

Holocarpha macradenia
(Santa Cruz tarplant)
5-Year Review:
Summary and Evaluation



Photos: Kim Hayes, Elkhorn Slough Foundation

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
Ventura, California
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5-YEAR REVIEW

Holocarpha macradenia (Santa Cruz tarplant)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

As summarized in the final listing rule for the species (Service 2000), *Holocarpha macradenia* (Santa Cruz tarplant) is an aromatic annual herb in the aster family (Asteraceae). *Holocarpha macradenia* is one of only four species of the genus *Holocarpha*, all geographically restricted to California. At the time of listing, we identified the primary threats to *H. macradenia* as: alteration and destruction of habitat due to historic and ongoing urban and commercial development; historic habitat alteration by grazing of native vegetation; limited success of seed transplant (experimentally seeded) populations; and competition from nonnative, invasive plants. *Holocarpha macradenia* occurs in 14 native and 4 to 8 experimentally seeded populations in coastal grasslands and prairies in Contra Costa, Santa Cruz, and Monterey Counties, California (Service 2000).

Methodology Used to Complete This Review:

This review was prepared by the Ventura Fish and Wildlife Office (VFWO), following guidance issued by the Pacific Southwest Region of the Service in March 2008. We used survey information from experts who have been monitoring various localities of this species and the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Wildlife (formerly the California Department of Fish and Game) (CDFW). Personal communications with experts were our primary sources of information used to update the species' status and threats. A recovery plan has not been prepared for this species. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing. We focus on current threats to

the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

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Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on May 21, 2010 (Service 2010). No comments were received as a result of that notice.

Listing History:

Original Listing

FR Notice: 65 FR 14898

Date of Final Listing Rule: March 20, 2000

Entity Listed: *Holocarpha macradenia* (Santa Cruz tarplant), a plant species

Classification: Threatened

State Listing

Holocarpha macradenia was listed by the State of California as endangered in 1979.

Associated Rulemakings:

Critical Habitat

FR Notice: 67 FR 63968

Date Designated: October 16, 2002

Area Designated: 2,902 acres (1,175 hectares (ha))

Review History: Since the listing rule was published in 2000 and critical habitat was designated in 2002, there have been no formal reviews conducted for *Holocarpha macradenia*.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Holocarpha macradenia* is 8 according to the Service's 2009 Recovery Data Call for the Ventura Fish and Wildlife Office (Service 2009). This number is based on a 1-18 ranking system where 1 is the highest ranked recovery priority and 18 is the lowest. This number indicates that *H. macradenia* is a species that faces a moderate degree of threat and has a high potential for recovery (Service 1983).

Recovery Plan or Outline

A recovery plan for *Holocarpha macradenia* has not been prepared.

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines “species” as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. Because the species under review is a plant, the DPS policy is not applicable, and the application of the DPS policy to the species’ listing is not addressed further in this review.

Information on the Species and its Status

Species Biology and Life History

Holocarpha macradenia is an aromatic annual herb in the aster family (Asteraceae), and is one of only four species of the genus *Holocarpha*, all geographically restricted to California. *Holocarpha macradenia* occurs in coastal terrace prairie habitat along the coast of central California in Contra Costa, Santa Cruz, and Monterey Counties.

Holocarpha macradenia is an upright annual plant, standing on average, less than 24 inches (61.0 centimeters (cm)) tall, and is distinguished from other members of the genus by its numerous ray flowers and black anthers. Like many tarplants, *H. macradenia* is strongly scented and produces a sticky resin (Keil 1993, Hayes 1998, Holl and Hayes 2006). Flowering from July to October, the inflorescences comprise yellow ray and disc flowers. Native bees, flies, wasps, and winged beetles have been observed pollinating *H. macradenia* (Barber 2002). Most seeds remain on the plant until the first significant rain (0.6-1.2 inches (15–30 millimeters (mm)) in late autumn (Service 2002, Holl and Hayes 2006).

Seed Ecology

The basal rosette (leaves radiating from the stem near ground-level) increases in size until approximately June, when plants produce a stem that reaches a height of 11.8 to 31.5 inches (30 to 80 centimeters (cm)). Plants produce 1 to 60 inflorescences with two types of flowers that produce two types of achenes (seeds) with different morphologies and requirements for germination. Seeds from the ray flowers have a thicker seed coat, long-term dormancy, and complex germination cues; whereas seeds from the disk flowers are lighter, and narrower. Neither type of seed appears to have a structural means for dispersal, and most fall within 17.7 inches (45 cm) of the plant (Holl and Hayes 2006) though it is possible that some ray seeds may be dispersed over long distances by animals (Satterthwaite *et al.* 2007).

Holocarpha macradenia is self-incompatible, meaning that individuals will not produce viable seeds without cross pollinating with other individuals (Baldwin, *in litt.* 2001). Gene flow between populations increases the likelihood of viability by maintaining genetic diversity;

therefore, gene flow is essential for the long-term survival of self-incompatible species (Ellstrand 1992).

Results of studies indicate that disk seeds produced by *Holocarpha macradenia* germinate within a year of production while ray seeds form persistent seed banks. The precise length of time *H. macradenia* seed banks remain viable is unknown, though there is an account of *H. macradenia* seedlings emerging from a pile of soil scraped from a construction site 8 years after it last hosted adult plants. It is possible that seed bank survival is high, since seeds known to be at least 15 years old have successfully germinated (Barber 2002). Because *H. macradenia* is capable of establishing seed banks, sites that support populations of the species, particularly small populations (fewer than 100 individuals), may not display any individuals in a given year, but can have viable populations in other years (Service 2000). Management of seed banks (i.e., scraping or other habitat manipulations to enhance germination) must be balanced between germination of seeds in the seed bank before they become too old, and the risk of overstimulation that may result in depletion of the seed bank and reduction of its ability to buffer against environmental variability (Satterthwaite *et al.* 2007, Watsonville Wetlands Watch 2009).

Spatial Distribution

Historically, habitat for *Holocarpha macradenia* occurred on grasslands and prairies found on coastal terraces in elevations below 330 feet (100 m), from Monterey County, north to Contra Costa and Marin Counties. *Holocarpha macradenia* was known from “low dry fields about San Francisco Bay” (Jepson 1925). Early herbarium collections were made in Santa Cruz County in 1881, Marin County in 1883, Alameda County in 1891, San Francisco County in 1916, and in Contra Costa County in 1974 (Service 2000, Consortium 2010). At the time of listing in 2000, *Holocarpha macradenia* was known from 12 natural and 8 experimentally seeded populations, in the counties of Contra Costa, Monterey, and Santa Cruz (Hayes 1998, Service 2000). With recent discovery of 2 additional populations, the current number of natural populations is 14. See Appendix A for a map of current populations and counties where the species has been extirpated and Appendix B for population abundance. Distribution by county is summarized below.

Contra Costa County

Habitat for the last naturally occurring population in the San Francisco Bay area in Contra Costa County was converted to a shopping center in 1993 (CDFW 1997, CNDDB 1997). Seeds taken from the population were transplanted to 22 locations in suitable habitat located in the Wildcat Canyon Regional Park in Contra Costa County within the historical range of the species between 1982 and 1986. Only 8 of the 22 locations have supported persistent populations over the years. In more recent years, 4 of these 8 populations have not contained any plants (W. Legard, East Bay Regional Parks, unpubl. data 2010)

Monterey County

Only one population (Porter Ranch) occurs in Monterey County, just south of the Santa Cruz County line and the City of Watsonville.

Santa Cruz County

Thirteen of the natural populations occur in Santa Cruz County: 7 occur around the City of Santa Cruz (Arana Gulch, De Laveaga, Fairway Drive, Graham Hill Road, O'Neill/Tan, Twin Lakes, and Winkle) and 6 occur around the City of Watsonville (Apple Hill, Atkinson Lane, Harkins Slough, Spring Hills Golf Course, Struve Slough, and Watsonville Airport). In July of 2000, a population of *Holocarpha macradenia* was discovered at the Santa Cruz Armory (De Laveaga population) during a rare plant survey, with estimated plant numbers at several thousand and stable (Olson 2003, J. Olson, California Army National Guard, pers. comm. 2010); however, numbers have since declined (Olson, pers. comm. 2013). In addition, a small population of *H. macradenia* was noted in a survey conducted in 2008, when 59 individuals were observed on a Pacific Gas & Electric (PG&E) easement just east of Atkinson Lane in the City of Watsonville. This population was originally observed approximately 15 years ago, but was not reported to the CNDDDB (EcoSystems West 2008).

Habitat

Specific biological and physical habitat components that are essential to the conservation of *Holocarpha macradenia* include but are not limited to: soils associated with coastal terrace prairies, including the Watsonville, Tierra, Elkhorn, Santa Inez, and Pinto series; and plant communities that support associated species, including native grasses such as *Nassella* spp. (needlegrass) and *Danthonia californica* (California oatgrass), and native herbaceous species such as members of the genus *Hemizonia* (other tarplants), *Perideridia gairdneri* ssp. *gairdneri* (Gairdner's yampah), *Plagiobothrys diffusus* (San Francisco popcorn flower), and *Trifolium buckwestiorum* (Santa Cruz clover). In addition, physical processes, particularly soils and hydrologic processes that maintain the soil structure and hydrology that produce the seasonally saturated soils characteristic of *H. macradenia* habitat, are necessary features for the conservation of the species. Smaller preserve areas with *Holocarpha macradenia* are cut off from many ecosystem functions dependent upon soil and hydrologic characteristics that would be present in larger, more contiguous sites. More often, these smaller areas are left as open spaces, but without the benefit of the grassland management needed to sustain them (Service 2002). In the final listing rule, we discussed that coastal grasslands and prairies were once much more widespread than they are today. Primary grassland has decreased both globally and in California (Buisson *et al.* 2006). As of 1996, there were just over 1,977 acres (800 ha) of high-quality coastal prairie remaining in California, of which less than 5 percent is *Holocarpha macradenia* habitat (Holl 1998, Service 2000).

Historically, coastal prairie species such as *Holocarpha macradenia* may have evolved under light grazing pressure and an intense fire regime used by California Native American groups (Heady *et al.* 1988). Once *H. macradenia* habitat has been altered by grazers and nonnative plants have proliferated throughout the native ecosystem, continued grazing may either be deleterious or beneficial to the viability of *H. macradenia*. The indirect effects of continued grazing depend on several factors, including the current condition of the site, and the timing and amount of grazing. Hayes and Holl (2003) reported that species richness and abundance of native annual herbaceous plants in California coastal prairie habitat increase in areas grazed by cattle. Grazing likely improves habitat quality for *H. macradenia* by removing plant biomass cover, reducing aboveground competition during the growing season, and reducing thatch accumulations that inhibit tarplant germination. Additionally, trampling by grazers can open,

roughen, and compact surface layers of soil. Grazers may also aid in dispersal of seed (City of Santa Cruz 2006). The cessation of grazing has resulted in decreased population sizes and is attributed to the decline of historical populations of *H. macradenia* in Monterey Bay (Service 2000, City of Santa Cruz 2006). Conversely, an indirect result of heavy grazing may be responsible for the decline or restriction of this species; or, may favor the presence of nonnative plants that outcompete *H. macradenia* (Service 2000). Management such as burning, mowing, and scraping habitat to reduce biomass of nonnative grasses and encouraging germination for *H. macradenia* has been utilized to enhance populations. Where habitat is still intact, management favorable to *H. macradenia* can allow seeds in the dormant seed bank of the species to germinate and grow (Service 2002).

Overgrowth of nonnative and invasive species and a lack of proper ecological disturbance continue to be a primary threat to *H. macradenia* habitat. More discussion of the challenges of nonnative and invasive species to *H. macradenia* habitat is discussed in the Factor A section below.

Abundance

The 14 natural and 8 experimentally seeded populations comprise the entirety of known populations of *Holocarpha macradenia* today. Population numbers fluctuate annually; however, the majority of populations of *H. macradenia* have decreased in numbers since the time of listing in 2000. Most populations of *H. macradenia* have been expressing numbers in the hundreds or less, or information on them is lacking. As of 2013, populations that have expressed plant numbers in the thousands or greater include: DeLaveaga, Mezue, Porter Ranch, Struve Slough (years previous were in the hundreds or less), and the Watsonville Airport. The Porter Ranch and Struve Slough populations have shown a substantial increase in 2013. Appendix B illustrates aboveground population data for *H. macradenia* populations from the time of listing in 2000 (some data are from before 2000) through 2013. These low and decreasing numbers are a concern for the future of *H. macradenia*, as small populations are vulnerable to the loss of genetic variability and the ability to withstand the occurrence of random, natural events. These topics are discussed further in the genetics and stochastic events sections below.

Because *Holocarpha macradenia* forms seed banks, it is important to consider location and numbers of seeds in the soil and not only aboveground plants. Without proper seed bank management, the increase of aboveground expression may deplete seed banks if ray seeds are germinating and not contributing to the long-term seed bank, decreasing the ability of the seed bank to buffer against environmental variability and decreasing longevity (Gilchrist & Associates 2007, Satterthwaite *et al.* 2007). Below is a summary of population data and trends for currently known populations of *H. macradenia*.

Apple Hill

The Apple Hill site is owned and managed by the California Department of Transportation (Caltrans). Surveys counted 248 plants in this population in 1993, 81 plants in 1994, 700 in 1995, 0 in 1999, reaching its highest numbers of 4,598 plants in 2000, and fluctuating and declining in numbers over the following years with 67 plants counted in 2009. In addition, the size of flower heads at Apple Hill has been observed to be smaller than average (T. Edell, Caltrans District Biologist, pers. comm. 2010), which may indicate lower fitness or contribution

to the seed bank because a correlation between size of seed head and number of seeds has been demonstrated by Barber (2003). *Holocarpha macradenia* was not observed at this site in 2010. In a June 2013 survey, 12 plants were observed. The plants ranged from 6 to 12 cm tall and flower heads were present but not open (Edell, *in litt.* 2013). The site is now mostly dominated by non-native species; the habitat is fragmented by the highway on one side and residences on the other.

