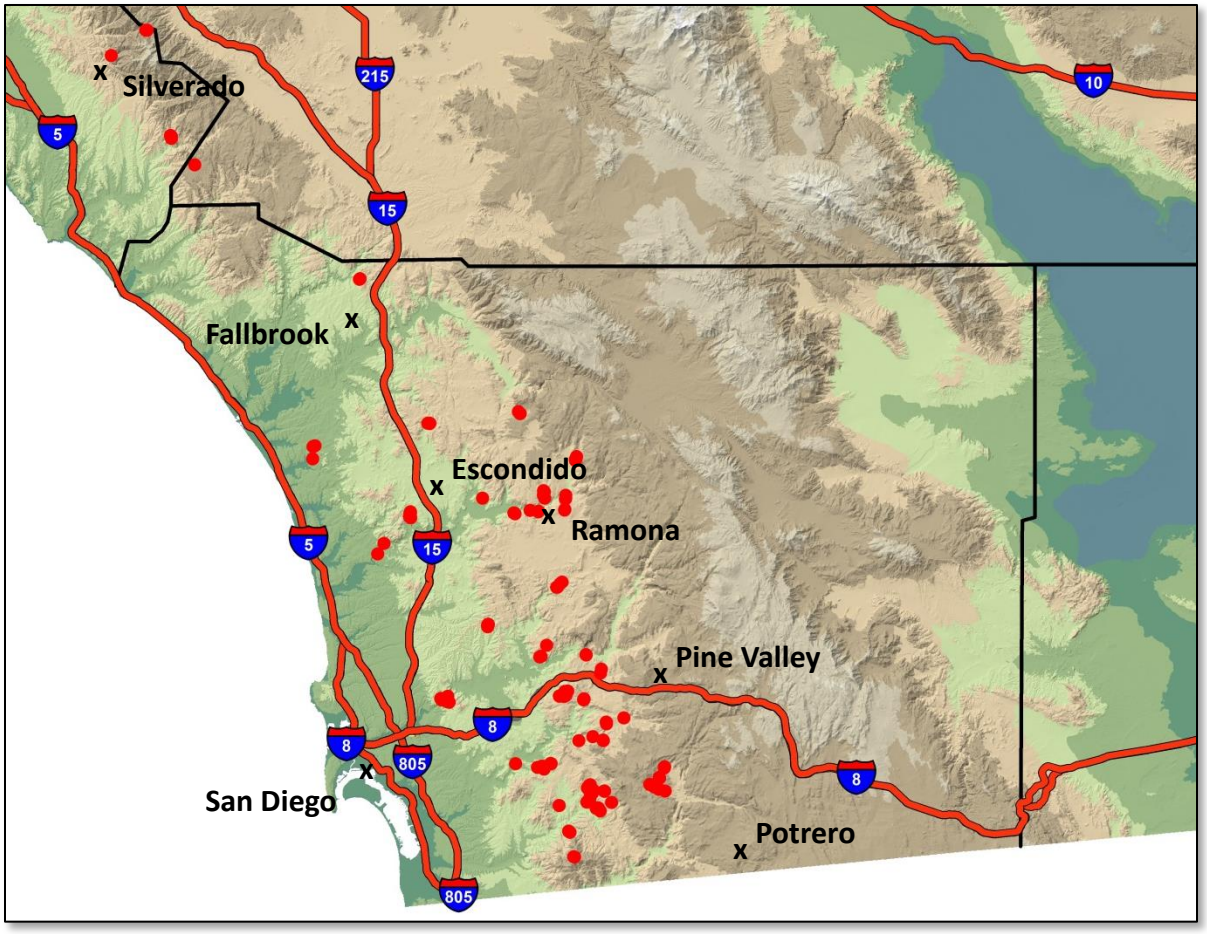

Figure 8. San Diego sedge locations from 2013-2014 searches.

Because we were able to inspect the sedges for larvae, we were able to identify nine new Harbison's dun skipper locations during initial host plant searches:

1) Barrett Lake
2) Boden Canyon Ecological Reserve
3) Hollenbeck Canyon Wildlife Area
4) Lake Hodges
5) Loveland Reservoir
6) Pamo Valley (Cleveland National Forest)
7) San Diego National Wildlife Refuges
8) Skye Valley Road (Cleveland National Forest)
9) Sycuan Peak Ecological Reserve

On four occasions, a dead larva was found in a hibernaculum. The causes of death were unknown.

During *Carex spissa* searches, we occasionally found what appears to be *Carex senta*, especially at higher elevations. *Carex senta* is also found along stream banks but is smaller with green leaves compared to

the larger *C. spissa* plants that have a slightly bluish color to the green leaves. On several occasions, larvae of the woodland skipper (*Ochlodes sylvanoides*) were found in hibernacula on this other sedge species. Careful inspection can result in the reliable differentiation of these two skipper species.

Adult Surveys

Adult Survey Methods

Multiple surveys were conducted during the 2014 flight season at 19 locations found to have San Diego sedge present. This repeated sampling provides the ability to estimate an index of population size and to evaluate butterfly detectability and observer efficiency. Prior to the flight season, frequent monitoring of two San Diego sedge patches with confirmed larval presence provided valuable information about the start of the adult flight season. Regular visits (2-3 times per week) were made several weeks following the first observed pupae to detect the start of the flight season. Once adults were detected, surveys were conducted at other locations.

Adult Harbison's dun skipper searches started at patches of San Diego sedge and expanded outward, focusing on potential nectar sources. Due to the dry conditions, few plants were in flower so we were able to inspect nearly all flowers immediately adjacent to the sedge. Surveys were conducted from 9:00-15:00 during periods of appropriate weather (sunny or partly sunny, 20-35°C, and modest wind speeds of less than 15mph).

Locations of all Harbison's dun skipper observations were recorded with a handheld GPS unit. We also recorded the skipper's behavior, species of plant if nectaring, whether the skipper was in the sun or shade, temperature at the exact location of the observation, and other butterfly and skipper species observed in the area. We also present data from our pilot surveys during the 2013 flight season. These earlier surveys were conducted with the goal of developing a better search image for Harbison's dun skipper adults and to begin to characterize their behavior. Plant identifications and taxonomy follows Lightner (2011) while butterfly and skipper identifications and taxonomy follows Glassberg (2001).

Adult Survey Results

We conducted repeated adult Harbison's dun skipper surveys at 19 locations (Table 2). Larvae were previously detected at 14 of these sites, possibly detected at one site, and not detected at four sites. Intensive larval searches were not conducted at Red Mountain. Adult surveys in areas with and without larval detection allowed us to compare the detectability of larvae/pupae versus adults.

In the 2013 pilot season, the first adult was observed on 23 May 2013 at Hollenbeck Canyon Wildlife Area and the last on 16 July 2013 at another location within Hollenbeck Canyon Wildlife Area. It is possible that adults emerged earlier, as we learned to expand our search to include flowers near sedge patches. The flight season may have continued for a short time after 16 July as we stopped surveys due to few observations of adults. The largest daily counts of Harbison's dun skipper adults at a single location included 8 at Loveland Reservoir, between 6 to 10 at Hollenbeck Canyon Wildlife Area, and 6 to 8 at Barrett Lake. A total of 163 adult sightings were made in 2013 (Appendix 2). Surveys in 2013 represent a limited effort, as we prepared for systematic surveys in 2014. For this reason, we are

uncertain if we adequately detected the maximum adult numbers. Even so, the number of adult skippers at each location was low (Table 2) suggesting that local populations are small.

In 2014, the first adult was observed on 15 May 2014 at Hollenbeck Canyon Wildlife Area and the last on 18 June 2014 at Pamo Valley and Hot Springs. The start of the flight season was likely detected within a day or two as the 15 May observation was a single, fresh (bright colors with no wear evident) individual. Harbison's dun skipper adult numbers dropped quickly at the end of the 2014 flight season. Repeated sampling at selected sites provided a reliable population size index by recording the daily maximum adult count. Local populations were smaller than those observed in 2013, likely due to the preceding winter being extremely dry (Table 2). The largest daily count was 5 to 6 adult skippers at Hollenbeck Canyon Wildlife Area. A total of 90 adult sightings were made in 2014 (Appendix 2). This is about half of the number seen in 2013 despite the increased number of surveys in 2014.

Harbison's dun skipper adults were typically observed in sunny areas, nectaring on flowers relatively close to San Diego sedge. On a local scale, the distribution was typically clumped around nectar sources. At most sites, the skippers were observed on a single plant or patch of plants. During surveys, we identified 39 other butterfly and skipper species (Appendix 3).

Table 2. Comparison of larva and adult detection at sites which adult surveys were conducted. Date or dates of maximum counts are provided (month represented by Roman numeral).

