

Santa Cruz Tarplant (*Holocarpha macradenia*)

**5-Year Review:
Evaluation and Summary**



Photo: Dylan Neubauer

**U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
Ventura, California**

July 2022

5-YEAR REVIEW

Santa Cruz Tarplant (*Holocarpha macradenia*)

GENERAL INFORMATION

Species: *Holocarpha macradenia*

FR citation: 65 FR 14898

Date listed: 20 March 2000

Classification: Threatened

BACKGROUND

Most recent status review

U.S. Fish and Wildlife Service. 2014. *Holocarpha macradenia* (Santa Cruz tarplant) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office. Ventura, California.

FR Notice citation announcing this status review

Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 76 species in California and Nevada. (86 FR 27462), May 20, 2021.

Critical Habitat Designation

Critical habitat for Santa Cruz tarplant was finalized 16 October 2002 (67 FR 63968). Eleven critical habitat units were defined with Contra Costa County, Santa Cruz County, and Monterey County (67 FR 63979 – 67 FR 63980). The primary constituent elements for Santa Cruz tarplant critical habitat include (67 FR 63978):

1. Soils associated with coastal terrace prairies, including the Watsonville, Tierra, Elkhorn, Santa Inez, and Pinto series.
2. Plant communities that support associated species, including native grasses such as needlegrass (*Stipa* [= *Nassella*] sp.) and California oatgrass (*Danthonia californica*); native herbaceous species such as members of the genus *Hemizonia* (other tarplants), Gairdner's yampah (*Perideridia gairdneri*), San Francisco popcorn flower (*Plagiobothrys diffusus*), and Santa Cruz clover (*Trifolium buckwestiorum*).
3. Physical processes, particularly soils and hydrologic processes, that maintain the soil structure and hydrology that produce the seasonally saturated soils characteristic of *Holocarpha macradenia* habitat.

State Listing

Listed as State Endangered under the California Endangered Species Act in 1979 (CNDDDB 2022, p. 12).

ASSESSMENT

Information acquired since the last status review

This 5-year review was conducted by the U.S. Fish and Wildlife Service (Service) Ventura Fish and Wildlife Office. Initiation of this review was announced through a Federal Register notice on May 20, 2021. We contacted land managers and species experts to request any data or information we should consider in our review, conducted a literature search, and reviewed information from monitoring reports, communications with land managers, and preliminary results in reintroduction efforts.

Distribution and Habitat

Santa Cruz tarplant historically occurred within coastal grasslands and prairies from Monterey County, north to Marin County. The statewide loss and degradation of coastal grasslands and prairies has resulted in extirpation of historical occurrences and fragmentation of the remaining occurrences which occur only within Monterey, Santa Cruz, and Contra Costa counties. Fifteen occurrences are located within Santa Cruz and Monterey Counties and four occurrences are located within Contra Costa County (Figure 1). The occurrences in Santa Cruz and Monterey Counties represent the remaining natural, although often managed, occurrences. The occurrences in Contra Costa County were introduced between 1982 and 1986 in an attempt to prevent extirpation of the species from its historical northern limit (Service 2000, p. 14905). The last natural population within Contra Costa County was extirpated in 1993 (Service 2000, p. 14898).

Within the current distribution, Santa Cruz tarplant exists under a variety of conditions ranging from highly invaded grasslands dominated by non-native annual grasses and forbs to relatively intact coastal prairie. Our understanding of the natural habitat characteristics that support Santa Cruz tarplant have not changed since the designation of critical habitat and the previous five-year review (67 FR 63978; Service 2014, pp. 4-7). Recent observational surveys throughout the species range have found that the most stable populations (based on annual abundance estimates) occur within relatively intact coastal prairie with seasonally saturated soils (K. Motamed 2022, pers. com), as exemplified by populations at Porter Ranch and Watsonville Airport. Associated plant species include native grasses such as needlegrass (*Stipa* [=*Nassella*] sp.) and California oatgrass (*Danthonia californica*); native herbaceous species such as members of the genus *Hemizonia* (other tarplants), Gairdner's yampah (*Perideridia gairdneri*), San Francisco popcorn flower (*Plagiobothrys diffusus*), and Santa Cruz clover (*Trifolium buckwestiorum*). Soils associated with Santa Cruz tarplant habitat include the Watsonville, Tierra, Elkhorn, Santa Inez, and Pinto soil series.

The management of Santa Cruz tarplant habitat is diverse. Many occurrences remain unmanaged and the occurrences that are actively managed use grazing, mowing, and hand weeding to reduce competing biomass and to create areas of bare ground for establishment. Scraping and prescribed fire have also been used as management tools.