Arana Gulch

The Arana Gulch population was historically grazed by cattle until 1988. Plants within Arana Gulch historically occurred in four subpopulations (A, B, C, and D), with subpopulation A being historically the largest and most consistent subpopulation. A census of subpopulation A in 1986 counted approximately 100,000 plants; however, no plants were seen within 2 years of the cessation of grazing at the site. We do not have 1986 survey data for subpopulations B, C, and D; though, reports indicate that there have been no plants counted in these subpopulations since 2004, and numbers in these subpopulations prior to 2004 were relatively low (Biotic Resources Group, unpubl. data 2010). In 1994, the City of Santa Cruz acquired the Arana Gulch property, and in 1995, a bulldozer was employed to scrape the soil over the area of the historical population (Hayes 1998). The following year, approximately 7,000 plants were observed, and the numbers increased to 65,000¹ in 1998 following a fire event which occurred in the fall of 1997 (City of Santa Cruz 2006, Hayes 1998)(This increase in 1998 may also be attributable to a high rainfall year as discussed in the Watsonville Airport section below). Since then, the City of Santa Cruz mowed and raked the site annually, though numbers have fluctuated and steadily declined. Substantial decreases in population numbers over time, particularly in the once large and genetically distinct population at Arana Gulch, are a concern. Surveys counted only 68 plants in 2009 and 0 plants in 2010 (Biotic Resources Group, unpubl. data 2010). Thirty-two plants were observed in 2011 and 16 in 2012 (Stanton 2013). Eighteen plants were observed in 2013 (Lyons, *in litt.* 2013a). It is important to note this population is genetically distinct than other populations of *Holocarpha macradenia*. The biggest decline of the Arana Gulch population occurred during the time of listing; the proposed rule included 1997 data, and the final rule included 1998 and 1999 data. Since 1998, various management strategies, including burning, scraping, and grazing have failed to result in any substantial increase in numbers over time and the current construction of a bike path through Arana Gulch will remove habitat, potentially fragmenting subpopulation areas from each other and/or creating an additional vector from which nonnative species can spread. Figure 1 depicts aboveground plant numbers of subpopulation A at Arana Gulch from 1986 -2013.

¹ Plant numbers from this year have also been reported at 12,800 plants in 1998 (Biotic Resources Group, unpubl. data 2010). The source of the discrepancy is unknown at this time; however, the 65,000 number was based on extensive survey efforts.

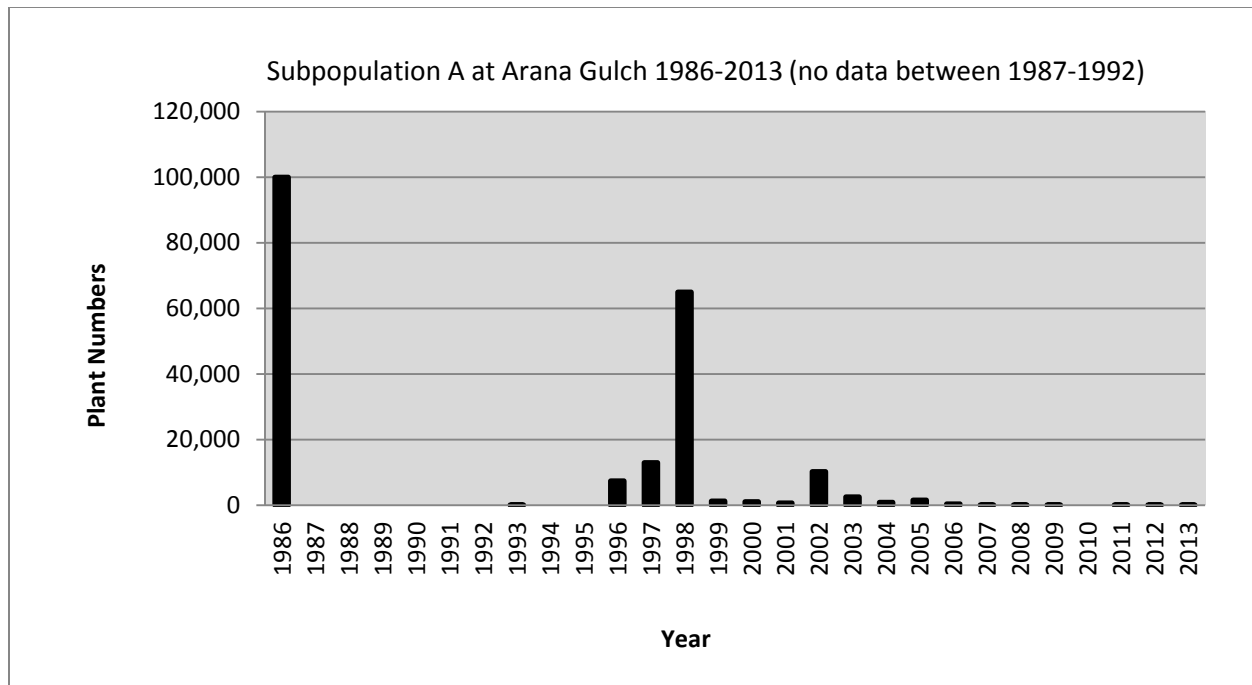


Figure 1. Population data of subpopulation A at Arana Gulch from 1986-2013 (Biotic Resources Group, unpubl. data 2010, Stanton 2013, Lyons, *in litt.* 2013a).

Atkinson Lane

This population is on a Pacific Gas & Electric easement just east of Atkinson Lane in the City of Watsonville. Though originally observed in the 1980s, the only formal population survey was completed in 2008, when 59 plants were observed. It appeared that a short duration, low intensity fire may have occurred in the area within 18 months prior to the survey. Annual deep tilling on the remainder of grassland habitat within the Atkinson Lane property is likely too disruptive to facilitate germination and persistence of *Holocarpha macradenia*; however it is possible that a viable seed bank has persisted in the area (EcoSystems West 2008; B. Davilla, Principal Biologist, Ecosystems West, pers. comm. 2010).

De Laveaga (Santa Cruz Armory)

The De Laveaga population of *Holocarpha macradenia* was discovered at the Santa Cruz armory on July 27, 2000. This population is managed by the California Army National Guard under an Integrated Natural Resource Management Plan (INRMP) (Jones and Stokes 2005). The population has remained fairly unchanged over the years since the land is not being used, and numbers have been reported at “several thousand” and stable (Olson 2003; Olson, pers. comm. 2010). The California Army National Guard has conducted restoration and management activities for this population, as described in the Conservation Measures Undertaken section below. In 2013, 1,173 plants were counted in two areas in contrast to the five or six areas where plants have been seen in years past. Current management includes invasive plant control (Olson, pers. comm. 2013).

Fairway Drive

This site is part of an 18-acre (7.3-ha) easement that is managed by a homeowners association. In 1989, the site supported a population of approximately 5,000 plants when grazing by horses

ceased. In 1993, the population was approximately 1,500 plants. The most recent population counts were 206 plants in 2003, 257 in 2004, and 777 plants in 2005 (Lyons, *in litt.* 2010a).

Graham Hill

This Coastal Prairie Conservation Easement has been managed by the Native Vegetation Network since 1998. A census in 1998 estimated 700 to 800 plants. Plant numbers at this site have been reported as 385 to 495 in 1999, 475 to 550 in 2000, 525 to 600 in 2001, and 875 to 950 in 2003. Surveys estimate plant numbers at 1,350 to 1,400 in 2006; 1,075 to 1,125 in 2008; and 1,675 to 1,725 in 2009 (Haley 2003; Haley, *in litt.* 2010). In spring of 2010, 850 to 900 plants were counted in a new area (as of 2006) of the Central Coastal Prairie Conservation Easement Area; 800 to 850 plants in the known section of the Central Coastal Prairie Conservation Easement Area; and 600 to 650 plants in the Northern Coastal Prairie Conservation Easement Area. In spring 2012, a total of 1,050 to 1,150 plants were counted in the three locations. Surveys in spring 2013 counted fewer plants in only one of the locations with 450 to 500 small, unbranched individuals. The drought was likely a contributing factor to poor performance in 2013 (Haley, *in litt.* 2013).

Harkins Slough

The Harkins Slough population has been managed by High Ground Organics since the winter of 2006-2007. This population was grazed by cattle until grazing was discontinued in 1990. In 1993, the CNDDDB reported that this population comprised 15,000 plants. Later surveys tallied considerably fewer plants, with 108 plants observed in 2005, 15 in 2006, 146 in 2007, 12 in 2008, and 205 in 2009 (Kummerer 2009). Formal surveys were not conducted between 2010 and 2012; however, a few plants were observed flowering in 2012 (Kummerer, *in litt.* 2013a). During a survey conducted in June 2013, 15 plants were observed. Seven of the plants were within an exclosure that was set up in 2005 to protect the small population from the grazing regime that was initiated to create more favorable conditions for the plant. The other eight plants were growing no more than 3 feet away from the exclosure and had been subjected to grazing by cows, horses, and a few goat visits during the year. No plants were found in the historic area on the northwest side of the property or in the seed bank scrapes conducted a few years ago. The grazers were removed from the paddock where the eight plants were flowering to allow the plants to set seed (Kummerer, *in litt.* 2013b).

O'Neill/Tan

The O'Neill/Tan population is partially on the Anna Jean Cummings Regional Park, previously known as O'Neill Ranch, which is managed by the County of Santa Cruz, and partially on private property (Tan) (Service 2002). The size of the *Holocarpha macradenia* population on the O'Neill property has fluctuated from 200 plants in 1979 to 0 in 1998. The size of the *H. macradenia* population on the adjoining Tan parcel was difficult to determine because historic surveys did not count these individuals separately from those on the O'Neill parcel; however, the total number of individuals in the combined population has never been larger than 200, with the Tan parcel supporting only a small portion of those. In 1996, only one tarplant individual was seen (Service 2000). *H. macradenia* has not been seen over approximately the past 10 years (J. Fodor, Central Coast Wilds, pers. comm. 2010).

Porter Ranch

The Porter Ranch population has been managed by the Elkhorn Slough Foundation since 1998 and is actively grazed. Population numbers at Porter Ranch have been reported at 1,500 in 1984; 18,000 in 1986; several thousand in 1988; 43,000 in 1989; 35,000 in 1990; 3,200 in 1993 (CNDDDB 2010), and estimated at 120,000 plants in 2001 (Service 2000, 2001). In previous years, this population was not surveyed for individual plants; instead it has been measured by occupied area. *Holocarpha macradenia* is present annually and the area covered by this population fluctuates from year to year (K. Hayes, Stewardship Director, Elkhorn Slough Foundation, pers. comm. 2010). In comparison to Arana Gulch, a site that does not undergo a grazing regime, the grasses at the Porter Ranch site were notably reduced, native annuals more abundant and diverse, and *H. macradenia* seedlings were present during a site visit on March 23, 2010 (L. Chang, Service biologist, pers. obs. 2010a). 2013 surveys counted 8,234 individual plants. The last detailed survey conducted in 2010 counted just over 2,200 plants. Individual plants were reported to be variable in height and branching, some plants having only one flower cluster and only a few inches tall, while other plants were over 12 inches tall with 50 or more flower heads. Plants were reported at approximately 30 plants per square meter in denser areas (Hayes, *in litt.* 2013).

Spring Hills Golf Course

The Spring Hills population is on the privately owned Spring Hills Golf Course. The population numbered at approximately 4,000 individuals in 1990 (CNDDDB 2001), and was observed in 1995 and 2001, though not counted (Service 2002). Around 2004, only one of four of the colonies known to occur at the golf course was observed. (Davilla, pers. comm. 2010). A few plants were observed in the same location in 2013, though fewer than what has been observed in the past (Davilla, pers. comm. 2013).

Struve Slough (Tarplant Hill)

The Struve Slough population has been managed by Watsonville Wetlands Watch since 2006. Census information is available since 1984, when approximately 10,000 plants were counted. In 1989, a survey counted 409,000 plants; the following year, numbers decreased to 38,000; only 1 plant was seen in the years of 1993, 1994, and 2003; 8 plants were counted in 2004, 60 plants in 2005, and 2 in 2006. Monitoring has documented 70 plants in 2007, 69 plants in 2008, and 189 plants in 2009 (Watsonville Wetlands Watch 2009). In 2010, 639 plants were counted; 213 in 2011, 55 in 2012, and 2,141 in 2013 (Pilch, *in litt.* 2013).

Twin Lakes

The Twin Lakes State Beach site is owned and managed by the California Department of Parks and Recreation. The population has been declining since 1986. Surveys counted 120 plants in 1986, fewer than 10 in 1994, 1 in 1996, 0 in 1997, and 12 in 1998 (Service 2000). This population includes both naturally occurring plants and plants that were raised off site and outplanted (transplanted from a nursery or greenhouse to an outside area) to supplement the population. Approximate plant numbers from 1999 to 2009 are: 7 in the 1999-2000 season, 19 in the 2000-2001 season, 19 in the 2001-2002 season, 349 in the 2002-2003 season 174 in the 2003-2004 season, 387 plants in the 2006-2007 season, and 914 in the 2008-2009 season (Hyland, T., California State Parks, unpubl. data 2002, 2004, 2007, 2009). The 2010 survey reported 55 total plants, a substantial reduction in the number of plants from the previous year.

This reduction may have been attributed to a normal rainfall year with both early and late rains, potentially favoring annual grass species and slugs and snails that have a negative impact on survivorship of this species at this site (Hyland, unpubl. data 2009). The 2010 report expressed concern that without an increased level of disturbance, the downward trend would likely continue (Hyland 2010). No plants were observed at this site in 2011 and 2012 (Hyland, unpubl. data 2010). In 2013, 37 plants were counted (Hyland, *in litt.* 2013). It is important to note that despite outplanting efforts from 2003 to 2006 and other management efforts such as thatch removal and removal of herbivores (snails), numbers at this site remain low overall.