Location	Larval Presence	Adult Presence	2013 Highest Count*	2014 Maximum Count & Date*
Barrett Lake	Yes	Yes	6-8	**4**: VI-6
Boden Canyon Ecological Reserve	Yes	Yes	5-6	**1**: V-27, VI-6
Blue Sky Ecological Reserve	No	No	0	**0**
Calavera Nature Preserve	No	No	0	-
Carlsbad Highlands Ecological Reserve	No	No	0	-
Crestridge Ecological Reserve	Yes	Maybe	1	**0**
Daley Ranch	Yes	Yes	1	**2**: VI-6
El Capitan (west of reservoir)	Maybe**	No	0	-
Hellhole Canyon County Park	Yes	Yes	4	**1**: VI-6,13
Hollenbeck Canyon Wildlife Area	Yes	Yes	6-10	**5-6**: VI-11
Lake Hodges	Yes	Yes	5-6	**4**: V-28
Loveland Reservoir	Yes	Yes	8	**4-5**: V-27 or **3-6**: V-29
Pamo Valley (CNF)	Yes	Yes	1-2	**2-3**: V-28, VI-2
Red Mountain	---	Yes	1	-
SDNWR- Las Montanas (South)	Yes	Yes	2	**1**: V-29
San Pasqual Academy	Yes	Maybe	0-1	-
Skye Valley Road (CNF)	Yes	Yes	2	**2**: VI-2
Sycamore Canyon County Park	No	No	0	**0**
Sycuan Peak Ecological Reserve	Yes	Yes	5-6	**2**: V-19,27

**2013 numbers do not necessarily represent an index of maximum adult numbers due to limited surveys. For this reason, the 2013 and 2014 counts are not directly comparable.*

***Unoccupied larval hibernaculum*

Determining the actual number of adults present at a site was very difficult due to their flight patterns. Adult skippers are so fast that observers were unable to track individuals for more than several meters. In addition, they would often move through and around tall, dense vegetation which would eventually obstruct our view of the skipper. Most adults were observed nectaring on one or a few flowers which assisted counting. However, adults would often come and go from a flower and it was not always possible to determine if it was the same one returning. In one case, a preliminary marking study resulted in the capture of three different males from the same perch within a ten minute span, suggesting lack of territoriality and use of the same area by multiple individuals.

The updated distribution of the Harbison's dun skipper (Figure 9A) includes locations in southern Orange County, extreme western Riverside County, San Diego County, and one observation in Mexico. This Mexico observation occurred on 13 June 2009 and was reported by K. Radamaker and D. Powell. MacNeill (1962) and Hoffmann (1941) suspected that the skipper would be found in the northern boreal regions of Baja California, Mexico but there was no confirmation.

Using information from San Diego sedge, larval, and adult surveys, we are able to provide an improved understanding of the Harbison's dun skipper status (Figure 9B). Of the 38 locations with San Diego sedge, two were on private property so they were not searched. Two other locations were not searched extensively so we were not able to determine the status of Harbison's dun skippers in these habitat patches. Of the remaining 34 locations, 18 (53%) were occupied. This value appears to be well below the occupancy rate reported in 1980-1981 where nearly all healthy stands of sedge showed signs of larvae (described in Brown 1982).

Figure 9B also displays sites that we were not able to survey, including several historic locations, so their current status remains uncertain. In addition, three historic locations (Bottle Mountain, Camp Pendleton, and Pechanga Indian Reservation) were obtained shortly prior to completion of this report so field visits were not possible. Six historic populations appear to be extirpated. These include Adobe Falls, Blue Sky Ecological Reserve, El Cajon, El Monte County Park, Flinn Springs County Park, and Sycamore Canyon County Park.

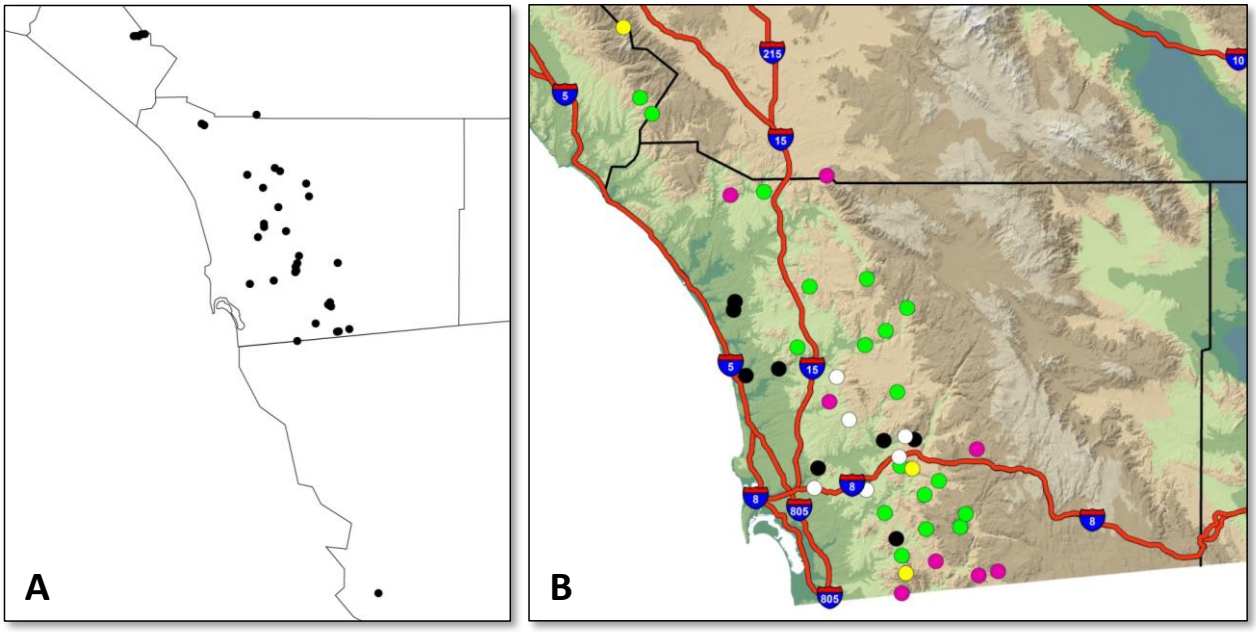

Figure 9. Harbison's dun skipper distribution based on current information. A: Map shows all known locations regardless of current status. B: Map of all known locations in the United States with current status (green = extant, yellow = probably extant but uncertainty exists, white = extirpated, purple = not surveyed).

In general, we were able to locate both larvae and adults at occupied sites (Table 2). There were no cases where we failed to detect larvae but found adults during the flight season. However, there were two sites where adult detection may have been problematic. Near El Capitan Reservoir (west of reservoir), we found what appeared to be a hibernaculum which was at least one year old so occupancy is unclear. Although we cannot be certain, larval presence may have been detected but adults were not. At the San Pasqual Academy site, larvae were easily detected but we were unable to confirm the presence of adults. One skipper was observed for a short period of time flying at a distance and could have been a Harbison's dun skipper or duskywing skipper. And during this dry year (2014), we were unable to detect adults at Crestridge Ecological Reserve.

It is clear that detecting the presence of larvae required less time compared to searching for adults. Moreover, the larval stage lasts for a longer period of time than the adult flight season. Initial indications are that the adult skippers cluster together and consistently use a small area for nectaring. This clumped distribution increases the probability of failing to detect the adults. Interestingly, it is possible to search for hibernacula when conducting adult butterfly surveys.

Activity Threshold: Time of Day

Midway through the flight season, we visited one site (Hollenbeck Canyon Wildlife Area) to determine if there was a time of day threshold for activity. The earliest we arrived to the site was 7:45am and an adult was immediately located at an ambient temperature of 77°F (25°C). It is likely that the skippers had just become active as two other individuals were detected for the first time in the same area during the following 8 minutes.

Activity Threshold: Temperature

We also visited a site (Lake Hodges) when temperatures were below 70°F (21°C), but after 9:00 to determine if there was a temperature threshold for activity. This visit started with cloudy skies and an ambient temperature of 65-67°F (18-19°C) from 9:00am to 9:50am, and eventually rose to 82°F (28°C) by 11:30am when the sun broke through the clouds. The first adult was observed in the sun when the temperature was around 73-75°F (23-24°C). Overall, there was one adult at 73-75°F (23-24°C, 10:15am), three at 75-79°F (24-26°C, 10:35am), and six at 80-84°F (27-29°C, 11:00am). Due to local variation in microclimates just meters away, the exact temperature threshold may be difficult to determine in the field.

Further evidence to suggest that full adult activity requires temperatures of at least 75°F (24°C) was obtained by observations at Hollenbeck Canyon Wildlife Area. Adults were observed nectaring in the shade (73°F) for about one minute, then they would bask in the sun (77°F, 25°C) for about three minutes. This pattern was repeated several times. This suggests that the temperature in the shade was too low for sustained activity since adults typically remain on flowers for extended periods of time.

Very high temperatures also appeared to impact the behavior of adult skippers. On several occasions, adults would be seen flying low through shaded areas or perched in the shade when temperatures in the sun reach upper 80s°F and 90s°F (31°C or hotter). These shaded areas often had relatively thick vegetation, resulting in difficulties with detecting and visually following adults. Specific temperatures were recorded during one survey and found that adults regularly perched in the shade (82°F, 28°C) rather than remain in the sun (88-90°F, 31-32°C) where they had been seen earlier.

Behavior

Of the 228 behavioral observations, Harbison's dun skipper adults were most often found on flowers with 139 observations of nectaring. We recorded 61 adults perching/basking, 13 defending, 13 flying, and 2 engaged in courtship. A total of 14 plant species were observed being used as a nectar source, and nearly all flowers were white, pink, or purple in color (Table 3). However, a yellow sunflower was observed being used once. Few (8) perched on San Diego sedge which has been suggested at least with females (Brown and McGuire 1983). Instead, females were either nectaring or occasionally flying low around and through vegetation. Males tended to perch on the tallest plant in a sunny opening or a horizontal leaf in the sun.

Table 3. Observed nectar sources for adult Harbison's dun skippers.

Common Name	Scientific Name	Flower Color
California Buckwheat	*Erigonum fasciculatum*	White
Black Sage	*Salvia mellifera*	Purple
Narrow-leaf Milkweed	*Asclepias fascicularis*	White
Indian Milkweed	*Asclepias eriocarpa*	White
Slender Sunflower	*Helianthus gracilentus*	Yellow
Bull Thistle	*Cirsium vulgare*	Pink
California Thistle	*Cirsium occidentale*	Pink/Purple
Italian Thistle	*Carduus pycnocephalus*	Pink
Fleabane Daisy	*Erigeron foliosus*	Purple
Coastal Bushmallow	*Malacothamnus fasciculatus*	Purple
Salt Heliotrope	*Heliotropium curassavicum*	White
Hedge Nettle	*Stachys rigida*	Purple
Morning Glory	*Calystegia macrostegia*	White
Watercress	*Nasturtium officinale*	White

We typically observed adults using only one or two species of plants at a particular location; however, this preference varied across sites. For example, adults at Hollenbeck Canyon Wildlife Area were observed nectaring on California buckwheat (predominately a single plant out of many) until narrow-leaf milkweeds started flowering. At Boden Canyon Ecological Reserve, adults would nectar on coastal bushmallow and on a bull thistle, apparently ignoring numerous California buckwheat plants. This strong association with a few plants in the area often resulted in observing 3-6 individuals on the same plant but nowhere else in the vicinity. This type of clumped distributions can be problematic for monitoring, as it increases the probability of failing to detect presence. This became apparent at Sycuan Peak Ecological Reserve as adult skippers were found nectaring on a bull thistle about 70m from San Diego sedge. It is likely that we would have missed these individuals if the path to the sedge had not happened to pass by the thistle.

Discussion

Suggested Monitoring Protocol

At this time, it is still unclear whether larval or adult surveys are more efficient or more reliable for estimating occupancy or population sizes. However, we are able to start outlining protocols for larval and adult surveys. Larvae (and hibernacula) can be fairly easily located on San Diego sedge plants from February to May, and possibly earlier. By looking down into the hibernaculum, larval presence can be confirmed with little or no disturbance to the larva and hibernaculum. For these reasons, we suggest conducting larval surveys to document presence/absence of the Harbison's dun skipper at specific locations. If adult surveys are conducted, they should occur mid-May to early July, with temperatures 75-85°F (24-29°C) and search efforts should be focused on flowering plants near the patches of San Diego sedge. An advantage of conducting adult surveys rather than searching for larvae is that the

skippers usually move out of the shaded ravine and out of the densest patches of poison oak (not surprisingly, poison oak presents a significant challenge to fieldwork).

Threats

Small Population Size and Restricted Distribution

In general, small populations and restricted distributions increase the susceptibility of a species to decline and extinction. This pattern may be typical for the Harbison's dun skipper, but recent extirpations have been documented which results in a further reduced distribution. Habitat loss not only results in local extirpations, but can also fragment habitat and lead to reduced dispersal and gene flow. Low levels of dispersal can be a key factor limiting site occupancy (WallisDeVries 2004) and increase inbreeding (Couvet 2002). Deleterious effects of inbreeding are a larger concern with small populations and include reduced survival and fecundity, which have been documented in other butterflies (Saccheri et al. 1998; Crnokrak and Roff 1999; Frankham 2005; Vandewoestijne et al. 2008).

Habitat Alteration

Adobe Falls is the only extirpation previously reported (Brown and McGuire 1983). Based on an initial assessment of the skipper, Brown (1982) concluded that it is easily extirpated by habitat modifications. Our observations support Brown's assertion. We documented local extirpations as the result of habitat alterations in parks and residential areas. This included bank stabilization/channelization via concrete-lined stream channels accompanied by clearing all vegetation down to the water's edge. This appears to have occurred at Flinn Springs County Park, as Brown and McGuire (1983) reported a relatively large population. Brown (1991) described the population as declining while the park was being constructed, and we were unable to locate *Carex spissa*. At other sites, what appeared to be appropriate habitat (oak woodland with a small stream) was found but all of the vegetation along the stream bank had been removed. At these sites, we did not have information on the historic conditions to use as a reference.

Although several sites have experienced habitat modifications, restoration of the habitat is possible. In areas where the vegetation has been cleared, plantings of San Diego sedge can be successful. At Crestridge Ecological Reserve, we found skipper larvae within a year or two of planting. Restoration should also include potential nectar sources for the adults in an area that receives full sunlight and at a similar elevation as the stream bank.

Fire

We were unable to detect the presence the Harbison's dun skipper in the Poway area at Sycamore Canyon Ecological Reserve and Blue Sky Ecological Reserve. It appears that the 2003 Cedar Fire and 2007 Witch Fire, respectively, extirpated these historic populations. The skipper was observed as recently as 1999 at Sycamore Canyon (G. Pratt pers. comm.). Fire does not always result in extirpation as we were able to detect the skipper at Crestridge Ecological Reserve (2003 Cedar Fire), Hollenbeck Canyon Wildlife Area (2007 Harris Fire), and near the San Pasqual Academy (2007 Witch Fire). The impact of fires can be direct or indirect. Fire can destroy populations or erosion following a fire can result in the removal of San Diego sedge during scouring of the creek bed. This was observed throughout Silverado Canyon and at one location at Crestridge Ecological Reserve. A second indirect impact of fires may be related to

increased grazing on San Diego sedge. Deer grazing may occur following fire where the sedge is often one of very few green plants (D. Faulkner pers. comm.).

Drought

Drought appears to be a significant threat to the skipper by negatively impacting its larval food plant. San Diego sedge inhabits drainages and canyons where water availability is greater than adjacent uplands. It also appears that the sedge benefits from the woodland canopy. In 2014, those sedge plants which were not directly under the riparian woodland canopy appeared stressed which made them unusable (dry, brown leaves) by dun skipper larvae (Figure 10).

Figure 10. Differing conditions of San Diego sedge plants in the same drainage at Hollenbeck Canyon Wildlife Area on 17 June 2014, during a drought year. A) Sedge plants under the woodland canopy were green, B) sedge plants not under a woodland canopy had few or no green leaves.

Goldspotted Oak Borer

The goldspotted oak borer (*Agrilus auroguttatus*) is an invasive, exotic beetle that is responsible for killing oak trees in San Diego County. This beetle appears to have killed trees in a riparian oak woodland at Crestridge Ecological Reserve, which is occupied by the Harbison's dun skipper (Figure 11). Oak tree mortality results in the thinning or loss of the canopy, reducing the amount of shade cast on sedge plants. In turn, this increases the water-stress of these sedge plants and will likely have detrimental impact as described above (Threats: Drought).

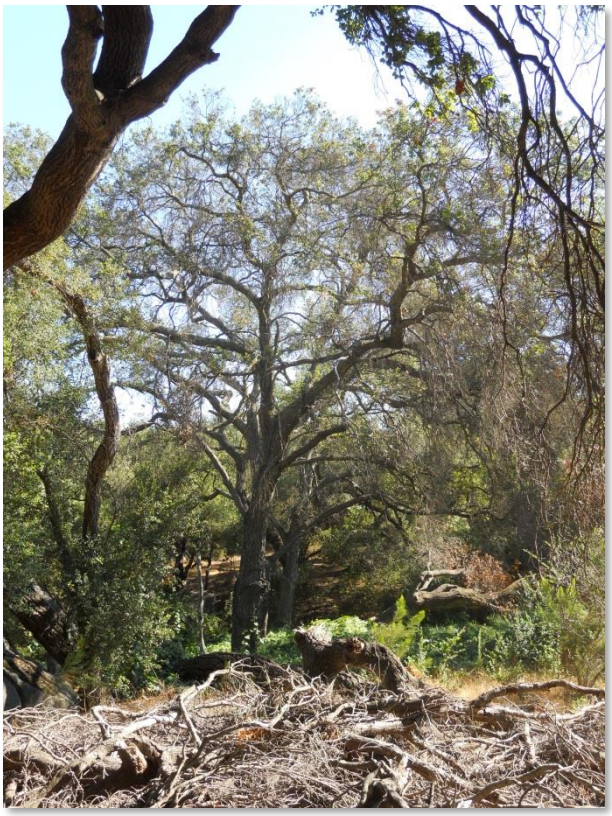

Figure 11. A fallen dead oak tree that has goldspotted oak borer exit holes in the trunk (foreground) and a second oak (middle of photo) has a thinning crown. Harbison's dun skipper larvae have been consistently observed on *Carex spissa* in this oak woodland at Crestridge Ecological Reserve.

Grazing

Cow grazing of San Diego sedges represents another threat to the skipper. At Pamo Valley (City of San Diego), a patch of sedge was found but nearly all leaves were grazed to about 25cm in height. This is at or below the level of where larger larvae would be found. The grazing would result in inadvertent consumption of the larvae and/or competition for the food source. It is unknown if the cows were responsible for an extirpation of a population, but it is likely since the skipper was recorded nearby (Cleveland National Forest).

Conclusion

As part of this comprehensive survey, we identified patches of the Harbison's dun skipper larval host plant, San Diego sedge (*Carex spissa*), on accessible conserved lands. We visited these sites during the larval and adult life stages. Adult surveys are generally the most accurate and cost-effective way to monitor Lepidopteran species, using adapted Pollard walks through suitable habitat. However, we found that locating larvae during the late winter and spring was relatively easy once the sedge had been located. This has been observed by others as well (E. Hein pers. obs. in USFWS 2001). For the Harbison's dun skipper, searching for larvae is likely more efficient than searching for adults because larvae are

present for a longer period of time, have reduced mobility, and are found at a predictable location (on the sedge). For purposes of determining habitat occupancy and distribution of the Harbison's dun skipper, we recommend conducting larval surveys.