Watsonville Airport

The Watsonville Airport is owned by the City of Watsonville. The airport manages the site to maintain visual clearance for safety and reduce fire risk. There are no population data for this site prior to a baseline survey conducted in 1993 which counted 459,000 plants. In 1995, airport staff initiated a program to establish the species in areas of the airport where it had not occurred previously. Between 1995 and 1997, airport staff successfully established new colonies on the airport property that resulted in 147,919 plants counted during 1998 surveys. 2007 surveys counted 195,400 plants. The establishment of these colonies, recurrent dispersal by mowing, and vehicles driving through the habitat expanded the distribution of the population after 1993 (Gilchrist & Associates 2007). This site currently supports the largest population of *Holocarpha macradenia*, with approximately 28 million plants in 1998, and 8,209,000 plants in 1999 (Service 2000). In the years following, numbers were 4,050,000 in 2000 and 2,491,000 in 2001. The aboveground abundance of plants at the Watsonville Airport is likely a result of ongoing mowing or grazing as a part airport maintenance that reduces competition from other vegetation (Gilchrist & Associates 2007). In 2003, a census similar to past years was not conducted; however, *H. macradenia* was found in areas and densities similar to previous years, but appeared to be less abundant. Since 2003, only limited plant censuses have been conducted.

The Watsonville Airport population is considered to be thriving due to the Airport's maintenance and mowing regime that controls competition from nonnative grasses (Kiguchi, *in litt.* 2010). Figure 2 depicts aboveground population data at this site from the first survey in 1993, the highest recorded numbers in 1998, to the last complete census conducted in 2001. The high abundance in 1998 was likely due to heavy rainfall in the El Niño winter of 1997-1998 (Gilchrist & Associates 2007, Kiguchi, *in litt.* 2010).

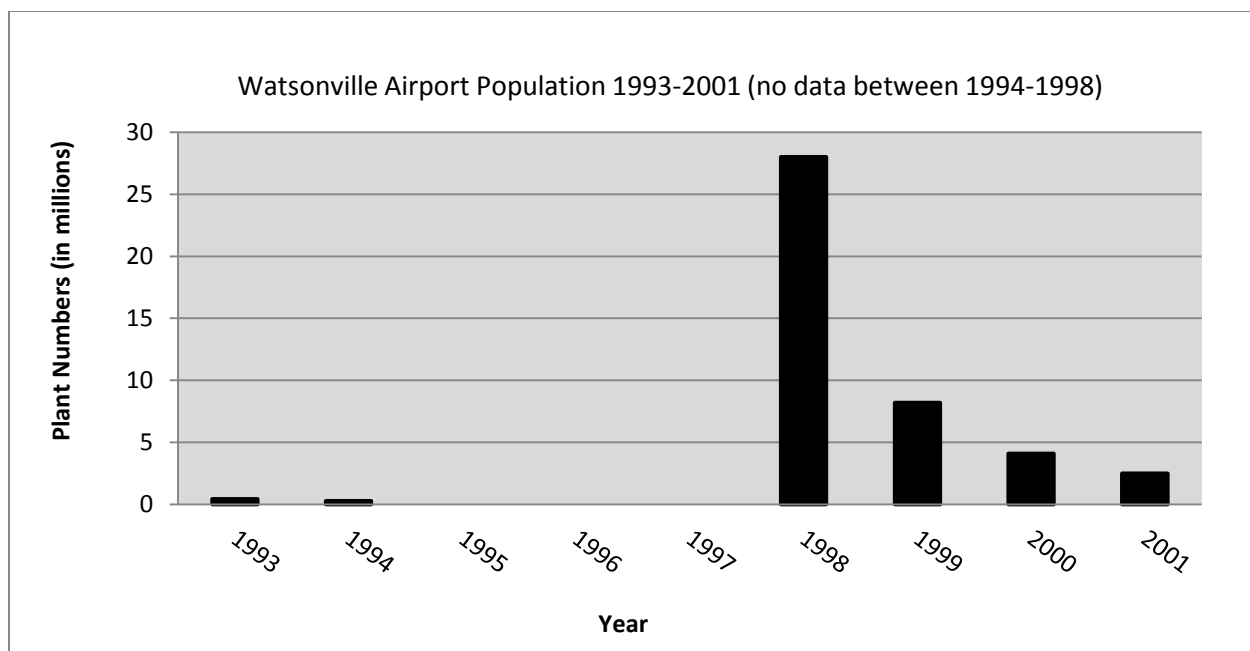


Figure 2. Population graph for *Holocarpha macradenia* at the Watsonville Airport 1998-2001

A Santa Cruz tarplant population assessment was conducted at the Watsonville Airport on July 23 and July 24, 2012. The assessment estimated approximately 512,000 individual plants within a 298-acre study area (Salix Consulting, Inc. 2012). Although the Watsonville Airport constitutes one of the largest populations, the habitat has been highly altered, fragmented by runways, and does not represent high quality habitat for the species.

Winkle (Santa Cruz Gardens)

The Winkle site is privately owned. The population was first recorded in the CNDDDB in 1983 with 50 to 100 plants. Subsequent observations reported 10 to 20 plants in 1984, 75 plants in 1985, and 60 plants in three subpopulations in 1986. Part of the *Holocarpha macradenia* population at this site was destroyed by two phases of residential development in 1986. During construction in 1986, soil containing tarplant seeds was salvaged and deposited into a pile. According to records, the upper 1 to 2 inches of soil were scraped for salvage and “tarplant grew in the pile” every year until 1994. Surveys reported 101 plants in the natural colony and no individuals at the transplant site in 1991. Approximately 101 plants were observed at the natural colony and 1 individual at the transplant site in 1993. Horse grazing was terminated in the early 1990s and the population size decreased over the next several years, likely due to competition with nonnative grasses and the lack of open areas suitable for the germination of tarplant seeds. Surveys performed in 1998, 2004, 2005, and 2007 have resulted in no plants found (Arnold and Lyons 2009; Lyons, *in litt.* 2010c). To date, no above ground *H. macradenia* have been observed at either the salvage site or the natural site (Lyons, *in litt.* 2013b).

Wildcat Canyon Regional Park (Experimental Populations)

The Wildcat Canyon Regional Park site is owned and managed by the East Bay Regional Park District. We originally recognized eight experimentally seeded populations at Wildcat Canyon Regional Park; however, in the past 10 years or more, 3 out of the 8 populations have expressed 0 to 1 plant, and there are no data for the Lower Sather population. Of the 4 populations that

have consistent aboveground plants, the Mezue population has the most substantial numbers with 17,231 plants in 2000; reaching 90,333 in 2003; and 31,862 in 2009. Other populations with consistent aboveground plants, although not as numerous, are the Big Belugum, Big Belugum West, and Upper Belugum populations (Legard, unpubl. data 2010). Surveys for the Mezue population resulted in counts of 12,650 in 2010, 4,727 in 2011, and 3,535 in 2012 (Legard, unpubl. data 2013). Management of invasive vegetation and annual grazing occurs on this site. Refer to Appendix B for more detailed data for these populations.

Genetics

The listing rule discusses the fragility of small populations; that the random loss of a few individuals in small populations can further decrease a species' already diminished gene pool. Loss of genetic diversity can affect the species' ability to adapt to routine environmental change, such as drought, and is often manifested in depressed reproductive vigor (Service 2000). A study by Espeland and Rice (2010) evaluates the effective population size (an indicator of the vulnerability of a population to allele loss through random processes, or genetic drift) in annual plants and its implications on the vulnerability of a population due to loss of alleles by genetic drift. Espeland and Rice (2010) discuss that in small populations, factors that reduce the estimated effective population size will also decrease the ability of a population to retain beneficial alleles. Reed (2005) finds that data strongly supports the theoretical conclusion that small populations have lower fitness on average than large populations. Leimu *et al.* (2006) have concluded that in plants: (1) overall, population size and fitness are significantly correlated; (2) the mean correlation between population size and genetic variation is significantly positive; and (3) the mean correlation between genetic variation and fitness is significantly positive.

Research indicates that the Arana Gulch population of *Holocarpha macradenia* is genetically unique compared to other populations. This population differs from other *H. macradenia* populations phenotypically and genetically by a chromosome translocation (Hayes 1998, Kyhos *et al.* 1990).

Species-specific Research and/or Grant-supported Activities

Susan Bainbridge, a researcher with the Jepson Herbarium at the University of California, Berkeley, performed demographic monitoring, experimental germination and competition studies from 2000-2003 through the Service's Cooperative Endangered Species Conservation Fund (section 6) grant program, in conjunction with the CDFW. These studies were conducted at the Porter Ranch, Arana Gulch, Watsonville Airport, Twin Lakes, and Wildcat Regional Park populations. Conclusions of the study were (Bainbridge 2003):

1. Seed bank growth rates (the rate at which the seed bank accumulates in soil, estimated using reproductive input, germination, survivorship, seed mortality, and seed bank density) investigated under experimental conditions suggest that populations increase under grazing and mowing management, yet more research is needed to determine if the reproductive rate and soil seed bank density at the Watsonville Airport is due to mowing alone;
2. Scraping at Arana Gulch was a more effective restoration technique than mowing or burning for stimulating recruitment (a multi-phased process involving seed production, dispersal, germination, seedling establishment, and survival (McAlpine and Jesson 2007))

from the seed bank; however, more information is needed on the potential negative effects of repeated scraping. In addition, mowing and/or grazing should be tested as a means to sustain the effects of scraping, and the use of fire should be investigated further as a possible restoration technique;

3. Viable seed material from the Twin Lakes State Park population is (at the time of this report) sufficient to start a recovery effort of that population by outplanting seedlings. Seeds from all cohorts and as many individuals as possible should be utilized to maximize genetic diversity (but not more than half the seed stock at a time), and a disturbance regime implemented once years of successful outplanting and deposition of seeds into the seed bank has been established; and
4. Seed from the Mezue population at Wildcat Canyon Regional Park is likely large enough that seed could be utilized to expand existing smaller populations in the park.

In addition, Bainbridge received funding from the Service in an effort to increase the population size and soil seed bank density of *Holocarpha macradenia* at Twin Lakes State Beach. Two cohorts of *H. macradenia* were cultivated, outplanted, and monitored between 2003 and 2006. Results of the study showed that survivorship, reproductive output, and seed input into the seed bank of outplanted individuals were high. Natural recruitment in the outplanted areas were 24 to 46 times higher than previous recruitment numbers suggesting that at least a transient soil seed bank was established; however, accumulation in the persistent soil seed bank was assumed to be much lower than the actual number of seeds input into the soil. In addition, the mean number of heads and seeds per head on outplanted individuals were significantly higher than on natural recruits, likely due to the much larger size of the outplanted individuals. These trials indicated the importance of initial size, including root mass, in reproductive outputs (Bainbridge 2007).

As a graduate student at the University of California, Santa Cruz, Adelia Barber conducted a study comparing reproductive fitness between small and large populations of *Holocarpha macradenia*. The results of this study indicated that plants in small populations produced fewer disk seeds and a higher proportion of ray seeds regardless of seed head size. They also produced smaller ray seeds, less seed weight per head, fewer seed heads, and less branched individuals than plants in larger populations. Barber concludes that these results provide preliminary evidence that small *H. macradenia* populations are experiencing adverse impacts on reproductive fitness, and as populations decline, they are producing mostly small numbers of lightweight dormant seeds. Barber suggests that management for small populations of *H. macradenia* should consider: (1) techniques that increase the quantity and quality of seed output in small populations for short-term population restoration; (2) encouraging non-dormant seed production such as aiding pollination or increasing plant size; and (3) that small populations put a large amount of their resources into dormant seeds, but these seeds are likely small and may be more sensitive than dormant seeds produced by larger populations (Barber 2003).

In 2006, with a grant from California's Wildlife Conservation Board, Watsonville Wetlands Watch purchased the Tarplant Hill parcel of 6 acres (2.4 ha) of native coastal prairie habitat which supports the Struve Slough population of *Holocarpha macradenia* (CDFW 2007; J. Pilch, Restoration Director, Watsonville Wetlands Watch pers. comm. 2010; Watsonville Wetlands Watch 2010). In 2007, the Tarplant Hill Restoration Project was funded with the Service's Private Stewardship Grant and Partners for Fish and Wildlife Programs. In cooperation with

Watsonville Wetlands Watch, this 3-year project has been implemented to restore and enhance the native coastal prairie habitat of *H. macradenia* at Tarplant Hill (Watsonville Wetlands Watch 2009). Management performed on Tarplant Hill includes seed bank management (stimulating germination with management techniques such as scraping, yet conserving some of the seed bank to prevent forcing too much germination), mowing, grassland monitoring, invasive plant control, and community outreach and volunteerism. Long-term goals of this project are to restore and enhance 4.5 acres (1.8 ha) of native coastal prairie habitat that is designated critical habitat for *H. macradenia*, to bring *H. macradenia* back to aboveground expression on Tarplant Hill, and to provide conditions that create a self-sustaining population reaching historic sizes (10,000 to 409,000 individuals) in good years. The Tarplant Hill Restoration Project is currently able to continue with funding from the State Water Resources Control Board, with assistance from the Resource Conservation District of Santa Cruz County, and the Natural Resource Employment Program's Wildlife Habitat Improvement Program (Watsonville Wetlands Watch 2009).

In 1993, the privately-owned Harkins Slough site had about 15,000 plants in two colonies. At the time of listing, the status of the population was unknown due to limited access to the property (Service 2000). In the winter of 2006-2007, High Ground Organics Farm began management of the 10-acre (4.05-ha) grassland that encompasses the Harkins Slough population of *Holocarpha macradenia*. This 10-acre open grassland is a part of a 19-acre (7.7-ha) conservation easement held jointly between the High Ground Organics Farm and the CDFW, formed to protect the natural resources of the property (Kummerer 2009). Funding assistance has been provided by the Natural Resources Conservation Service (High Ground Organics 2010). Management of the Harkins Slough population includes grazing with goats and horses to manage nonnative grass and herbaceous species, reduction of thatch that inhibits annual seedlings from germinating, and limiting competition from invasive plant species. In addition, light scraping has been performed to prepare soil for planting of site specific native grass seed. Mowing and grazing of the scraped area will continue to create lower vegetation height and minimize thatch (Kummerer 2009). Management, monitoring, and population data are compiled in an annual report.