Based on surveys for larvae and adults in 2013-2014, the current Harbison's dun skipper distribution includes the foothills in the northern and southern parts of San Diego County, extreme western Riverside County, and southern Orange County. In San Diego County, there appears to be a significant gap in their distribution around the Poway area due to at least two extirpations. Locations of additional historic populations in the Poway area still need to be surveyed.

In Orange County, it is unclear whether the dun skipper is found in Silverado Canyon, its northernmost location, following the 1987 Silverado Fire. Initial fears that the subspecies may have been extirpated from Orange County are not true, but extirpation from Silverado Canyon could represent a substantial range restriction. At the southern end of its range, the Harbison's dun skipper has been documented in northern Baja California, Mexico. Skipper observations from Riverside County and Mexico are not represented in the published literature.

Despite the tendency of adults to congregate in a small area around a few flowering plants, local populations are extremely small. Smaller populations would be expected during a drought (2014), but we were unable to positively detect more than 10 individuals in any single drainage in 2013 as well. The largest single day counts provided by Brown and McGuire (1983) for a particular site were 13 adults at Flinn Springs in 1939 and 7 adults on the north slope of Tecate Peak in 1982.

Surveys during the flight season are important because holometabolous insects generally differ greatly in terms of larval and adult biology. Understanding the biology and behavior of adults provides critical information in terms of describing habitat requirements and dispersal patterns (local and landscape connectivity). Initial observations are that Harbison's dun skipper adults are capable of strong flights; however it is unknown how far they are capable of traveling and how landscape features influence flight patterns.

Based on initial surveys, adults are not specialist feeders but do seem to exhibit strong preferences. However, 2013 and especially 2014 were dry years and likely reduced the number of flowering plants. This resulted in few choices, and could generate the appearance of a strong preference. Additional flight seasons will be required to assess suitable and preferred adult nectar sources.

Recommendations

While we were able to assess the status of most of the historical Harbison's dun skipper populations and document new locations, additional efforts are required to fully describe the distribution of this subspecies, particularly in San Diego County. Due to the remoteness and rugged terrain associated with many riparian oak woodlands in the foothills region, a substantial amount of time is spent just reaching the lower areas where San Diego sedge tends to grow.

One area of particular interest is near Poway. Based on current information, there appears to be a gap in the distribution that was not present in 1981-1982 (Brown 1982, Brown and McGuire 1983) and is likely

the result of the recent wildfires. However, our surveys in the Poway area did not include the immediate area around Poway Lake. Additional surveys near Tecate Peak are also necessary to assess the impacts of recent wildfires. The northern portion of the county, including Camp Pendleton, is another region in need of additional surveys.

Work during additional flight seasons should continue to assess population sizes, annual variation in population size, and nectar source preferences. Identifying additional populations in areas with differing surrounding vegetation types could provide the opportunity to record different nectar sources (habitat requirements). Non-lethal genetic samples (leg) should be collected from all local populations so that a landscape genetics project can assess the genetic structure of the population and infer the dispersal ability of this subspecies.

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Appendix 1: *Carex spissa* Locations.

Site	Relative Quantity of *Carex spissa*
Barrett Lake	Many *Carex spissa* plants
Blue Sky Ecological Reserve	Many *Carex spissa* plants
Boden Canyon Ecological Reserve	Many *Carex spissa* plants
Canada de Vicente Ecological Reserve	Many *Carex spissa* plants
Carlsbad Highlands Ecological Reserve	Several *Carex spissa* plants
Corral Canyon (Cleveland National Forest)	No *Carex spissa*
Crestridge Ecological Reserve	Several *Carex spissa* plants
Daley Ranch	Several *Carex spissa* plants
Dos Picos County Park	No *Carex spissa*
El Capitan Reservoir (South)	Two *Carex spissa* plants
El Capitan Reservoir (West)	Several *Carex spissa* plants
Felicitas Park	Several *Carex spissa* plants
Flinn Springs County Park	No *Carex spissa*
Fox Springs (Cleveland National Forest)	Several *Carex spissa* plants
Harding Canyon (Cleveland National Forest)	One *Carex spissa* plant
Hauser Mountain	No *Carex spissa*
Hellhole Canyon County Park	Several *Carex spissa* plants
Hollenbeck Canyon Wildlife Area	Many *Carex spissa* plants
Hot Springs Canyon (Cleveland National Forest)	Few *Carex spissa* plants
Iron Mountain	No *Carex spissa*
Kit Carson Park	No *Carex spissa*
Lake Calavera Preserve	Many *Carex spissa* plants
Lake Hodges	Many *Carex spissa* plants
Lake Morena	No *Carex spissa*
Lake Murray	No *Carex spissa*
Lopez Canyon	No *Carex spissa*
Loveland Reservoir	Several *Carex spissa* plants
Mission Trails Regional Park	Several *Carex spissa* plants
Oak Creek Nature Center	No *Carex spissa*
Old Ironsides County Park	Several *Carex spissa* plants
Otay Mountain	Many *Carex spissa* plants
Pamo Valley (City of San Diego)	Several *Carex spissa* plants
Pamo Valley (Cleveland National Forest)	Many *Carex spissa* plants
Rancho Jamul Ecological Reserve	Three *Carex spissa* plants
Red Mountain (Rainbow Creek)	Many *Carex spissa* plants
Ronald W Caspers Wilderness Park	No *Carex spissa*
San Diego NWR- Las Montanas (South)	Many *Carex spissa* plants
San Diego NWR- Las Montanas (North)	Several *Carex spissa* plants

Appendix 1: *Carex spissa* Locations (continued)

Site	Relative Quantity of *Carex spissa*
San Diego Zoo Safari Park	Few *Carex spissa* plants
San Dieguito River Park (Clevenger North and South)	No *Carex spissa*
San Dieguito River Park (Del Dios Gorge)	Few *Carex spissa* plants
San Dieguito River Park (Santa Fe Valley)	Few *Carex spissa* plants
San Juan Loop Trail (Cleveland National Forest)	No *Carex spissa*
San Pasqual Academy	Many *Carex spissa* plants
Santiago Canyon	No *Carex spissa*
Silverado Canyon	Few *Carex spissa* plants
Skye Valley Road	Several *Carex spissa* plants
Sloan Canyon Road	Two *Carex spissa* plants
Stetzer County Park	Few *Carex spissa* plants
Sutherland Lake	No *Carex spissa*
Sycamore Canyon County Park	Many *Carex spissa* plants
Sycuan Peak Ecological Reserve	Several *Carex spissa* plants
Wildcat Canyon Road	One *Carex spissa* plant
Whiting Ranch Wilderness Park (Borrego Canyon)	No *Carex spissa*

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
Barrett Lake	32.694356	-116.692838
Barrett Lake	32.696716	-116.703527
Barrett Lake	32.699496	-116.707651
Barrett Lake	32.699604	-116.70786
Barrett Lake	32.699675	-116.707996
Barrett Lake	32.699705	-116.708034
Barrett Lake	32.69971	-116.707976
Barrett Lake	32.699828	-116.708262
Barrett Lake	32.699864	-116.708295
Barrett Lake	32.699892	-116.708243
Barrett Lake	32.69991	-116.709043
Barrett Lake	32.699948	-116.709627
Barrett Lake	32.699967	-116.708541
Barrett Lake	32.69999	-116.708603
Barrett Lake	32.700358	-116.710872
Barrett Lake	32.700371	-116.710919
Barrett Lake	32.700377	-116.710949
Barrett Lake	32.700477	-116.711139
Barrett Lake	32.700495	-116.711134
Barrett Lake	32.700634	-116.711328
Barrett Lake	32.703179	-116.716499
Barrett Lake	32.703491	-116.718202
Barrett Lake	32.712273	-116.70229
Barrett Lake	32.712348	-116.702307
Barrett Lake	32.712747	-116.702298
Barrett Lake	32.712919	-116.702531
Barrett Lake	32.712996	-116.702557
Barrett Lake	32.712999	-116.702558
Barrett Lake	32.713008	-116.702562
Barrett Lake	32.713014	-116.702543
Barrett Lake	32.713016	-116.70254
Barrett Lake	32.713286	-116.702515
Barrett Lake	32.713465	-116.702665
Boden Canyon Ecological Reserve	33.084726	-116.902401
Boden Canyon Ecological Reserve	33.08519	-116.902327
Boden Canyon Ecological Reserve	33.103494	-116.8926
Boden Canyon Ecological Reserve	33.10701	-116.894223
Boden Canyon Ecological Reserve	33.10735	-116.894158
Boden Canyon Ecological Reserve	33.107885	-116.894315

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
Boden Canyon Ecological Reserve	33.108285	-116.894034
Boden Canyon Ecological Reserve	33.10855	-116.893971
Boden Canyon Ecological Reserve	33.111687	-116.892797
Boden Canyon Ecological Reserve	33.112271	-116.892721
Boden Canyon Ecological Reserve	33.112462	-116.892957
Boden Canyon Ecological Reserve	33.11332	-116.893629
Boden Canyon Ecological Reserve	33.11361	-116.894073
Carlsbad Highland Ecological Reserve	33.158246	-117.275448
Crestridge Ecological Reserve	32.826541	-116.860337
Crestridge Ecological Reserve	32.827037	-116.867501
Crestridge Ecological Reserve	32.827288	-116.867681
Crestridge Ecological Reserve	32.827331	-116.859792
Crestridge Ecological Reserve	32.827341	-116.867593
Crestridge Ecological Reserve	32.827343	-116.867602
Crestridge Ecological Reserve	32.827347	-116.867632
Crestridge Ecological Reserve	32.827462	-116.867771
Crestridge Ecological Reserve	32.827508	-116.86791
Crestridge Ecological Reserve	32.827512	-116.867941
Crestridge Ecological Reserve	32.82816	-116.857054
Crestridge Ecological Reserve	32.828211	-116.857234
Crestridge Ecological Reserve	32.82822	-116.857129
Crestridge Ecological Reserve	32.828777	-116.857549
Crestridge Ecological Reserve	32.828781	-116.858003
Crestridge Ecological Reserve	32.828884	-116.858277
Crestridge Ecological Reserve	32.828941	-116.858371
Crestridge Ecological Reserve	32.829029	-116.859374
Crestridge Ecological Reserve	32.833704	-116.858125
Crestridge Ecological Reserve	32.833727	-116.858625
Crestridge Ecological Reserve	32.834044	-116.8566
Crestridge Ecological Reserve	32.834381	-116.854988
Crestridge Ecological Reserve	32.834496	-116.853967
Daley Ranch	33.207423	-117.082495
Daley Ranch	33.207448	-117.0822
Daley Ranch	33.207451	-117.085198
Daley Ranch	33.207553	-117.082015
El Capitan Reservoir (South)	32.859132	-116.800035
El Capitan Reservoir (South)	32.8648	-116.798451
El Capitan Reservoir (West)	32.8848	-116.823398
El Capitan Reservoir (West)	32.885045	-116.823689

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
El Capitan Reservoir (West)	32.885069	-116.823858
El Capitan Reservoir (West)	32.885107	-116.82389
El Capitan Reservoir (West)	32.885109	-116.823888
Hellhole Canyon County Park	33.221011	-116.932823
Hellhole Canyon County Park	33.221095	-116.932753
Hellhole Canyon County Park	33.221095	-116.932644
Hellhole Canyon County Park	33.221173	-116.932868
Hellhole Canyon County Park	33.221186	-116.93258
Hellhole Canyon County Park	33.221295	-116.933136
Hellhole Canyon County Park	33.223204	-116.935783
Hollenbeck Canyon Wildlife Area	32.666635	-116.800467
Hollenbeck Canyon Wildlife Area	32.669597	-116.804411
Hollenbeck Canyon Wildlife Area	32.669774	-116.804284
Hollenbeck Canyon Wildlife Area	32.66991	-116.804213
Hollenbeck Canyon Wildlife Area	32.670078	-116.804107
Hollenbeck Canyon Wildlife Area	32.67035	-116.807189
Hollenbeck Canyon Wildlife Area	32.670548	-116.807075
Hollenbeck Canyon Wildlife Area	32.670549	-116.803806
Hollenbeck Canyon Wildlife Area	32.670692	-116.803757
Hollenbeck Canyon Wildlife Area	32.670853	-116.803674
Hollenbeck Canyon Wildlife Area	32.679057	-116.822686
Hollenbeck Canyon Wildlife Area	32.679228	-116.821942
Hollenbeck Canyon Wildlife Area	32.679685	-116.821702
Hollenbeck Canyon Wildlife Area	32.679884	-116.82163
Hollenbeck Canyon Wildlife Area	32.680081	-116.821447
Hollenbeck Canyon Wildlife Area	32.680292	-116.821189
Hollenbeck Canyon Wildlife Area	32.68093	-116.819252
Hollenbeck Canyon Wildlife Area	32.680958	-116.819006
Hollenbeck Canyon Wildlife Area	32.681182	-116.818721
Hollenbeck Canyon Wildlife Area	32.681486	-116.818451
Hollenbeck Canyon Wildlife Area	32.682306	-116.817974
Hollenbeck Canyon Wildlife Area	32.683812	-116.817787
Hollenbeck Canyon Wildlife Area	32.689051	-116.816192
Hollenbeck Canyon Wildlife Area	32.690021	-116.813968
Hollenbeck Canyon Wildlife Area	32.691169	-116.81323
Hollenbeck Canyon Wildlife Area	32.692102	-116.812749
Hollenbeck Canyon Wildlife Area	32.694286	-116.793145
Hollenbeck Canyon Wildlife Area	32.694443	-116.793067
Hollenbeck Canyon Wildlife Area	32.694562	-116.793685

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
Hollenbeck Canyon Wildlife Area	32.694854	-116.811428
Hollenbeck Canyon Wildlife Area	32.6954	-116.811148
Lake Calavera Preserve	33.175111	-117.275116
Lake Calavera Preserve	33.17512	-117.274844
Lake Calavera Preserve	33.175357	-117.274453
Lake Calavera Preserve	33.175567	-117.274025
Lake Calavera Preserve	33.175882	-117.273769
Lake Calavera Preserve	33.176142	-117.271805
Lake Hodges	33.016487	-117.006481
Lake Hodges	33.01685	-117.018325
Lake Hodges	33.076241	-117.113429
Lake Hodges	33.077685	-117.115485
Lake Hodges	33.077706	-117.115579
Lake Hodges	33.077709	-117.115476
Lake Hodges	33.078493	-117.115524
Lake Hodges	33.078621	-117.115424
Lake Hodges	33.079503	-117.115256
Lake Hodges	33.079669	-117.115085
Lake Hodges	33.07979	-117.114825
Lake Hodges	33.07982	-117.114784
Lake Hodges	33.079963	-117.114773
Lake Hodges	33.080547	-117.114692
Lake Hodges	33.081521	-117.114533
Lake Hodges	33.081526	-117.114506
Lake Hodges	33.081555	-117.114466
Lake Hodges	33.081955	-117.114498
Lake Hodges	33.082295	-117.114757
Lake Hodges	33.082442	-117.114668
Lake Hodges	33.082548	-117.114616
Lake Hodges	33.082895	-117.114263
Lake Hodges	33.083661	-117.114471
Lake Hodges	33.084267	-117.114235
Loveland Reservoir	32.788569	-116.789857
Loveland Reservoir	32.789396	-116.78988
Loveland Reservoir	32.790593	-116.790105
Loveland Reservoir	32.790635	-116.790107
Loveland Reservoir	32.790896	-116.790341
Loveland Reservoir	32.790933	-116.790305
Loveland Reservoir	32.796886	-116.761139

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
Mission Trails Regional Park	32.818818	-117.050262
Mission Trails Regional Park	32.819109	-117.052462
Mission Trails Regional Park	32.819531	-117.052749
Mission Trails Regional Park	32.821996	-117.062529
Mission Trails Regional Park	32.822705	-117.062841
Mission Trails Regional Park	32.822844	-117.062787
Mission Trails Regional Park	32.823271	-117.063244
Mission Trails Regional Park	32.823934	-117.063662
Old Ironsides County Park	32.821678	-116.827725
Old Ironsides County Park	32.822652	-116.827455
Old Ironsides County Park	32.822683	-116.827489
Old Ironsides County Park	32.822803	-116.827417
Old Ironsides County Park	32.823423	-116.82706
Otay Mountain	32.601603	-116.844172
Otay Mountain	32.602144	-116.842631
Otay Mountain	32.636121	-116.85049
Otay Mountain	32.637693	-116.853044
Pamo Valley (City of San Diego)	33.102252	-116.857772
Pamo Valley (City of San Diego)	33.102432	-116.857981
Pamo Valley (City of San Diego)	33.102509	-116.857951
Pamo Valley (CNF)	33.155892	-116.841217
Pamo Valley (CNF)	33.156057	-116.841298
Pamo Valley (CNF)	33.156086	-116.841271
Pamo Valley (CNF)	33.156117	-116.841354
Pamo Valley (CNF)	33.156261	-116.841494
Pamo Valley (CNF)	33.156945	-116.841646
Pamo Valley (CNF)	33.157173	-116.841077
Pamo Valley (CNF)	33.15749	-116.840743
Pamo Valley (CNF)	33.157535	-116.840596
Pamo Valley (CNF)	33.157562	-116.840594
Pamo Valley (CNF)	33.157865	-116.840559
Pamo Valley (CNF)	33.161142	-116.839682
Pamo Valley (County of San Diego)	33.086834	-116.858813
Pamo Valley (County of San Diego)	33.087388	-116.858856
Poser Mountain (Viejas Grade Road)	32.863599	-116.689247
Poser Mountain (Viejas Grade Road)	32.863921	-116.689246
Rancho Jamul Ecological Reserve	32.673999	-116.868038
Rancho Jamul Ecological Reserve	32.674114	-116.868034
Rancho Jamul Ecological Reserve	32.674213	-116.867998

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
Red Mountain	33.407892	-117.198441
Red Mountain	33.407906	-117.198363
Red Mountain	33.408357	-117.197868
Red Mountain	33.408397	-117.197764
Red Mountain	33.408479	-117.197594
San Diego Zoo Safari Park	33.10322	-116.994802
San Dieguito River Park (Del Dios Gorge)	33.040393	-117.157808
San Dieguito River Park (Santa Fe Valley)	33.025704	-117.168172
San Pasqual Academy	33.08166	-116.941402
San Pasqual Academy	33.082659	-116.942617
San Pasqual Academy	33.082796	-116.942892
SDNWR- Las Montanas (North)	32.732653	-116.881692
SDNWR- Las Montanas (North)	32.732679	-116.881529
SDNWR- Las Montanas (North)	32.732935	-116.882266
SDNWR- Las Montanas (South)	32.724964	-116.893377
SDNWR- Las Montanas (South)	32.725656	-116.893489
SDNWR- Las Montanas (South)	32.725964	-116.893598
SDNWR- Las Montanas (South)	32.726141	-116.893603
SDNWR- Las Montanas (South)	32.726211	-116.893703
SDNWR- Las Montanas (South)	32.726273	-116.893752
SDNWR- Las Montanas (South)	32.726442	-116.893733
SDNWR- Las Montanas (South)	32.726743	-116.893967
SDNWR- Las Montanas (South)	32.726913	-116.894042
SDNWR- Las Montanas (South)	32.727013	-116.894148
SDNWR- Las Montanas (South)	32.727181	-116.894273
SDNWR- Las Montanas (South)	32.727464	-116.894302
SDNWR- Las Montanas (South)	32.727642	-116.903918
SDNWR- Las Montanas (South)	32.727644	-116.9037
SDNWR- Las Montanas (South)	32.727685	-116.904121
SDNWR- Las Montanas (South)	32.728378	-116.899827
SDNWR- Las Montanas (South)	32.728554	-116.895333
SDNWR- Las Montanas (South)	32.72857	-116.895378
SDNWR- Las Montanas (South)	32.72861	-116.895392
SDNWR- Las Montanas (South)	32.728612	-116.895362
SDNWR- Las Montanas (South)	32.728757	-116.895419
SDNWR- Las Montanas (South)	32.728757	-116.895313
SDNWR- Las Montanas (South)	32.728858	-116.895451
SDNWR- Las Montanas (South)	32.728892	-116.895501
SDNWR- Las Montanas (South)	32.729041	-116.895987