In 1993 and 1995, CDFW funded and hosted three recovery workshops for *Holocarpha macradenia* to review the status of the species and identify actions needed for conservation. These workshops resulted in the development of a Memorandum of Understanding (MOU) between the CDFW and the City of Santa Cruz to address management of the population at Arana Gulch. The workshops also initiated discussion with the City of Watsonville regarding the development of the MOU for management of the Watsonville Airport site (Service 2000).

From 2002-2004, the Service funded a Partners for Fish and Wildlife project to enhance habitat for *Holocarpha macradenia* in East Bay Regional Parks. The 3-year project was designed to recover, enhance, and preserve *H. macradenia* and its habitat, primarily by focusing on removal of *Cynara cardunculus* (artichoke thistle) from the site. In addition, the project focused on range improvement, experimental prescribed fire, and monitoring of a 140-acre (56.7-ha) area over 3 years (Brownfield 2002, East Bay Regional Parks 2004). The project has been implemented, but we have not received a report to date.

The Elkhorn Slough Foundation hosted a recovery workshop in 2003 and a managers' field day in 2008, assembling agencies, scientists, and land managers of *Holocarpha macradenia* populations. The goals of these workshops were to provide information on the species, management and monitoring protocols, discuss research priorities, and methods to increase numbers and recover *H. macradenia* (Elkhorn Slough Foundation 2010).

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

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

Historically, populations of *Holocarpha macradenia* were extirpated primarily by residential and commercial development (CNDDB 2010). At the time of listing, the greatest threat to *H. macradenia* continued to be habitat alteration and destruction caused by development. Encroachment by nonnative, invasive vegetation was also discussed in the listing rule as one of the most prevalent forms of habitat alteration occurring within the coastal prairie habitat of *H. macradenia* (Service 2000). These factors continue to threaten *H. macradenia* populations, particularly populations that undergo little or no management.

Habitat Destruction Due to Development

In Santa Cruz County, coastal prairie habitat was converted to ranching and agricultural lands in the late 1800s and early 1900s; subsequently, this habitat was favored for the expansion of urban centers, especially around the cities of Santa Cruz and Watsonville. California coastal prairies have been affected by humans to the extent that their recovery is extremely slow or even unlikely, and will require human intervention (Stromberg and Griffin 1996; Hamilton *et al.* 2002, as cited in Buisson *et al.* 2006). As mentioned previously, coastal prairie species such as *H. macradenia* may historically have evolved under light grazing pressure and an intense fire regime used by California Native American groups. Increased grazing, introduction of highly competitive nonnative species, elimination of periodic fire, and cultivation are major factors that have contributed to changes in the distribution and composition of coastal prairie habitat (Heady *et al.* 1988).

The Apple Hill population is located on a small Caltrans right-of-way. The population was once comprised of three colonies, two of which were extirpated by the construction of a housing development on adjacent private property. The remaining colony occurs on a strip of land between the housing development and Highway 152. At the time of listing, this population was also being threatened by use of the habitat by local residents as a recreational area, repository for yard waste, and a walkway to adjacent businesses (Service 2000). Presently, these activities may occur occasionally on the site, but the use is not extensive; however, the spread of *Lonicera* sp. (honeysuckle) and *Baccharis pilularis* (coyote brush) may pose a threat to the population (Edell, pers. comm. 2010).

The Arana Gulch population and its designated critical habitat will be subject to additional habitat alteration and destruction with the construction of a bike path proposed by the City of

Santa Cruz. The proposed bike path will traverse critical habitat containing four subpopulations of *Holocarpha macradenia*, leaving two subpopulations on each side of the paved trail, and potentially impacting the hydrology of the site (City of Santa Cruz 2006, Service 2008). The Service issued a biological opinion in 2008 and letter acknowledging a minor revision of the bike path project in 2012 (Service 2012) concluding that the proposed project would not jeopardize the continued existence of *H. macradenia* nor adversely modify its critical habitat and the revision would not affect Santa Cruz tarplant in a manner or to an extent not already considered in the biological opinion. This determination was based on: (1) Caltrans and the City of Santa Cruz proposed a trail alignment that will avoid the Santa Cruz tarplant colonies within Arana Gulch; (2) the direct impacts of the project would only affect approximately 0.4 acre of the 65 acres of critical habitat at Arana Gulch; (3) Caltrans and the City of Santa Cruz proposed measures to reduce the adverse effects of the proposed work on the Santa Cruz tarplant and its critical habitat; (4) the project may benefit the Santa Cruz tarplant and its critical habitat by improving Santa Cruz tarplant habitat quality at Arana Gulch through the implementation of the Santa Cruz Tarplant Adaptive Management Program (Service 2008).

The California Coastal Commission held several public hearings regarding implementation of the Arana Gulch Master Plan, which includes the construction of the bike path and habitat management. After a number of revisions to the Arana Gulch Master Plan, the City of Santa Cruz proposed to construct improved connecting trail segments outside of the greenbelt area; include management and restoration of habitat areas, including trail segment retirements; improvements to and realignments of the existing trail system, including some paved multi-use paths; construction of a bridge over Hagemann Gulch; interpretive displays and trail signage; and installation of fencing and a water supply to allow cattle grazing. The California Coastal Commission approved the Arana Gulch Master Plan on December 8, 2011 (California Coastal Commission 2011). Implementation of the Arana Gulch Habitat Management Plan (HMP) is underway.

This genetically distinct population at Arana Gulch has fluctuated and declined over the years. In addition to development, this population is currently being threatened by thatch buildup from invasive nonnative grasses (Cheap, *in litt.* 2010). Arana Gulch was historically a dairy. Cattle grazed the site from 1795 until grazing ceased in 1988 (Hayes 1998). Some mowing and raking occurs presently; however, most of the coastal prairie habitat that supports *Holocarpha macradenia* at Arana Gulch is overgrown with vegetation. There is less overgrowth and density in the vicinity of subpopulation A where *H. macradenia* has been most abundant and found in recent years. *Camissonia californica* (California suncup), another native annual that is known to be easily out-competed in dense vegetation, was observed growing in the vicinity of subpopulation A where the grasses were less dense. No *H. macradenia* seedlings were observed during this site visit on March 24, 2010 (L. Chang, Service biologist, pers. obs. 2010).

A portion of the habitat associated with the Watsonville Airport may be subject to additional alteration; a proposed development project would permanently impact approximately 2 acres (0.8 ha) of *Holocarpha macradenia* critical habitat within the Watsonville critical habitat area (Unit I) (Olberding Environmental 2009). In past years, this portion of habitat was bisected by a road and commercially developed, and is reported to be disturbed and overgrown. *Holocarpha macradenia* has not been observed on this particular parcel in at least 3 decades (Kiguchi, *in litt.*

2010a). In addition, the Watsonville Airport is proposing a series of improvements to be implemented through the year 2020. A mitigation plan is in development for these projects (Gilchrist & Associates 2007). The details of the mitigation plan are discussed in the Conservation Measures Undertaken section of this review.

The Winkle population of *Holocarpha macradenia*, also referred to as the Santa Cruz Gardens population, was partially destroyed by development in 1986 (Arnold and Lyons 2009). Further development has been proposed within a 58.6-acre (23.7-ha) project site that includes the Winkle population. Nine residential units are proposed for development on 2.96 acres (1.20 ha); the remaining 55.6 acres (22.5 ha) will be held as a conservation parcel, held in fee title by the Homeowners Association (HOA). Development of the 2.96-acre (1.20-ha) portion of the project site will result in the loss of approximately 1.24 acres (0.5 ha) of coastal prairie habitat, 0.87 acre (0.35 ha) of mixed grassland-shrub and nonnative grassland, and 0.65 acre (0.26 ha) of coast live oak woodland. A habitat conservation plan (HCP) has been completed for this site (Arnold and Lyons 2009). This HCP is discussed in more detail in the Conservation Measures Undertaken section below.

Habitat Alteration Due to Increase of Nonnative Species

Overgrowth of nonnative invasive species is a principal ongoing threat for *Holocarpha macradenia* populations. Even with management, most populations are in decline due to *H. macradenia*'s inability to compete with the overgrowth of nonnative vegetation. Invasive species that have been identified as threats to *H. macradenia* populations include but are not limited to: *Genista monspessulana* (French broom), *Foeniculum vulgare* (fennel), *Eucalyptus* spp. (eucalyptus); *Acacia decurrens*, *A. melanoxylon* (acacia); artichoke thistle; *Rubus discolor* (Himalayan blackberry); *Phalaris aquatica* (harding grass); *Festuca arundinacea* (tall fescue); *Cardaria draba* (hoary cress); *Carduus pycnocephala* (Italian thistle); *Picris echioides* (bristly ox-tongue); *Trifolium angustifolium* (narrow-leafed clover); *Convolvulus arvensis* (field bindweed); and *Conium maculatum* (poison hemlock) (Service 2000, Watsonville Wetlands Watch 2009).

Nonnative species alter habitat in several different ways. They may out-compete native species, suppress recruitment of native species, alter community structure, degrade or eliminate habitat for native animals, and provide food and cover for undesirable nonnative animals. In some circumstances, invasive nonnative weeds can prevent reestablishment of native species following natural or human-caused disturbance, altering natural succession. Some nonnatives, including eucalyptus and fennel, exude allelopathic substances that inhibit the growth of other plants (Bossard *et al.* 2000). Nonnative grasses may quickly gain a competitive advantage over native grasses because they germinate early and seed prolifically (Heady 1977, McClintock 1986).

In their study of grazing impacts in mesic grasslands of California, Hayes and Holl (2003) include discussion of the importance of maintaining the types, frequencies, and intensities of disturbance regimes, such as grazing, under which species have evolved. Hayes and Holl (2003) indicated that species richness and abundance of native annuals in California coastal prairie habitat is increased in areas grazed by cattle. In addition, proper timing of mowing and grazing is also an important factor in management of the species (Holl and Hayes 2006). For *Holocarpha macradenia*, mowing and grazing regimes have been used to ameliorate the threat of

overgrowth of nonnative vegetation. Mowing may be a useful method for vegetation removal for populations at the Watsonville Airport, but may not be sufficient as the only technique for nonnative vegetation removal at other locations. Nonnative vegetation management for populations of *H. macradenia* is discussed further in the Conservation Measures Undertaken section below.

A number of *H. macradenia* populations have exhibited population declines after the cessation of grazing. The Fairway Drive site which consisted of 5,000 plants when grazing ended in 1989, declined to approximately 1,500 plants by 1993, and even less in recent years. The Arana Gulch population that was grazed by cattle until 1988 decreased from approximately 100,000 plants in 1986, to 0 plants within two years. The Harkins Slough population was grazed by cattle until 1990, with reports estimating 15,000 plants in 1993, and numbers fluctuating at approximately 200 or less in recent years. The Winkle population comprised 101 plants in 1993, had no plants found in surveys conducted in 1998, 2004, 2005, and 2007, which also was likely due to the cessation of horse grazing on the site in the early 1990s. These declines in aboveground numbers are likely due to competition with and overgrowth of nonnative vegetation due to the cessation of grazing. It is important to consider the long term implications of the cessation of grazing for *H. macradenia* populations, as it may not be feasible to maintain or initiate grazing regimes for all populations in the future. For more information on these population data, see the Abundance section above and Appendix B.

Conservation Measures Undertaken

Since the time of listing, the following measures are ongoing or have been newly implemented. Even with implementation of management and conservation measures, many populations of *Holocarpha macradenia* continue to decline.

Apple Hill

This small parcel is managed by Caltrans (Service 2002). Annual mowing and some raking and scraping occur; however, plant numbers and flower head sizes have declined over the years (Edell, pers. comm. 2010). It is unclear why these management methods have been successful at stimulating germination at other sites but not at Apple Hill.

Arana Gulch

The City of Santa Cruz entered into a Memorandum of Understanding with the CDFW in 1997 to manage *Holocarpha macradenia* (Service 2002). Mowing and raking has occurred there annually (Lyons *in litt.* 2010a). In 2013, a draft HMP was developed as part of implementation of the Arana Gulch Master Plan. An Adaptive Management Working Group (AMWG), established in 2013, will implement this HMP. The AMWG is comprised of a group of cooperative and committed stakeholders interested in the outcomes of decision-making and in the technical process of managing the resources on the property. The City of Santa Cruz has made the commitment to provide long-term funding for the AMWG and the implementation of HMP (Stanton 2013).

De Laveaga (Santa Cruz Armory)

In 2002, the California Army National Guard removed invasive eucalyptus from the site to enhance habitat for *Holocarpha macradenia*. Restoration projects including wood chip, log, and

nonnative plant removal have been conducted at the Armory, and the population was reported to be numerous in the area where wood chips were removed (Olson 2003; Olson, pers. comm. 2010). Additional measures have been developed by the Department of the Army in an INRMP to avoid potentially adverse effects on the *H. macradenia* population (Department of the Army 2003, Jones and Stokes 2005). Current management includes invasive plant control (Olson, pers. comm. 2013).

Fairway Drive

The Fairway Drive site is privately owned. When horse grazing ceased in 1989, several woody nonnative species invaded the grasslands and were rapidly spreading. In 1996, the County of Santa Cruz approved a lot split into four parcels, with the condition that the coastal terrace prairie habitat be placed in a preservation easement of approximately 15 acres (6 ha) and a management plan be developed and implemented by the Homeowner's Association (HOA) (Service 2000). The HOA implements annual mowing; however, in the past, HOA was negligent in implementation of the required management and reporting. The County of Santa Cruz remedied the situation through issuance of a notice of noncompliance to the HOA in 2003 to ensure the measures would be implemented (Service 2000; Cheap, *in litt.* 2010; Lyons *in litt.* 2010b). It is our understanding that mowing still occurs at this site; however, there have been no recent surveys conducted and the status of the condition of the site is uncertain.