Appendix 1: *Carex spissa* Locations (continued)

Site	Latitude	Longitude
SDNWR- Las Montanas (South)	32.729105	-116.897313
SDNWR- Las Montanas (South)	32.729157	-116.897471
SDNWR- Las Montanas (South)	32.729174	-116.897161
SDNWR- Sweetwater	32.732847	-116.940447
Skye Valley Road	32.726691	-116.693786
Skye Valley Road	32.726801	-116.694115
Skye Valley Road	32.727951	-116.694122
Sloan Canyon Road	32.76502	-116.835928
Steltzer County Park	32.881935	-116.900449
Steltzer County Park	32.882203	-116.899762
Steltzer County Park	32.882351	-116.899189
Steltzer County Park	32.882576	-116.898679
Steltzer County Park	32.882605	-116.898572
Steltzer County Park	32.882632	-116.898238
Sycamore Canyon County Park	32.924208	-116.986544
Sycamore Canyon County Park	32.924397	-116.986581
Sycamore Canyon County Park	32.925269	-116.986378
Sycamore Canyon County Park	32.925421	-116.986486
Sycamore Canyon County Park	32.926101	-116.986639
Sycamore Canyon County Park	32.926507	-116.986328
Sycamore Canyon County Park	32.926519	-116.986427
Sycamore Canyon County Park	32.927078	-116.98562
Sycamore Canyon County Park	32.927236	-116.985632
Sycamore Canyon County Park	32.927293	-116.985554
Sycamore Canyon County Park	32.927312	-116.985539
Sycamore Canyon County Park	32.927373	-116.985553
Sycamore Canyon County Park	32.927479	-116.985556
Sycamore Canyon County Park	32.927525	-116.985477
Sycamore Canyon County Park	32.927582	-116.985407
Sycamore Canyon County Park	32.92762	-116.985382
Sycuan Peak Ecological Reserve	32.764797	-116.795321
Sycuan Peak Ecological Reserve	32.765891	-116.795559
Sycuan Peak Ecological Reserve	32.770505	-116.812779
Wildcat Canyon Road	32.899157	-116.888471

Appendix 2: Harbison's dun skipper observations, adults.

Date	Site	Latitude	Longitude
23-May-13	Hollenbeck Canyon WA	32.695412	-116.811159
29-May-13	Hollenbeck Canyon WA	32.695533	-116.811126
29-May-13	SDNWR- Las Montanas South	32.728584	-116.89517
29-May-13	SDNWR- Las Montanas South	32.728591	-116.895171
31-May-13	Barrett Lake	32.696642	-116.703388
31-May-13	Barrett Lake	32.696642	-116.703388
31-May-13	Daley Ranch	33.207456	-117.085203
31-May-13	Hellhole Canyon Co Pk	33.221151	-116.93276
31-May-13	Hellhole Canyon Co Pk	33.221152	-116.932735
31-May-13	SDNWR- Las Montanas South	32.728603	-116.895247
31-May-13	SDNWR- Las Montanas South	32.728604	-116.895265
31-May-13	Loveland Reservoir	32.796605	-116.760922
3-Jun-13	Hellhole Canyon Co Pk	33.221063	-116.932695
3-Jun-13	Hellhole Canyon Co Pk	33.221137	-116.932706
3-Jun-13	Hellhole Canyon Co Pk	33.221142	-116.932724
3-Jun-13	Hellhole Canyon Co Pk	33.221165	-116.932926
3-Jun-13	Lake Hodges	33.082874	-117.114021
3-Jun-13	Lake Hodges	33.082879	-117.11404
3-Jun-13	Lake Hodges	33.083207	-117.113657
3-Jun-13	Lake Hodges	33.083216	-117.113622
3-Jun-13	Lake Hodges	33.083216	-117.113622
4-Jun-13	Crestridge ER	32.828148	-116.857045
5-Jun-13	Barrett Lake	32.696656	-116.703354
5-Jun-13	Barrett Lake	32.696661	-116.703314
5-Jun-13	Barrett Lake	32.696788	-116.703428
5-Jun-13	Barrett Lake	32.712454	-116.70226
5-Jun-13	Barrett Lake	32.713448	-116.702587
5-Jun-13	Hollenbeck Canyon WA	32.681485	-116.818452
5-Jun-13	Hollenbeck Canyon WA	32.694465	-116.792981
5-Jun-13	Hollenbeck Canyon WA	32.694529	-116.793045
5-Jun-13	Hollenbeck Canyon WA	32.69463	-116.793696
5-Jun-13	Hollenbeck Canyon WA	32.69463	-116.793697
5-Jun-13	Hollenbeck Canyon WA	32.694637	-116.79363
5-Jun-13	Hollenbeck Canyon WA	32.695503	-116.811053
5-Jun-13	Sky Valley Rd	32.726797	-116.694171
5-Jun-13	Sky Valley Rd	32.726884	-116.6942
5-Jun-13	Sycuan Peak ER	32.76539	-116.795766
5-Jun-13	Sycuan Peak ER	32.765391	-116.795769
5-Jun-13	Sycuan Peak ER	32.76541	-116.795805

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
5-Jun-13	Sycuan Peak ER	32.765426	-116.795807
5-Jun-13	Sycuan Peak ER	32.765917	-116.795658
6-Jun-13	Boden Canyon ER	33.112081	-116.892723
6-Jun-13	Boden Canyon ER	33.112877	-116.893339
6-Jun-13	Boden Canyon ER	33.112984	-116.893396
6-Jun-13	Boden Canyon ER	33.112984	-116.893403
6-Jun-13	Boden Canyon ER	33.112985	-116.893404
6-Jun-13	Boden Canyon ER	33.11299	-116.893373
6-Jun-13	Boden Canyon ER	33.407909	-117.198233
6-Jun-13	Hollenbeck Canyon WA	32.694557	-116.793788
6-Jun-13	Hollenbeck Canyon WA	32.694558	-116.793788
6-Jun-13	Hollenbeck Canyon WA	32.694564	-116.793746
6-Jun-13	Hollenbeck Canyon WA	32.69457	-116.793542
6-Jun-13	Hollenbeck Canyon WA	32.694582	-116.793657
7-Jun-13	Boden Canyon ER	32.796359	-116.760787
7-Jun-13	Lake Hodges	33.082893	-117.114017
7-Jun-13	Lake Hodges	33.082985	-117.114069
7-Jun-13	Lake Hodges	33.082985	-117.114056
7-Jun-13	Lake Hodges	33.082986	-117.114053
7-Jun-13	Lake Hodges	33.083038	-117.113993
7-Jun-13	Lake Hodges	33.083245	-117.113641
7-Jun-13	Loveland Reservoir	32.796355	-116.760785
7-Jun-13	Loveland Reservoir	32.796355	-116.760785
7-Jun-13	Loveland Reservoir	32.796355	-116.760785
10-Jun-13	Boden Canyon ER	33.112073	-116.892842
10-Jun-13	Boden Canyon ER	33.112854	-116.893392
10-Jun-13	Boden Canyon ER	33.113	-116.893374
10-Jun-13	Boden Canyon ER	33.113002	-116.89338
10-Jun-13	Boden Canyon ER	33.113002	-116.89338
10-Jun-13	Boden Canyon ER	33.113003	-116.89338
10-Jun-13	Lake Hodges	33.082987	-117.114002
10-Jun-13	Lake Hodges	33.083138	-117.113637
10-Jun-13	Lake Hodges	33.083212	-117.113624
10-Jun-13	Lake Hodges	33.221195	-116.93303
11-Jun-13	Hollenbeck Canyon WA	32.694542	-116.793793
11-Jun-13	Hollenbeck Canyon WA	32.694596	-116.793991
11-Jun-13	Hollenbeck Canyon WA	32.694598	-116.793998
11-Jun-13	Hollenbeck Canyon WA	32.694604	-116.793761
11-Jun-13	Hollenbeck Canyon WA	32.694604	-116.793761

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
11-Jun-13	Hollenbeck Canyon WA	32.694616	-116.793775
11-Jun-13	Hollenbeck Canyon WA	32.694624	-116.793569
11-Jun-13	Hollenbeck Canyon WA	32.694624	-116.793569
12-Jun-13	Barrett Lake	32.696417	-116.70275
12-Jun-13	Barrett Lake	32.696468	-116.70273
12-Jun-13	Barrett Lake	32.697782	-116.702139
12-Jun-13	Barrett Lake	32.712401	-116.702306
12-Jun-13	Loveland Reservoir	32.796282	-116.760751
12-Jun-13	Loveland Reservoir	32.796287	-116.760749
12-Jun-13	Loveland Reservoir	32.796324	-116.760759
12-Jun-13	Loveland Reservoir	32.796385	-116.760777
12-Jun-13	Loveland Reservoir	32.796385	-116.760776
12-Jun-13	Loveland Reservoir	32.796385	-116.760776
12-Jun-13	Loveland Reservoir	32.79649	-116.760871
12-Jun-13	Loveland Reservoir	32.796502	-116.760854
12-Jun-13	Pamo Valley	33.157714	-116.840549
12-Jun-13	Pamo Valley	33.157934	-116.840631
12-Jun-13	Sky Valley Rd	32.726866	-116.694276
12-Jun-13	Sky Valley Rd	32.7269	-116.694219
12-Jun-13	Sycuan Peak ER	32.765453	-116.795743
13-Jun-13	Barrett Lake	33.083022	-117.114314
13-Jun-13	Boden Canyon ER	33.112845	-116.89338
13-Jun-13	Boden Canyon ER	33.112845	-116.89338
13-Jun-13	Boden Canyon ER	33.113034	-116.89349
13-Jun-13	Hellhole Canyon Co Pk	33.083287	-117.113554
13-Jun-13	Hollenbeck Canyon WA	32.694571	-116.793681
13-Jun-13	Hollenbeck Canyon WA	32.694575	-116.793789
13-Jun-13	Hollenbeck Canyon WA	32.694576	-116.793786
13-Jun-13	Hollenbeck Canyon WA	32.694577	-116.793789
13-Jun-13	Hollenbeck Canyon WA	32.694583	-116.793779
13-Jun-13	Loveland Reservoir	33.082786	-117.113992
13-Jun-13	Loveland Reservoir	33.082819	-117.114002
13-Jun-13	Loveland Reservoir	33.083161	-117.11363
13-Jun-13	Loveland Reservoir	33.112818	-116.893357
13-Jun-13	Red Mountain	33.112845	-116.89338
17-Jun-13	Hollenbeck Canyon WA	32.694557	-116.793991
17-Jun-13	Hollenbeck Canyon WA	32.694563	-116.793752
17-Jun-13	Hollenbeck Canyon WA	32.694565	-116.79399
17-Jun-13	Hollenbeck Canyon WA	32.69457	-116.793752

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
17-Jun-13	Hollenbeck Canyon WA	32.6946	-116.793712
17-Jun-13	Hollenbeck Canyon WA	32.694615	-116.79328
17-Jun-13	Hollenbeck Canyon WA	32.694627	-116.793317
17-Jun-13	Hollenbeck Canyon WA	32.694627	-116.793316
17-Jun-13	Hollenbeck Canyon WA	32.694628	-116.793294
19-Jun-13	Hollenbeck Canyon WA	32.694601	-116.793794
19-Jun-13	Hollenbeck Canyon WA	32.694602	-116.79379
19-Jun-13	Hollenbeck Canyon WA	32.694602	-116.79379
19-Jun-13	Hollenbeck Canyon WA	32.69464	-116.793352
19-Jun-13	Hollenbeck Canyon WA	32.694673	-116.793238
19-Jun-13	Hollenbeck Canyon WA	32.694673	-116.793238
19-Jun-13	Sycuan Peak ER	32.76546	-116.795747
19-Jun-13	Sycuan Peak ER	32.76558	-116.795713
19-Jun-13	Sycuan Peak ER	32.76586	-116.795724
20-Jun-13	Barrett Lake	32.696697	-116.703331
20-Jun-13	Barrett Lake	32.69671	-116.703317
20-Jun-13	Barrett Lake	32.69671	-116.703317
20-Jun-13	Barrett Lake	32.69671	-116.703317
20-Jun-13	Barrett Lake	32.69671	-116.703317
20-Jun-13	Lake Hodges	32.69671	-116.703317
20-Jun-13	Loveland Reservoir	32.796503	-116.760826
21-Jun-13	Boden Canyon ER	33.112862	-116.893425
21-Jun-13	Boden Canyon ER	33.112862	-116.893424
21-Jun-13	Boden Canyon ER	33.112862	-116.893424
21-Jun-13	Lake Hodges	33.082649	-117.114457
21-Jun-13	Lake Hodges	33.082837	-117.114007
25-Jun-13	Hollenbeck Canyon WA	32.694511	-116.7937
25-Jun-13	Hollenbeck Canyon WA	32.694544	-116.793675
25-Jun-13	Hollenbeck Canyon WA	32.694579	-116.793823
25-Jun-13	Hollenbeck Canyon WA	32.69458	-116.793823
25-Jun-13	Hollenbeck Canyon WA	32.694658	-116.793229
27-Jun-13	Hollenbeck Canyon WA	32.694558	-116.793679
27-Jun-13	Hollenbeck Canyon WA	32.694581	-116.793657
27-Jun-13	Hollenbeck Canyon WA	32.694604	-116.793807
27-Jun-13	Hollenbeck Canyon WA	32.694607	-116.793803
27-Jun-13	Hollenbeck Canyon WA	32.694667	-116.793918
1-Jul-13	Barrett Lake	32.698252	-116.705013
1-Jul-13	Barrett Lake	32.698587	-116.706331
1-Jul-13	Loveland Reservoir	32.796356	-116.760742

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
1-Jul-13	Loveland Reservoir	32.796356	-116.760738
3-Jul-13	Hollenbeck Canyon WA	32.694464	-116.79377
3-Jul-13	Hollenbeck Canyon WA	32.694464	-116.79377
3-Jul-13	Hollenbeck Canyon WA	32.694464	-116.79377
3-Jul-13	Hollenbeck Canyon WA	32.694464	-116.793769
3-Jul-13	Hollenbeck Canyon WA	32.694464	-116.793769
16-Jul-13	Hollenbeck Canyon WA	32.694556	-116.793669
15-May-14	Hollenbeck Canyon WA	32.694582	-116.793146
19-May-14	Barrett Lake	32.696723	-116.703281
19-May-14	Loveland Reservoir	32.796282	-116.760746
19-May-14	Loveland Reservoir	32.79637	-116.760719
19-May-14	Loveland Reservoir	32.796281	-116.760731
19-May-14	Loveland Reservoir	32.796443	-116.760784
19-May-14	Sycuan Peak ER	32.765442	-116.795728
19-May-14	Sycuan Peak ER	32.765929	-116.795708
19-May-14	Lake Hodges	33.083208	-117.113673
25-May-14	Hollenbeck Canyon WA	32.694549	-116.793173
27-May-14	Sycuan Peak ER	32.765442	-116.795707
27-May-14	Sycuan Peak ER	32.765551	-116.795764
27-May-14	Loveland Reservoir	32.796435	-116.760807
27-May-14	Loveland Reservoir	32.7965	-116.760784
27-May-14	Loveland Reservoir	32.796461	-116.760827
27-May-14	Loveland Reservoir	32.796251	-116.760774
27-May-14	Pamo Valley (CNF)	33.158001	-116.840667
27-May-14	Pamo Valley (CNF)	33.157752	-116.840567
27-May-14	Pamo Valley (CNF)	33.160731	-116.839805
27-May-14	Boden Canyon ER	33.111952	-116.892811
28-May-14	Lake Hodges	33.083104	-117.11439
28-May-14	Lake Hodges	33.083166	-117.113603
28-May-14	Lake Hodges	33.083323	-117.112931
28-May-14	Lake Hodges	33.083304	-117.113275
29-May-14	Hollenbeck Canyon WA	32.694624	-116.794009
29-May-14	Hollenbeck Canyon WA	32.694552	-116.793718
29-May-14	Loveland Reservoir	32.796436	-116.76081
29-May-14	Loveland Reservoir	32.796465	-116.760758
29-May-14	Loveland Reservoir	32.79652	-116.760761
29-May-14	Las Montanas (FWS)	32.729319	-116.897252
30-May-14	Daley Ranch	33.20747	-117.0852
2-Jun-14	Pamo Valley (CNF)	33.157702	-116.840544