Graham Hill

The Graham Hill population is located within a 17-acre (7-ha) area that was set aside through a conservation easement to the County of Santa Cruz for conservation of coastal prairie habitat and *Holocarpha macradenia* as mitigation for adjacent development (Service 2002). This Coastal Prairie Conservation Easement has been managed by the Native Vegetation Network since 1998. Management has included habitat enhancement, weeding, scraping, mowing, thatch removal, burning, and an annual census (Haley 2003; V. Haley, Botanist, Native Vegetation Network, pers. comm. 2010).

Harkins Slough

As discussed in the Species-specific Research and/or Grant-supported Activities section of this review, the Harkins Slough site is managed by High Ground Organics Farm as part of a 19-acre (7.7-ha) conservation easement held jointly between the High Ground Organics Farm and the CDFW, formed to protect the natural resources of the property. High Ground Organics farm has continued the rotational grazing regime, moving to a year round rotation rather than removing the animals in the fall as they have in years previous. This grazing regime should not impact the population because it is exclosed from the grazing (Kummerer, *in. litt.* 2013).

O'Neill/Tan

Anna Jean Cummings Regional Park, also known as O'Neill Ranch, is managed by the County of Santa Cruz. The remaining portion is privately owned. The 2002 critical habitat designation describes that on the park lands, the population had been fenced, and portions of the habitat for the plant were being mowed and raked in accordance with a management plan (Service 2002). The County of Santa Cruz approved a housing development for the privately owned parcel (previously known as Tan, but now called Seacrest) in 1997. The development, completed in the late 1990s, included an approximately 10-acre (4-ha) parcel to be set aside for conservation and a

plan to manage the habitat for *Holocarpha macradenia* (Service 2002). There has been no management and no plants seen since 2005 (Fodor, *in litt.* 2010).

Porter Ranch

This population is privately owned by the Elkhorn Slough Foundation (Foundation). Since 1998, the CDFW has held a conservation easement on an approximately 40-acre (16-ha) parcel that overlaps in part with this population, and the Foundation is managing the parcel for its biological values (Service 2000, 2002). This population is actively managed with a grazing regime, and *Holocarpha macradenia* is present yearly (Hayes, pers. comm. 2010).

Spring Hills Golf Course

This site is privately owned. It is unknown what management may currently be occurring at this site.

Struve Slough (Tarplant Hill)

As discussed in the Species-specific Research and/or Grant-supported Activities section of this review, the Tarplant Hill Restoration Project has been implemented to restore and enhance the native coastal prairie habitat of *Holocarpha macradenia* at Tarplant Hill. Although this site gets intensive management and numbers have increased compared to the time of listing, they are still substantially below historic numbers.

Twin Lakes

Since 1997, the California Department of Parks and Recreation has been actively managing *Holocarpha macradenia* habitat at this site by removing invasive, nonnative species and attempting various methods of enhancing the population (mowing, raking, soil disturbance, outplanting) (Service 2000, Hyland, unpubl. data 2002, 2004, 2007, 2009). The California Department of Parks and Recreation has also funded research on *H. macradenia* seed bank dynamics and to learn more about best enhancement techniques at this site (Service 2002).

Watsonville Airport

The Watsonville Airport site is owned by the City of Watsonville. The City of Watsonville and the CDFW are in the process of completing the draft Mitigation Plan for Santa Cruz Tarplant and Coastal Terrace Prairie at the Watsonville Airport (Gilchrist & Associates 2007). This plan will mitigate impacts of a series of airport improvements to be implemented through the year 2020. The goal of the mitigation program is to establish healthy, self-sustaining colonies of *Holocarpha macradenia* and coastal terrace prairie habitat in permanently protected areas so that a net benefit to both elements will result from implementation of the proposed project. This will be achieved by a combination of 1:1 replacement of *H. macradenia* and coastal terrace prairie habitat losses, an increase in *H. macradenia* density, formal habitat protection afforded by a permanent easement status, and the formal delineation of management practices (Gilchrist & Associates 2007).

Wildcat Canyon Regional Park

As discussed earlier, the Service funded a Partners for Fish and Wildlife project to enhance habitat for *Holocarpha macradenia*, primarily by focusing on removal of artichoke thistle from

the site. The project also included range improvement, experimental prescribed fire, and monitoring. Management of invasive vegetation and annual grazing are implemented at this site (Legard *in litt.* 2010).

Winkle (Santa Cruz Gardens)

Development of the HCP for Santa Cruz Gardens was prompted by the presence of the federally endangered Ohlone tiger beetle (*Cicindela ohlone*), in addition to Gairdner's yampah and *Holocarpha macradenia* in the proposed development area. The HCP will protect 9.3 acres (3.8 ha) of coastal prairie, mixed grassland, and mixed grassland-scrub habitat, and manage and restore nonnative grassland, in perpetuity. The plan will also protect 46.3 acres (18.7 ha) of the conservation parcel for overall open space and wildlife habitat values. Goals outlined in the HCP for *H. macradenia* are to (1) permanently preserve upland habitats for *H. macradenia*, (2) manage conserved lands to benefit *H. macradenia*, (3) implement actions that will protect *H. macradenia* during construction activities, and (4) determine the status of *H. macradenia* populations at the Santa Cruz Gardens site (Arnold and Lyons 2009).

The rate of habitat destruction due to development may have slowed since the time of listing and the number of populations with conservation measures being implemented increased; however, most *Holocarpha macradenia* populations, both with and without conservation measures being implemented, are in decline when comparing current numbers to historic figures. This decline is in great part due to habitat alteration caused by the presence of nonnative species.

Similarly, the federally endangered Ohlone tiger beetle that also occurs on coastal terrace prairie habitat, has shown declines since the cessation of grazing, and shares common factors with *Holocarpha macradenia* that threaten its continued existence. The Ohlone tiger beetle has been extirpated from more than half of its occurrences since listing in 2001 (Service 2009a). The decline of both *H. macradenia* and the Ohlone tiger beetle indicates that these threats extend beyond individual species to the entire ecosystem; the already rare coastal terrace prairie and grassland habitat and ecosystem is in decline.

In summary, threats from Factor A that continue to threaten *Holocarpha macradenia* populations are habitat alteration and destruction caused by development and encroachment by nonnative, invasive vegetation (Service 2000). Appendix C outlines the percentage of *H. macradenia* populations and critical habitat on private and public lands, management efforts, and current threats.

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

Overutilization for commercial, recreational, scientific, or educational purposes was not known to be a factor in the 2000 final listing rule for *Holocarpha macradenia* (Service 2000), and does not appear to be a threat at this time.

FACTOR C: Disease or Predation

Disease was not known to be a factor in the 2000 final listing rule for *Holocarpha macradenia* (Service 2000), and does not appear to be a threat at this time. Predation of adult plants by cattle, livestock, or other wildlife species has not been known to be a problem, most likely due to the presence of oil glands that make the plant unpalatable (Service 2000). However, in the 2003-2004 status report for *H. macradenia* at Twin Lakes State Beach, it was reported that herbivory by slugs and snails had been observed in previous years on seedlings in the experimentally planted plots. Slug and snail bait was used in the 2003-2004 season, with one untreated control plot. Herbivory was so severe on the untreated plot that it was eventually treated as well (Hyland, unpubl. data 2004). Although these experimental seedlings were affected by predation, reports have not included herbivory as a significant problem for other populations of *H. macradenia*.

A study by Maze (2009) indicated that invertebrate herbivory on *Holocarpha macradenia* significantly affected the survivability of *H. macradenia* seedlings. Most of the herbivory observed in the study was caused by the nonnative grey garden slug (*Deroceras reticulatum*). Although results of this study indicate that herbivory could potentially be a problem for *H. macradenia*, or possibly exacerbate other threats to *H. macradenia* populations, herbivory does not appear to be a significant threat at this time.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect *Holocarpha macradenia* included: (1) endangered listing under the California Native Plant Protection Act; (2) endangered listing under the California Endangered Species Act; (3) the California Environmental Quality Act; and (4) the Santa Cruz County General Plan. The listing rule (Service 2000) provides an analysis of the level of protection that was anticipated from these State and County regulatory mechanisms. This analysis is currently valid, with additional discussion of the California Coastal Act and Endangered Species Act below. A brief summary of the possible effects of these mechanisms on *H. macradenia* are described below.

State Protections

California Native Plant Protection Act (CNPPA) and the California Endangered Species Act (CESA): The CESA (California Fish and Game Code, section 2080 et seq.) prohibits the unauthorized take of state listed threatened or endangered species. Under the CESA, the CNPPA (Division 2, Chapter 10, section 1908) also prohibits the unauthorized take of state listed threatened or endangered plant species. The CESA requires consultation with the CDFW for those activities that may affect a state listed species and to mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The state may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities. Most of the development projects within *Holocarpha macradenia* habitat have received permits from CDFW to conduct mitigation-related management conducted on portions of the project site that have been set aside as open space and/or dedicated as a conservation easement. Although the take of state listed

plants is prohibited under the CNPPA, these statutes do not provide adequate protection for such plants from the impacts of habitat modification and land use change. Under CNPPA, certain activities, such as agricultural or timber operations, mining assessment work, or removal of plants from a right-of-way are exempt from the general take prohibitions. Also under CNPPA, after the CDFW notifies a landowner that a state listed plant grows on his or her property, the statute requires only that the landowner notify the agency “at least ten days in advance of changing the land use to allow salvage of such plant.”

California Environmental Quality Act (CEQA): The CEQA requires review of any project that is undertaken, funded, or permitted by the state or a local governmental agency. Conservation of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). In the latter case, projects may be approved that could cause significant environmental damage, such as destruction of endangered species. Most development projects in *Holocarpha macradenia* habitat have fallen within the purview of the County or City of Santa Cruz (see County Protections section below); however, because the species is state listed, provisions of CESA would likely provide more protections to the species than CEQA.

California Coastal Act: At time of listing, we did not include discussion of the California Coastal Act (CCA) in Factor D. Occupied habitat of a federally listed species occurring within the Coastal Zone is considered an environmentally sensitive habitat area (ESHA) under section 30107.5 of the California Coastal Act. Section 30241 of the CCA requires that environmentally sensitive habitat areas “shall be protected against any significant disruption of habitat values.” Therefore, the CCA can provide protection to *Holocarpha macradenia* in those cases where it would be affected by a proposed project requiring a coastal development permit. The CCA would not provide benefits to *H. macradenia* occurring outside the Coastal Zone or those affected by ongoing activities. Certain local jurisdictions have developed their own local coastal programs or land use plans that have been approved by the Coastal Commission. Some of the major accomplishments of the CCA include protection of prime habitat along the coast, restoration of coastal streams and rivers, and a reduction in the rate of wetland loss. The California Coastal Commission ruled at a public hearing on March 11, 2010, for an alternative route to be considered for the proposed paved bike path project at Arana Gulch in *H. macradenia* habitat.

County Protections: Under the County of Santa Cruz Coastal Program and General Plan (revised in 1994), “grasslands in the coastal zone” are identified as one of a number of designated Sensitive Habitats. Uses allowed within Sensitive Habitat areas are restricted to those that are dependent on the habitat’s resources unless other uses are “(a) consistent with protection policies and serve a specific purpose beneficial to the public; (b) it is determined through environmental review that any adverse impacts on the resource will be completely mitigated and that there is no feasible less-damaging alternative; and (c) legally necessary to allow a reasonable economic use of the land, and there is no feasible less-damaging alternative.” The County attempts to protect *Holocarpha macradenia* during the review of proposals for development that fall under their jurisdiction with conservation easements voluntarily established by the project applicant, or

preservation easements requested of the applicant by the County. These included development projects at the Graham Hill Road, O'Neill, Tan, Winkle, and Fairway Drive sites. These easements typically set aside all or most of the occupied habitat of *H. macradenia* and provide for implementation of management plans for the coastal prairie habitat; however, the easements cover only small remnants that represent a fragment of the coastal prairie habitat that historically occurred in the region, and management prescriptions have not always been carried out. Intensive grassland management will be needed to sustain and enhance populations of *H. macradenia* on these sites (Service 2000).

Federal Protections

Section 7(a)(2) of the Endangered Species Act requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize federally listed species or destroy or adversely modify their critical habitat. Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the "take" of federally endangered wildlife; however, the take prohibition does not apply to plants. Instead, plants are protected in three particular circumstances. Section 9 prohibits (1) the removal and reduction to possession (i.e., collection) of endangered plants from lands under Federal jurisdiction, (2) the malicious damage or destruction any such species on any such area and (3) the removal, cutting, digging, damage, or destruction of endangered plants on any other area in knowing violation of a state law or regulation or in the course of any violation of a state criminal trespass law. Federal agencies are associated with the Santa Cruz Armory, Watsonville Airport, and Arana Gulch populations, and are required to consult with the Service regarding projects that may affect *Holocarpha macradenia* and its habitat. Federally listed plants may be incidentally protected if they co-occur with federally listed wildlife species; for instance, the Service has been involved with the Santa Cruz Gardens HCP (which includes the Winkle population of *H. macradenia*) that would result in issuance of an incidental take permit for the federally endangered Ohlone tiger beetle that occurs on the site.

In 2002, the Department of the Army's California Army National Guard (CAARNG) consulted with the Service regarding restoration projects at the Santa Cruz Armory. The consultation resulted in a concurrence that the proposed restoration projects were not likely to adversely affect *Holocarpha macradenia*. Restoration projects including wood chip, log, and nonnative plant removal were conducted. The population at the Santa Cruz Armory was reported to be numerous in the area where the wood chips were removed (Olson 2003; Olson, pers. comm. 2010). An INRMP has been developed by the CAARNG, ensuring management and monitoring for the *H. macradenia* population at the Santa Cruz Armory (Jones and Stokes 2005).