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
2-Jun-14	Pamo Valley (CNF)	33.15763	-116.840557
2-Jun-14	Loveland Reservoir	32.796524	-116.760823
2-Jun-14	Loveland Reservoir	32.796472	-116.760859
2-Jun-14	Skye Valley Rd	32.726798	-116.694206
2-Jun-14	Skye Valley Rd	32.726806	-116.694208
2-Jun-14	Barrett Lake	32.696665	-116.703303
2-Jun-14	Barrett Lake	32.696663	-116.703301
2-Jun-14	Barrett Lake	32.696887	-116.703529
2-Jun-14	Barrett Lake	32.713432	-116.702598
3-Jun-14	Hollenbeck Canyon WA	32.694591	-116.793757
4-Jun-14	Hollenbeck Canyon WA	32.694562	-116.793677
4-Jun-14	Hollenbeck Canyon WA	32.694592	-116.793709
4-Jun-14	Hollenbeck Canyon WA	32.694616	-116.793987
4-Jun-14	Hollenbeck Canyon WA	32.694551	-116.793671
5-Jun-14	Sycuan Peak ER	32.76587	-116.795691
6-Jun-14	Daley Ranch	33.207613	-117.085125
6-Jun-14	Daley Ranch	33.207593	-117.085132
6-Jun-14	Hellhole Canyon Co Pk	33.221115	-116.932725
6-Jun-14	Boden Canyon ER	33.112317	-116.892852
9-Jun-14	Hollenbeck Canyon WA	32.694588	-116.793758
9-Jun-14	Hollenbeck Canyon WA	32.694543	-116.793776
9-Jun-14	Hollenbeck Canyon WA	32.694607	-116.793993
9-Jun-14	Hollenbeck Canyon WA	32.694606	-116.793993
9-Jun-14	Loveland Reservoir	32.796597	-116.760898
9-Jun-14	Loveland Reservoir	32.796625	-116.760778
9-Jun-14	Barrett Lake	32.696644	-116.703273
10-Jun-14	Lake Hodges	33.08295	-117.113935
10-Jun-14	Lake Hodges	33.082871	-117.114039
10-Jun-14	Lake Hodges	33.083143	-117.114433
10-Jun-14	Lake Hodges	33.08332	-117.113006
11-Jun-14	Hollenbeck Canyon WA	32.694626	-116.793765
11-Jun-14	Hollenbeck Canyon WA	32.694625	-116.793766
11-Jun-14	Hollenbeck Canyon WA	32.694625	-116.793975
11-Jun-14	Hollenbeck Canyon WA	32.694579	-116.794057
11-Jun-14	Hollenbeck Canyon WA	32.694556	-116.79377
11-Jun-14	Hollenbeck Canyon WA	32.694578	-116.793991
11-Jun-14	Hollenbeck Canyon WA	32.694618	-116.793751
12-Jun-14	Barrett Lake	32.696615	-116.70324
12-Jun-14	Hollenbeck Canyon WA	32.694577	-116.793964

Appendix 2: Adult Harbison's dun skipper observations (continued)

Date	Site	Latitude	Longitude
12-Jun-14	Hollenbeck Canyon WA	32.694576	-116.793965
12-Jun-14	Otay Mountain	32.638875	-116.85439
13-Jun-14	Hollenbeck Canyon WA	32.69459	-116.793768
13-Jun-14	Hollenbeck Canyon WA	32.694572	-116.793994
13-Jun-14	Hellhole Canyon Co Pk	33.221126	-116.932705
16-Jun-14	Loveland Reservoir	32.796588	-116.76073
16-Jun-14	Loveland Reservoir	32.796587	-116.760729
16-Jun-14	Loveland Reservoir	32.796587	-116.760728
16-Jun-14	Loveland Reservoir	32.79649	-116.760787
16-Jun-14	Lake Hodges	33.08284	-117.114021
16-Jun-14	Lake Hodges	33.082842	-117.114015
16-Jun-14	Lake Hodges	33.082863	-117.113841
16-Jun-14	Lake Hodges	33.083331	-117.11287
17-Jun-14	Barrett Lake	32.696666	-116.703284
17-Jun-14	Otay Mountain	32.638362	-116.854194
18-Jun-14	Hot Springs (CNF)	33.606957	-117.510641
18-Jun-14	Pamo Valley (CNF)	33.157967	-116.840666
18-Jun-14	Pamo Valley (CNF)	33.157896	-116.840579

Appendix 2: Larval Harbison's dun skipper observations

Date	Site	Latitude	Longitude
7-Mar-13	Crestridge ER	32.827331	-116.859792
18-Mar-13	Hollenbeck Canyon WA	32.694286	-116.793145
18-Mar-13	Hollenbeck Canyon WA	32.694562	-116.793685
18-Mar-13	Hollenbeck Canyon WA	32.694286	-116.793145
18-Mar-13	Hollenbeck Canyon WA	32.694286	-116.793145
18-Mar-13	Hollenbeck Canyon WA	32.694286	-116.793145
28-Mar-13	SDNWR- Las Montanas South	32.728554	-116.895333
28-Mar-13	SDNWR- Las Montanas South	32.72857	-116.895378
28-Mar-13	SDNWR- Las Montanas South	32.728892	-116.895501
28-Mar-13	SDNWR- Las Montanas South	32.72857	-116.895378
11-Apr-13	SDNWR- Las Montanas South	32.729157	-116.897471
11-Apr-13	Hollenbeck Canyon WA	32.678503	-116.781345
11-Apr-13	SDNWR- Las Montanas South	32.729157	-116.897471
11-Apr-13	SDNWR- Las Montanas South	32.729157	-116.897471
11-Apr-13	Hollenbeck Canyon WA	32.678503	-116.781345
15-Apr-13	Hollenbeck Canyon WA	33.221011	-116.932823
15-Apr-13	Hollenbeck Canyon WA	33.221186	-116.93258
15-Apr-13	Hollenbeck Canyon WA	33.221173	-116.932868
15-Apr-13	Hollenbeck Canyon WA	33.221011	-116.932823
15-Apr-13	Hollenbeck Canyon WA	33.221186	-116.93258
25-Apr-13	Barrett Lake	32.699892	-116.708243
25-Apr-13	Barrett Lake	32.696716	-116.703527
25-Apr-13	Barrett Lake	32.713465	-116.702665
25-Apr-13	Barrett Lake	32.696716	-116.703527
25-Apr-13	Barrett Lake	32.696716	-116.703527
25-Apr-13	Barrett Lake	32.696716	-116.703527
8-May-13	Loveland Reservoir	32.790593	-116.790105
13-Dec-13	Hollenbeck Canyon WA	32.702727	-116.817415
13-Dec-13	Hollenbeck Canyon WA	32.702727	-116.817415
24-Mar-14	Hot Springs (CNF)	33.606959	-117.510606
8-Apr-14	Hollenbeck Canyon WA	32.694582	-116.793662

Appendix 2: Pupal Harbison's dun skipper observations

Date	Site	Latitude	Longitude
25-Apr-13	Barrett Lake	32.713465	-116.702665
25-Apr-13	Barrett Lake	32.712747	-116.702298
26-Apr-13	Lake Hodges	33.082895	-117.114263
2-May-13	Daley Ranch	33.207451	-117.085198
8-May-13	Loveland Reservoir	32.790933	-116.790305
8-May-13	Loveland Reservoir	32.796886	-116.761139
8-May-13	Loveland Reservoir	32.790933	-116.790305
8-May-13	Loveland Reservoir	32.790933	-116.790305
13-May-13	Sycuan Peak	32.765891	-116.795559
13-May-13	Sycuan Peak	32.765891	-116.795559
28-May-13	Pamo Valley	33.156057	-116.841298
28-May-13	Pamo Valley	33.155892	-116.841217
28-May-13	Pamo Valley	33.155892	-116.841217
28-May-13	Pamo Valley	33.155892	-116.841217
22-Apr-14	Crestridge ER	32.828863	-116.85834
12-Jun-14	Otay Mountain	32.638499	-116.854281

Appendix 3. Other butterfly and skipper species observed during surveys.

Common Name	Scientific Name	Common Name	Scientific Name
*Western Giant Swallowtail	*Papilio rumiko*	Acmon Blue	*Plebejus acmon*
Western Tiger Swallowtail	*Papilio rutulus*	Lupine Blue	*Plebejus lupinus*
Pale Swallowtail	*Papilio eurymedon*	Mormon Metalmark	*Apodemia mormo*
Checkered White	*Pontia protodice*	Callippe Fritillary	*Speyeria callippe*
Cabbage White	*Pieris rapae*	Gabb's Checkerspot	*Chlosyne gabbii*
Sara Orangetip	*Anthocharis sara*	Mylitta Crescent	*Phyciodes mylitta*
Orange Sulphur	*Colias eurytheme*	Mourning Cloak	*Nymphalis antiopa*
Harford's Sulphur	*Colais Alexandra harfordii*	American Lady	*Vanessa virginiensis*
California Dogface	*Colais eurydice*	Painted Lady	*Vanessa cardui*
Cloudless Sulphur	*Phoebis sennae*	Common Buckeye	*Junonia coenia*
Sleepy Orange	*Eurema nicippe*	Lorquin's Admiral	*Limenitis lorquini*
Dainty Sulphur	*Nathalis iole*	California Sister	*Adelpha bredowii*
Great Copper	*Lycaena xanthoides*	Common Ringlet	*Coenonympha tullia*
California Hairstreak	*Satyrium californica*	Monarch	*Danaus plexippus*
Sylvan Hairstreak	*Satyrium sylvinus*	Queen	*Danaus gilippus*
Hedgerow Hairstreak	*Satyrium saepium*	Propertius Duskywing	*Erynnis propertius*
Gold-hunter's Hairstreak	*Satyrium auretorum*	Funereal Duskywing	*Erynnis funeralis*
Mountain Mahogany Hairstreak	*Satyrium tetra*	Northern White Skipper	*Heliopetes ericetorum*
Brown Elfin	*Callophrys augustinus*	Orange Skipperling	*Copaeodes aurantiaca*
Gray Hairstreak	*Strymon melinus*	Fiery Skipper	*Hylephila phyleus*
Marine Blue	*Leptotes marina*	Woodland Skipper	*Ochlodes sylvanoides*
Spring Azure	*Celastrina ladon*	Rural Skipper	*Ochlodes agricola*
Spotted/Dotted Blue	*Euphilotes sp.*	Umber Skipper	*Poanes melane*

Unconfirmed but suspected: mournful duskywing (*Erynnis tristis*), sachem skipper (*Atalopedes capestris*)

* Giant swallowtails (*Papilio cresphontes*) were recently split into two separate species, with the western giant swallowtail described from the western United States (Shiraiwa et al. 2014). Citation: Shiraiwa K, Q Cong and NV Grishin. 2014. A new *Heraclides* swallowtail (Lepidoptera, Papilionidae) from North America is recognized by the patter on its neck. ZooKeys. 468:85-135.