The Federal Aviation Administration (FAA) will provide funding for various airport improvements that are proposed through the year 2020. The FAA is the responsible Federal agency to undertake consultation with the Service for the Watsonville Airport site (Gilchrist & Associates 2007).

The proposed bike path at Arana Gulch involved a formal consultation in 2008 between the Service and Caltrans, which has been designated as the non-Federal representative for the Federal Highways Administration for projects in California. As discussed, the Service

determined that the proposed project was not likely to jeopardize the continued existence of *Holocarpha macradenia* or adversely modify its critical habitat (Service 2008).

In summary, the ability of existing regulatory mechanisms to reduce and remove impacts to *Holocarpha macradenia* and its habitat is limited because: (1) under CNPPA and CESA, certain activities are exempt from the general take prohibitions, and statutes for landowners with state listed plants on their property requires only

that they notify the agency “at least ten days in advance of changing the land use to allow salvage of such plant;” (2) under CEQA, protection of listed species are dependent upon the discretion of the lead agency involved, therefore either significant effects are identified, or overriding considerations could make mitigation infeasible; and (3) County easements cover only small remnants that represent a fragment of the coastal prairie habitat that historically occurred in the region.

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

At the time of listing, three additional factors that could threaten the continued existence of *Holocarpha macradenia* were identified as: (1) limited success of transplant efforts conducted as part of mitigation projects; (2) competition with nonnative plants; and (3) extinction caused by random, naturally occurring events (environmental stochasticity) (Service 2000). Additionally, we have identified climate change as a new threat since the time of listing.

Low Reproductive Success

The eight populations of *Holocarpha macradenia* in Contra Costa County are the result of 22 experimental seedings performed from 1982 to 1986, within Wildcat Canyon Regional Park on East Bay Municipal Utility District land. The 22 experimental seedings have been managed with invasive plant removal and a grazing regime, yet have resulted in only 8 lasting populations, with only one of these populations (Mezue) showing substantial numbers and an increasing trend over time. Additionally, of the 8 remaining populations, data show that only about half of these have had persistent numbers of aboveground plants over the past 10 years (Legard, unpubl. data 2010).

Some of the supplemental plantings at Twin Lakes State Beach have shown that once established, and with management (mowing, raking, and scraping), *Holocarpha macradenia* can thrive. Planted individuals that survived were robust and produced almost 18 flower heads per individual in the 2001-2002 growing season (Hyland, unpubl. data 2002). In the following season, outplanting efforts resulted in approximately 6,400 seeds produced from roughly 600 seeds planted (Hyland, unpubl. data 2004). The 2006-2007 growing season was a good year for the tarplant at this site; however, no plants were detected in the areas where outplanting had not occurred recently. This suggested that all of the plants counted that year were seedlings of plants raised and outplanted over the previous 2 years, or perhaps of seedlings from those plants. This raised some concern for the long term viability of the plant at the site (Hyland, unpubl. data 2007). In the 2008-2009 growing season, plants were found outside of original planting blocks, possibly indicating that populations can expand and may be sustained with ongoing management

(Hyland, unpubl. data 2009). 2010 saw a great reduction in the number of plants and no plants were seen in 2011 and 2012 (Hyland, *in litt.* 2013).

Seeding attempts were conducted at the Watsonville Airport site in the fall of 1995. Tarplant seeds collected from selected areas were planted and resulted in persistent tarplant colonies. After approximately 10 years, the two areas that received the most seed continued to express plants; one with 133 plants and the other with 110,850 plants. In August of 1996, transplanting of 30 flowering *H. macradenia* individuals was attempted in a small area, though these plants did not survive (Gilchrist & Associates 2007).

Although some seeding attempts have been somewhat successful, it appears that the management, timing, location of plantings, and techniques greatly influence the results of the persistence of *Holocarpha macradenia*, and long term viability in these cases remains unclear. Holl and Hayes (2006) identified the following four possible explanations for the failure of *H. macradenia* introduction efforts: (1) choosing poor quality habitat, (2) introductions timed poorly with respect to climatic conditions, (3) the number of plants introduced may be too small to establish viable populations, and (4) overlooking the lack of an established seed bank.

Competition with Nonnative Plants

In the listing rule, the conversion of the plant community from one dominated by native grasses to one dominated by nonnative grass species was identified as one of the most prevalent forms of habitat alteration occurring within the coastal prairie habitat of *Holocarpha macradenia*. Refer to Factor A for a detailed discussion of this threat.

Environmental Stochasticity

The listing rule discusses the concern that so much of the coastal prairie habitat that supports *Holocarpha macradenia* has been altered, fragmented, or destroyed, that most of the remaining habitat is of small acreage and supports only very small populations. Species with a small number of populations and few individuals (compared to historical numbers) are vulnerable to the threat of local extinction from random, naturally occurring events. Such random events can affect long-term survival, subjecting populations to genetic, demographic, environmental, and natural catastrophic stochasticity (Shaffer 1981). As discussed in the genetics section, the loss of a few individuals in small populations can disproportionately decrease an already diminished gene pool, and in other circumstances, sites with small populations or few individuals may be vulnerable to forces that negatively affect their ability to successfully complete their life cycle. Conservation biology literature frequently notes the vulnerability of taxa known from one or very few locations and/or from small populations with highly variable population sizes (e.g., Shaffer 1981, 1987; Primack 2006; Groom *et al.* 2006). A small population size may make it difficult for a species to persist while sustaining other impacts such as habitat alteration that favors nonnative species. Because *H. macradenia* is not capable of self-fertilization, individuals cannot produce viable seeds without cross pollinating with other individuals. Small populations may have a more difficult time attracting pollinators and therefore may experience lower seed production rates, leading to reduced species viability and possible extirpation over time (Service 2000, Satterthwaite 2007). Additionally, the genetic distinctiveness of the Arana Gulch population increases the urgency of preserving that population (Palmer 1987, Hayes 1998). Many of the *H. macradenia* populations have shown a considerable decrease in plant numbers

over time, and it is difficult to determine the size of seed banks and whether they are viable. With only 14 naturally occurring populations in a limited portion of its historic range, environmental stochasticity remains a threat to *H. macradenia*, and is currently a greater threat than it was at the time of listing.

Climate Change

At the time of listing, we did not discuss the potential effects of climate change on the long-term persistence of *Holocarpha macradenia*. Impacts to *H. macradenia* under predicted future climate change are unclear. Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field *et al.* 1999, Cayan *et al.* 2005, IPCC 2007). However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. The potential impacts of climate change on the flora of California were discussed by Loarie *et al.* (2008). Based on modeling, they predicted that species' distributions will shift in response to climate change and that species will "move" to higher elevations and northward, depending on the ability of each species to do so. Increases in species diversity in these higher elevations and northern locations due to climate change have the potential to result "...in new species mixes, with consequent novel patterns of competition and other biotic interactions..." with unknown consequences to the species that currently exist there (Loarie *et al.* 2008). While it appears reasonable to assume that both plant and animal species may be affected, we lack sufficient certainty on knowing how and how soon climate change will affect species, the extent of average temperature increases in California, or potential changes to the level of threat posed by drought or fire. While we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to *H. macradenia* at this time.

III. RECOVERY CRITERIA

A recovery plan for *Holocarpha macradenia* has not been completed, and therefore recovery criteria have not been established; however, recovery actions that will benefit the species are listed in the recommendations section of this review.

IV. SYNTHESIS

Historically, habitat for *Holocarpha macradenia* occurred on grasslands and prairies from Monterey County, north to Contra Costa and Marin Counties. Early herbarium collections were made in Santa Cruz County in 1881, Marin County in 1883, Alameda County in 1891, San Francisco County in 1916, and in Contra Costa County in 1974. At the time of listing in 2000, *H. macradenia* was known from 12 natural and 8 experimentally seeded populations, in the counties of Contra Costa, Monterey, and Santa Cruz. Currently, *H. macradenia* is known from 14 natural and 8 experimentally seeded populations; however, since the time of listing, *H. macradenia* has been present in only 4 of the 8 experimentally seeded populations in Wildcat Canyon Regional Park. Furthermore, since the time of listing, most populations of *H. macradenia* have shown substantial decline. Most populations of *H. macradenia* have been expressing numbers in the hundreds or less, or information on them is lacking (see Appendix B). As of 2013, populations that have expressed plant numbers in the thousands or greater include: DeLaveaga, Mezue, Porter Ranch, Struve Slough (years previous were in the hundreds or less),

and the Watsonville Airport. The Porter Ranch and Struve Slough populations have shown a substantial increase in 2013.

Historically, most extirpations of *Holocarpha macradenia* populations were caused by residential and commercial development. A number of populations continue to be threatened by development and lack of management of the rare coastal prairie and grassland habitat that supports *H. macradenia*. In addition, the Arana Gulch population is genetically distinct, which heightens the urgency of managing and protecting that habitat to better support the species.

As mentioned previously, because *Holocarpha macradenia* forms seed banks, location and numbers of seeds in the soil must be considered in addition to aboveground plants. Without proper seed bank management, too much of an increase of aboveground expression may deplete seed banks, decreasing the ability of the bank to buffer against environmental variability and decreasing longevity. *Holocarpha macradenia* is incapable of producing viable seeds without cross pollinating with other individuals; therefore, small populations may have a difficult time attracting pollinators and may experience lower seed production rates. Many of the *H. macradenia* populations have shown a considerable decrease in aboveground plant numbers over the years, and the size and viability of seed banks is unknown. Decreases in population numbers over time, such as with the genetically distinct and once large population (100,000 plants) at Arana Gulch, increases our concern that small populations will further compromise the genetic viability of *H. macradenia* and its ability to withstand environmental changes, or lead to extirpation of populations altogether.

Habitat alteration and destruction caused by development; presence of (and competition with) nonnative, invasive vegetation; and lack of proper ecological disturbance continue to pose a threat to *Holocarpha macradenia* and its habitat. In addition, low reproductive success and environmental stochasticity remain relevant threats to the species. Stochastic extinction is currently a greater threat than at the time of listing, as population numbers and potential genetic viability of *H. macradenia* continue to decline. Climate change is a potential new threat that we have identified since the time of listing. Of these, habitat alteration and destruction and competition with and the presence of nonnative, invasive vegetation appear to be primary threats to the species. The steady decline of populations of *H. macradenia* since it was listed in 2000, and lack of knowledge of existing seed bank size and viability, are causes for concern for the survival of the species overall.

Currently, *Holocarpha macradenia* is classified as a federally threatened species. Since the time of listing, and comparing current numbers to numbers prior to the time of listing, most populations of *H. macradenia* have declined and threats continue to persist. Based on information received from species experts, population data, and current threats to the species, we conclude that *H. macradenia* still qualifies as a threatened species; however, if the current trajectory continues, the status of the species could decline to the degree it is in danger of extinction throughout all or a significant portion of its range. Uplisting to the status of endangered may need to be considered during the development of the next 5-year status review.

V. RESULTS

Recommended Listing Action:

- ☐ Downlist to Threatened
- ☐ Uplist to Endangered
- ☐ Delist (indicate reason for delisting according to 50 CFR 424.11):
 - ☐ Extinction
 - ☐ Recovery
 - ☐ Original data for classification in error
- ☒ No Change

New Recovery Priority Number and Brief Rationale: 11

The recovery priority number is based on a 1-18 ranking system where 1 is the highest ranked recovery priority and 18 is the lowest (Service 1983). The new recovery number of 11 indicates that the *Holocarpha macradenia* is a species that faces a moderate degree of threat and has low potential for recovery. A moderate degree of threat means the species will not face extinction if recovery is temporarily held off, although there is continual population decline or threat to its habitat. A low potential for recovery indicates that biological and ecological limiting factors are poorly understood; threats to the species' existence are poorly understood or pervasive and difficult to alleviate; and intensive management is needed, with uncertain probability or success, or techniques are unknown or still experimental (Service 1983). Management of some populations of *H. macradenia* has resulted in improved conditions for the species, and we have an understanding of threats that *H. macradenia* faces and types of management it responds to; however, the determination that *H. macradenia* faces a moderate degree of threat with a low potential for recovery is appropriate based on the fragmentation and isolation of remaining populations; the downward trend of expression in most populations both with and without management; and the continuing threats of competition with other plant species, habitat degradation, and irreversible habitat loss.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. Coordinate a meeting with CDFW and the Elkhorn Slough Foundation, including species experts and managers of *Holocarpha macradenia* populations, to collaborate on current status of the species, successful management and census techniques, and to continue efforts toward management of the species and conservation of habitat.
2. Work with the appropriate governing agencies or landowners to continue and/or improve management for *Holocarpha macradenia* populations, and initiate programs for populations that do not currently undergo a management regime. Possibilities may include but are not limited to: At Fairway Drive, working with the County of Santa Cruz and the Homeowners Association toward more active long-term management and restoration of habitat and populations; working with the Spring Hills Golf Course to investigate possibilities to restore and manage habitat and populations on their property; at O'Neill/Tan, working with the County of Santa Cruz and private landowners toward more active long-term management and restoration of habitat and populations; at Atkinson Lane, working with PG&E toward the

possibility of long-term management and restoration of habitat and populations; at Apple Hill, working with Caltrans to better manage and restore habitat and populations; and at Arana Gulch, working with the City of Santa Cruz toward more vigorous long-term management and restoration of habitat and populations.

3. Investigate opportunities for conservation of lands that support suitable habitat for the species and for future outplanting.
4. Evaluate suitable habitat for future outplanting, and investigate seeding and transplanting techniques that will lead to large, self-sustained populations.
5. Based on research already conducted by Satterthwaite *et al.* (2007), Bainbridge (2003, 2007), and the California Department of Parks and Recreation (Hyland, unpubl. data 2002, 2004, 2007, 2009), undertake additional research to investigate seed bank dynamics, particularly how to maintain optimal balance between aboveground populations and the seed bank.
6. Conduct research to investigate mowing, raking, grazing, and other techniques that are beneficial to *Holocarpha macradenia* and develop best management strategies, particularly for management of thatch and nonnative species, utilizing these techniques.
7. Investigate the impacts of climate change on *Holocarpha macradenia*.

VII. REFERENCES CITED

- Arnold, R.A. and Lyons, K. 2009. Habitat conservation plan for the Ohlone tiger beetle, the Santa Cruz tarplant, and the Gairdner's yampah, Santa Cruz Gardens unit 12 project site, (APNs 025-391-01, 025-401-01, 025-401-02, & 025-491-01), Soquel, California. Prepared for the Porter-Livingston Development, Inc. and O'Hara-Balfour LP, Brentwood, California.
- Bainbridge, S. 2003. *Holocarpha macradenia* Greene (Santa Cruz tarplant) demography and management studies. Prepared for the California Department of Fish and Game (Wildlife) by Susan Bainbridge, The Jepson Herbarium, University of California Berkeley, California.
- Bainbridge, S. 2007. Final report for the *Holocarpha macradenia* Greene (Santa Cruz tarplant) population enhancement project, 2005-2006, Twin Lakes State Beach, Santa Cruz, California. Received May 31. 10 pp.
- Barber, A. 2003. Summary of presentation presented at the Santa Cruz tarplant workshop at the Elkhorn Slough Foundation, Watsonville, California. Dated August 20, 2003.
- Biotic Resources Group. 2010. Census estimates and management actions for subpopulations of Santa Cruz tarplant at Arana Gulch. Biotic Resources Group, Soquel, California. Dated June 28, 2010.
- Bossard, C.C., J.M. Randall, and M.C. Hoshovsky. 2000. Invasive plants of California's wildlands. University of California Press, Los Angeles. Species profile for *Brassica tournefortii* on pp. 68-72. Species profile for *Ehrharta* spp. on pp. 164-170.
- Brownfield, N. 2002. Private lands/Partners for Fish and Wildlife habitat restoration proposal. Submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received January 28. 7 pp.
- Buisson, E., K.D. Holl, S. Anderson, E. Corcket, G.F. Hayes, F. Torre, A. Peteers, and T. Dutoit. 2006. Effect of seed source, topsoil removal and plant neighbor removal on restoring California coastal prairies. *Restoration Ecology* 14:569-577.
- California Coastal Commission. 2011. Coastal development permit application (application number 3-11-074), Arana Gulch Master Plan. Issued to the City of Santa Cruz on December 8, 2011, Santa Cruz, California.
- [CDFW] California Department of Fish and Game (Wildlife). 1997. Santa Cruz tarplant conservation plan, including a plan to mitigate impacts from the Gemtel Project. Sacramento, California. 8pp.

- [CDFW] California Department of Fish and Game (Wildlife). 2007. Permit application for authorization to conduct research on a state-designated endangered, threatened, or rare plant (*Holocarpha macradenia*). California Department of Fish and Game (Wildlife) Research Permit 07-05-RP.
- Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent changes towards earlier springs: early signs of climate warming in western North America. U.S. Geological Survey, Scripps Institution of Oceanography, La Jolla, California.
- City of Santa Cruz. 2006. Arana Gulch Draft Master Plan. Santa Cruz, California.
- City of Santa Cruz. 2010. Arana Gulch master plan alternatives. Santa Cruz, California.
- [CNDDDB] California Department of Fish and Game (Wildlife), Natural Diversity Data Base. 1997. Field survey forms and unpublished reports from the files for *Holocarpha macradenia*.
- [CNDDDB] California Department of Fish and Game (Wildlife), Natural Diversity Data Base. 2001. Element occurrence reports for *Holocarpha macradenia*. Unpublished cumulative data current to 2001.
- [CNDDDB] California Department of Fish and Game (Wildlife), Natural Diversity Data Base. 2010. Element occurrence reports for *Holocarpha macradenia*. Unpublished cumulative data current to April 2010.
- Consortium of California Herbaria. 2010. Consortium of California Herbaria. Berkeley, California. Available on the internet at < <http://ucjeps.berkeley.edu/consortium/>>. Accessed April 28, 2010.
- County of Santa Cruz. 1994. General plan. Available on the internet at <<http://www.sccoplanning.com/pdf/policy/chapter5.pdf>>. Accessed April 23, 2010.
- Department of the Army. 2003. Santa Cruz tarplant interim management. Memorandum submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received October 31, 2003. 5 pp.
- East Bay Regional Parks. 2004. Wildcat Canyon Santa Cruz tarplant restoration 2004 map. East Bay Regional Parks District, Sacramento, California. 2 pp.
- EcoSystems West. 2008. Santa Cruz tarplant – Atkinson Lane Population. Unofficial report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received April 29, 2010. 2 pp.

- Elkhorn Slough Foundation. 2010. Coastal Training Program for Santa Cruz tarplant. Available on the internet at http://www.elkhornsloughctp.org/reference/subissue_detail.php?SUBISSUE_ID=5. Accessed March 10, 2010.
- Ellstrand, N. 1992. Gene flow by pollen: implications for plant conservation genetics. *Oikos* 63:77-86.
- Espeland, E.K. and K.J. Rice. 2010. Ecological effects on estimates of effective population size in an annual plant. *Biological Conservation* 143:946-951.
- Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting climate change in California. Ecological impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, Massachusetts, and the Ecological Society of America, Washington, DC.
- Gilchrist & Associates. 2007. Draft mitigation plan for Santa Cruz tarplant and coastal terrace prairie at the Watsonville Airport. Prepared for the City of Watsonville and the California Department of Fish and Game (Wildlife) by John Gilchrist & Associates, Santa Cruz, California.
- Groom, M.J., G.K. Meffe, and C.R. Carroll. 2006. Principles of conservation biology, third edition. Sinauer Associates, Inc., Sunderland, Massachusetts.
- Hamilton, J. G., J. R. Griffin, and M. R. Stromberg. 2002. Long-term population dynamics of native *Nassella* (Poaceae) bunchgrasses in Central California. *Madroño* 49:274–284.
- Haley, V. 2003. Santa Cruz tarplant population at the Graham Hill Road site. Available on the internet at <http://www.elkhornsloughctp.org/uploads/1108409350GrahamHill.pdf>. Accessed March 8, 2010.
- Hayes, G. 1998. The saga of the Santa Cruz tarplant. *Four Seasons* 10:18-21.
- Hayes, G. and K. Holl. 2003. Cattle grazing impacts on annual forbs and vegetation composition of mesic grasslands in California. *Conservation Biology* 17:1694-1702.
- Heady, H. F. 1988. Valley grassland. Pages 491-514 in Major, J. and M.G. Barbour (editors), *Terrestrial vegetation of California*. California Native Plant Society, Spec. Pub. No. 9, Sacramento, California.
- Heady, H. F., T. C. Foin, M. M. Hektner, D. W. Taylor, M. G. Barbour, and W. J. Barry. 1988. Coastal prairie and northern coastal scrub. Pages 733-762, in: M. G. Barbour and J. Major, (editors), *Terrestrial vegetation of California*. California Native Plant Society, Spec. Pub. No. 9, Sacramento, California.

- High Ground Organics. 2010. Habitat restoration at High Ground Organics. Available on the internet at < <http://www.highgroundorganics.com/Restoration.html>>. Accessed March 8, 2010.
- Hoekstra, J. M., T. M. Boucher, T. H. Ricketts, and C. Roberts. 2005. Confronting a biome crisis: global disparities of habitat loss and protection. *Ecology Letters* 8:23–29.
- Holl, K. 1998. Proposal to conduct research on Santa Cruz tarplant (*Holocarpha macradenia*) a state listed taxon. Proposal submitted to California Department of Fish and Game (Wildlife), Sacramento, California. 23 pp.
- Holl, K.D. and G.F. Hayes. 2006. Challenges to introducing and managing disturbance regimes for *Holocarpha macradenia*, an endangered annual grassland forb. *Conservation Biology* 20:1121-1131.
- Hyland, T. 2002. Status report, *Holocarpha macradenia* Santa Cruz tarplant, October 1, 2001 through July, 24, 2002. Unpublished report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received February 1, 2010.
- Hyland, T. 2004. Status report, *Holocarpha macradenia* Santa Cruz tarplant, October 1, 2003 through July, 2004. Unpublished report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received February 1, 2010.
- Hyland, T. 2007. Status report, *Holocarpha macradenia* Santa Cruz tarplant, October 1, 2006 through July, 2007. Unpublished report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received February 1, 2010.
- Hyland, T. 2009. Status report, *Holocarpha macradenia* Santa Cruz tarplant, October 1, 2008 through July, 2009. Unpublished report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received February 1, 2010.
- Hyland, T. 2010. Status report, *Holocarpha macradenia* Santa Cruz tarplant, October 1, 2009 through July, 2010. Unpublished report submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Received April 22, 2013.
- [IPCC] Intergovernmental Panel on Climate Change. 2007. Climate change 2007: the physical science basis. Summary for policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC Secretariat, World Meteorological Organization and United Nations Environment Programme, Geneva, Switzerland.
- Jepson, W.L. 1925. A manual of the flowering plants of California. U.C. Press, Berkeley. Pg. 1088.

- Jones and Stokes. 2005. Santa Cruz Armory integrated natural resources management plan (second revised administrative draft). Prepared for the California Army National Guard, Sacramento, California.
- Keil, D.J. 1993. *Holocarpha*. Pp. 288-293. In: J.C. Hickman (editor), The Jepson Manual: Higher Plants of California. U.C. Press, Berkeley, California.
- Kummerer, L. 2009. Report on the status of the High Ground Organics *Holocarpha macradenia* population (CNDDDB #40). Dated October 30, 2009.
- Kyhos, D.W., G.D. Carr, B.G. Baldwin. 1990. Biodiversity and cytogenetics of the tarweeds (Asteraceae: Helianthea-Madiinae). *Annals of the Missouri Botanical Garden* 77:84-95.
- Legard, W. 2010. District Botanist, East Bay Regional Park District. Unpublished population data for *Holocarpha macradenia* populations in Wildcat Canyon, submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated February 3, 2010.
- Legard, Wilde. 2013. District Botanist, East Bay Regional Park District, Oakland, California. Unpublished population data for *Holocarpha macradenia* populations in Wildcat Canyon, submitted to the U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated May 14, 2013.
- Leimu, R., P. Mutikainen, J. Koricheva, and M. Fischer. 2006. How general are positive relationships between plant population size, fitness and genetic variation? *Journal of Ecology* 94:942-952.
- Loarie, S.R., B.E. Carter, K. Hayhoe, S. McMahon, R. Moe, C.A. Knight, D.D. Ackerly. 2008. Climate change and the future of California's endemic flora. *Plos ONE* 3(6): e2502 doi 10.1371/journal.pone 0002502.
- Maze, D.M. 2009. Effect of terrestrial mollusk herbivory on *Holocarpha macradenia* (Asteraceae) seedlings in California coastal prairie under different clipping regimes. *Madroño* 56:1-7.
- McAlpine, K.G., and L.K. Jesson. 2007. Linking seed dispersal, germination and seedling recruitment in the invasive species *Berberis darwinii* (Darwin's barberry). *Plant Ecology* 197(1):119-128.
- McClintock, E. 1986. The displacement of native plants by exotics. Pages 185-188 in: Elias, T. (editor), Conservation and management of rare and endangered plants. California Native Plant Society, Sacramento.
- Olberding Environmental. 2009. Biological assessment for the Westgate property, Santa Cruz County, California. Report submitted to the U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office, Ventura, California. Received January 28, 2010.

- Olson, J. 2003. Management of Santa Cruz tarplant at the Santa Cruz Armory. Available on the internet at < <http://www.elkhornsloughctp.org/uploads/1108411391SCTPwkshp.pdf>>. Accessed March 1, 2010.
- Palmer, R. 1987. Evolutionary relationships of *Holocarpha macradenia*. In: Conservation and management of rare and endangered plants. California Native Plant Society. Sacramento. Pp. 295-304.
- Pavlik, B.M. and E.K. Espeland. 2005. A management program for Santa Cruz tarplant (*Holocarpha macradenia*) at Arana Gulch. Report prepared for the City of Santa Cruz. Santa Cruz, California.
- Primack, R.B. 2006. Essentials of conservation biology (fourth edition), chapter 11: problems of small populations. Sinauer Associates, Sunderland, Massachusetts.
- Reed, D.H. 2005. Relationship between population size and fitness. Conservation Biology 19:563-568.
- Salix Consulting, Inc. 2012. Santa Cruz tarplant population assessment for the $\pm$ 298-acre Watsonville Airport study area, City of Watsonville, Santa Cruz County, California. Prepared for the City of Watsonville, Watsonville Municipal Airport. Auburn, California.
- Santa Cruz Sentinel. 2010. California coastal commission delays Arana Gulch vote, asks city to study another option. Available on the internet at <http://www.santacruzsentinel.com/ci_14661492>. Accessed March 12, 2010.
- Satterthwaite, W.H., K.D. Holl, G.F. Hayes, and A.L. Barber. 2007. Seed banks in plant conservation: case study of Santa Cruz tarplant restoration. Biological Conservation 135:57-66.
- Shaffer, M.L. 1981. Minimum population sizes for species conservation. Bioscience 31:131-134.
- Shaffer, M.L. 1987. Minimum viable populations: coping with uncertainty. Pages 69-86 in: M.E. Soulé (editor). Viable populations for conservation. Cambridge University Press, New York, NY.
- Stanton, A. 2013. Research Botanist, South Lake Tahoe, California. Draft Arana Gulch Habitat Management Plan. Prepared for the City of Santa Cruz Planning Department and the Department of Parks and Recreation.
- Stromberg, M. R., and J. R. Griffin. 1996. Long-term patterns in coastal California grasslands in relation to cultivation, gophers, and grazing. Ecological Applications 6:1189–1211.
- [Service] U.S. Fish and Wildlife Service. 1983. Endangered and threatened species listing and recovery priority guidelines. Federal Register 48:43098-43105, September 21, 1983.

- [Service] U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants; threatened status for *Holocarpha macradenia* (Santa Cruz tarplant). Federal Register 65:14898-14909, March 20, 2000.
- [Service] U.S. Fish and Wildlife Service. 2002. Endangered and threatened wildlife and plants; final designation of critical habitat for *Holocarpha macradenia* (Santa Cruz Tarplant); final rule. Federal Register 67:30642-30643, May 7, 2002.
- [Service] U.S. Fish and Wildlife Service. 2008. Biological Opinion for the Broadway-Brommer Pedestrian-Bicycle Path, Santa Cruz County, California (1-8-07-F-46). Ventura, California.
- [Service] U.S. Fish and Wildlife Service. 2009. Recovery priority number for Santa Cruz tarplant (*Holocarpha macradenia*). 2009 Recovery Data Call, Ventura Fish and Wildlife Office, Ventura, California.
- [Service] U.S. Fish and Wildlife Service. 2009a. Ohlone tiger beetle (*Cicindela ohlone*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California.
- [Service] U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; initiation of 5-year reviews of 34 species in California and Nevada; availability of 96 completed 5-year reviews in California and Nevada. Federal Register 75:28636-28642, May 21, 2010.
- [Service] U.S. Fish and Wildlife Service. 2012. Revision to the Broadway-Brommer Trail Project, City of Santa Cruz, Santa Cruz County, California (Federal Project Number CML-5025(012)). Ventura Fish and Wildlife Office, Ventura, California.
- Watsonville Wetlands Watch. 2009. Restoration of Santa Cruz tarplant (*Holocarpha macradenia*) and coastal prairie on Tarplant Hill, Santa Cruz County, final report. Unpublished report submitted by Watsonville Wetlands Watch, Watsonville, California, to the U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office, Ventura, California.
- Watsonville Wetlands Watch. 2010. Current restoration projects. Available on the internet at http://www.watsonvillewetlandswatch.org/restoration_projects.htm. Accessed March 1, 2010.

In litteris

- Baldwin, Bruce. 2001. Jepson Herbarium. Letter addressed to Jim Bartel, U.S. Fish and Wildlife Service, Carlsbad, California, regarding reproductive systems in Otay tarplant (*Deinandra conjugens*). Dated March 6, 2001.

- Cheap, Vince. 2010. Chapter Conservation Chair, Santa Cruz Chapter, California Native Plant Society, Santa Cruz, California. Electronic mail regarding status of the Arana Gulch population of *Holocarpha macradenia*. Received by Lena Chang, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated February 9, 2010.
- Edell, Tom. 2013. District Biologist, Caltrans, San Luis Obispo, California. Electronic mail regarding the status of the Apple Hill population of *Holocarpha macradenia*. Received by Lena Chang, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated June 11, 2013.
- Fodor, Josh. 2010. Central Coast Wilds, Santa Cruz, California. Electronic mail regarding the O'Neill/Tan population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 11, 2010.
- Haley, Valerie. 2010. Botanist, Native Vegetation Network, Santa Cruz, California. Electronic mail regarding the Graham Hill Road population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated May 3, 2010.
- Haley, Valerie. 2013. Botanist, Native Vegetation Network, Santa Cruz, California. Electronic mail regarding the Graham Hill Road population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated June 25, 2013.
- Hayes, Kim. 2013. Stewardship Director, Elkhorn Slough Foundation, Watsonville, California. Electronic mail regarding the Porter Ranch population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated June 27, 2013.
- Hyland, Tim. 2013. Environmental Scientist, California Department of Parks and Recreation, Santa Cruz, California. Electronic mail regarding the 2013 status of *Holocarpha macradenia* at Twin Lakes State Park. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated September 5, 2013.
- Kiguchi, Laurie. 2010. Botanist for the *Holocarpha macradenia* population at Watsonville Airport. Electronic mail regarding *Holocarpha macradenia* at the Watsonville Airport. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 18, 2010.
- Kiguchi, Laurie. 2010a. Botanist for the *Holocarpha macradenia* population at Watsonville Airport. Electronic mail regarding a historic location of *H. macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 17, 2010.

- Kummerer, Laura. 2013a. Restoration Specialist, High Ground Organics, Watsonville, California. Electronic mail regarding the Harkins Slough population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated June 4, 2013.
- Kummerer, Laura. 2013b. Restoration Specialist, High Ground Organics, Watsonville, California. Electronic mail regarding the Harkins Slough population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated July 13, 2013.
- Legard, Wilde. 2010. District Botanist, East Bay Regional Park District, Oakland, California. Electronic mail regarding management of *Holocarpha macradenia* populations in Wildcat Canyon. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 17, 2010.
- Lyons, Kathleen. 2010a. Botanist, Biotic Resources Group, Soquel, California. Electronic mail regarding population status at Arana Gulch and Fairway Drive. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated February 11, 2010.
- Lyons, Kathleen. 2010b. Botanist, Biotic Resources Group, Soquel, California. Electronic mail regarding horses at the Fairway Drive site. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 3, 2010.
- Lyons, Kathleen. 2010c. Botanist, Biotic Resources Group, Soquel, California. Electronic mail regarding the Winkle population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated March 8, 2010.
- Lyons, Kathy. 2013a. Botanist, Biotic Resources Group, Soquel, California. Electronic mail regarding the 2013 population of *Holocarpha macradenia* at Arana Gulch. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated August 29, 2013.
- Lyons, Kathy. 2013b. Botanist, Biotic Resources Group, Soquel, California. Electronic mail regarding the Winkle/Santa Cruz Gardens population of *Holocarpha macradenia*. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated April 19, 2013.
- Pilch, Jonathan. 2013. Restoration Director, Watsonville Wetlands Watch, Watsonville, California. Electronic mail regarding the Tarplant Hill population. Received by Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. Dated June 22, 2013.

Personal Communications

- Davilla, Bill. 2010. Principal Biologist, Ecosystems West, Santa Cruz, California. Phone conversation regarding the status of the Spring Hills population of *Holocarpha macradenia* with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. April 20, 2010.
- Davilla, Bill. 2013. Principal Biologist, Ecosystems West, Santa Cruz, California. Phone message regarding the status of the Spring Hills population of *Holocarpha macradenia* for Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. June 5, 2013.
- Edell, Tom. 2010. District Biologist, Caltrans, San Luis Obispo, California. Phone conversation regarding the status of the Apple Hill population of *Holocarpha macradenia* with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. February 17, 2010.
- Fodor, Josh. 2010. Central Coast Wilds, Santa Cruz, California. Phone conversation regarding the status of the O'Neill/Tan population of *Holocarpha macradenia* with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. May 21, 2010.
- Haley, Valerie. 2010. Botanist, Native Vegetation Network, Santa Cruz, California. Phone conversation regarding the *Holocarpha macradenia* population at Graham Hill Road with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. March 16, 2010.
- Hayes, Kim. 2010. Stewardship Director, Elkhorn Slough Foundation, Watsonville, California. Conversation about *Holocarpha macradenia* at the Porter Ranch Site with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. March 23, 2010.
- Olson, Jody. 2010. Botanist, California Army National Guard, Camp Roberts, California. Phone conversation regarding the status of the *Holocarpha macradenia* population at the Santa Cruz Armory with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. February 23, 2010.
- Olson, Jody. 2013. Botanist, California Army National Guard, Camp Roberts, California. Phone conversation regarding the status of the *Holocarpha macradenia* population at the Santa Cruz Armory with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. July 10, 2013.
- Pilch, Jonathan. 2010. Restoration Director, Watsonville Wetlands Watch, Watsonville, California. Phone conversation regarding the history of the Tarplant Hill site with Lena Chang, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. May 3, 2010.

Personal Observations

Chang, Lena. 2010. Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Ventura, California. Personal observation of the Arana Gulch population of *Holocarpa macradenia*, Santa Cruz, California. March 24, 2010.

Chang, Lena. 2010a. Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Ventura, California. Personal observation of the Porter Ranch population, Watsonville, California. March 23, 2010.

VIII. APPENDICES

APPENDIX A: Map showing distribution of *Holocarpha macradenia* populations



Holocarpha macradenia (Santa Cruz tarplant)

-  California counties with current (and historic) populations
-  California counties where historic populations have been extirpated
-  Cities
-  Current populations



Prepared for the 2014 5-year review

APPENDIX B: Aboveground population data for
Holocarpha macradenia from 2000-2013, expressed as number of individual plants (some numbers in the year 2000 column are pre-2000)

	Natural Populations	2000¹	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	Apple Hill	4,598	477	1,334	351	1	37	0			67	0			12
2	Arana Gulch ²	1,053	619	10,230	2,536	797	1,552	348	27	44	68	0	32	16	18
3	Atkinson Lane									59					
4	De Laveaga	numbers have been estimated at "several thousand" and have remained stable													1,173
5	Fairway Drive	1,500* (1993)			206	257	777								
6	Graham Hill Rd.	475-550	525-600	525-600	875-950			1,350-1,400		1,075-1,125	1,675-1,725	2,250-2,400		1,050-1,150	450-500
7	Harkins Slough	15,000* (1993)					108	15	146	12	205			"a few"	15
8	O'Neill/Tan	0					0	0	0	0	0				
9	Porter Ranch		120,000	population is monitored by area; area is variable, but H. macradenia is present annually								2,200+			8,234
10	Spring Hills Golf Course	4,000* (1990)				1 of 4 original colonies seen									"a few"
11	Struve Slough	1* (1994)	0	0	1	8	60	2	70	69	189	639	213	55	2,141
12	Twin Lakes	7	19	19	349	174			387		914	55	0	0	37
13	Watsonville Airport	4 million	2.5 million		less abundant than previous years	limited census information								512,000	
14	Winkle	101* (1993)				0	0		0						

¹ Numbers with a * are pre-2000

² These are numbers associated with Arana Gulch subpopulation A

Empty boxes represent years with no available population data

Experimental Populations: Wildcat Canyon Regional Park ¹		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Big Belgum	273		921	342	130	425	3	2	56	128	14	3	1
2	Big Belgum West	44		84	189	23	129	0	1	18	75	8	2	1
3	Upper Belgum	126		154	380	623	410	247	179	241	401	369	145	3
4	Fowler	0		0	9	0	1	0	0	0	0	0	0	0
5	Lower Sather													
6	Mezue	17,231		29,657	90,333	63,183	80,849	7,839	25,878	22,721	31,862	12,650	4,727	3,535
7	Nimitz Way	0* (1997)			0	0	0	0	0	0	0			
8	Upper Havey	0		1	0	0	0		0	0	0	0	0	0

¹ Numbers are approximations based on unpublished data
Empty boxes represent years with no available population data

APPENDIX C. Percentage of *Holocarpha macradenia* populations and critical habitat by landowner category, current management efforts, and current conservation status.

Percentage of <i>Holocarpha macradenia</i> Populations and Critical Habitat on Private and Public Lands	Populations and Ownership	Management Actions	Conservation Status
Private 40 percent of total populations 78 percent of critical habitat	Fairway Drive/Private (PVT)	mowing; managed by HOA	easement (County of Santa Cruz)
	Graham Hill Road/PVT	weeding, scraping; managed by Native Vegetation Network	easement (County of Santa Cruz)
	Harkins Slough/ High Ground Organics (HGO)	grazing, scraping, monitoring, weed clipping, watering with fish emulsion; managed by HGO	easement (HGO/CDFW)
	Porter Ranch/ Elkhorn Slough Foundation/CDFW	grazing regime; managed by Elkhorn Slough Foundation	easement (CDFW)
	Spring Hills Golf Course/PVT	mowing by golf course	
	Struve Slough (Tarplant Hill)/Watsonville Wetlands Watch	scraping, mowing, monitoring, invasive plant control, community outreach	undergoing restoration plan by Watsonville Wetlands Watch
	Tan ¹ /PVT	no management since 2005	
	Winkle (Santa Cruz Gardens)/PVT	HCP	HCP will protect 9.3 acres of habitat in perpetuity
	Atkinson Lane/PG&E	unknown	
State 10 percent of total populations 2 percent of critical habitat	Apple Hill/ Caltrans	mowing, raking, scraping; managed by Caltrans	
	De Laveaga/ California Army National Guard (CAARNG)	closed access, restoration, invasive removal; managed by CAARNG	INRMP
	Twin Lakes State Beach/ California Department of Parks and Recreation (CDPR)	scraping, mowing, raking, invasive removal, habitat enhancement, trimming, seeding, outplanting; managed by CDPR	
County/City 50 percent of total populations 20 percent of critical habitat	Arana Gulch/City of Santa Cruz	mowing, raking; managed by the City of Santa Cruz	
	O'Neill ¹ (Anna Jean Cummings Regional Park)/County of Santa Cruz	no management since 2005	
	Watsonville Airport/ City of Watsonville	mowing, grazing, occasional disking; managed by Airport	draft mitigation plan in progress (City of Watsonville/CDFW)
	Wildcat Canyon Regional Park/East Bay Regional Parks District ² (EBRPD)	grazing, invasive removal; managed by EBRPD	

¹Comprises a portion of the O'Neill/Tan population

² Comprises 8 experimentally seeded populations

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW

***Holocarpha macradenia* (Santa Cruz tarplant)**

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

☐ Downlist to Threatened

☐ Uplist to Endangered

☐ Delist

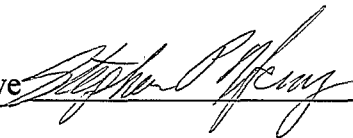
☒ No change needed

Appropriate Listing/Reclassification Priority Number: NA

Review Conducted By: Lena Chang

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve  Date 2/25/14