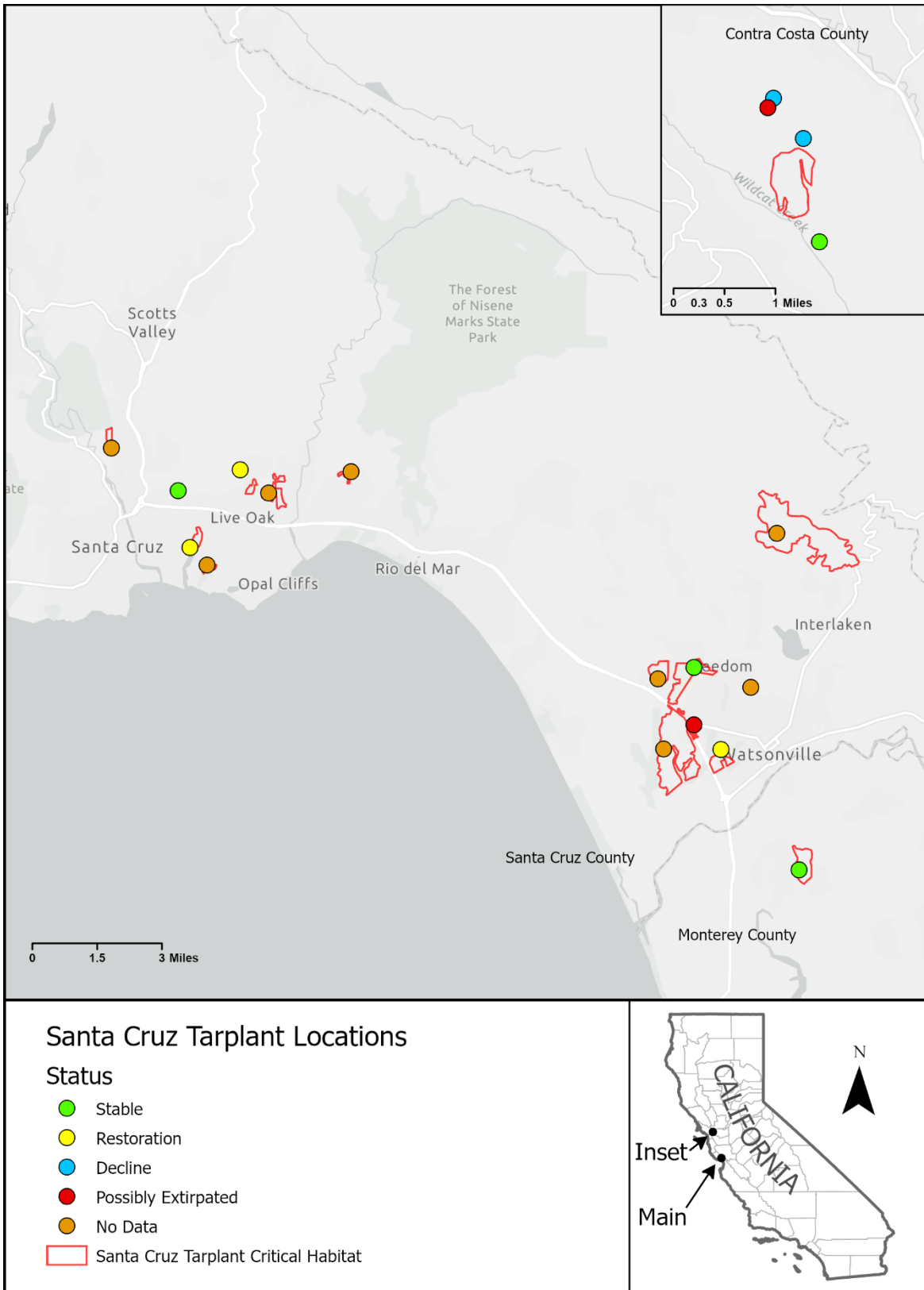


Figure 1. Santa Cruz tarplant (*Holocarpha macradenia*) locations and critical habitat units (Service 2002, data).

Abundance and Population Trends

There are currently 19 known occurrences that support Santa Cruz tarplant or are presumed to have a viable seedbank and suitable habitat (Table 1). This is an increase of one occurrence, located on private land, since the 2014 5-year review. Eleven occurrences have regular or periodic monitoring that estimate annual abundance of Santa Cruz tarplant and also have active management and/or reintroduction efforts. The remaining eight occurrences have no monitoring and management efforts, or have ceased monitoring and management since 2014.

Table 1 Location names, California Natural Diversity Database (CNDDDB) occurrence number, management, and ownership of Santa Cruz tarplant locations (CNDDDB 2022, data). Hyphens (-) represent areas with no known management of Santa Cruz tarplant.

Occurrence Number	Location Name	Management	Ownership
5	Apple Hill	-	Caltrans
6	Aran Gulch	experimental including grazing, mowing, scraping, reintroduction	City of Santa Cruz
na	Atkinson Lane	-	Private/PG&E Easement
47	De Laveaga (Santa Cruz Armory)	monitoring, mowing, grazing	California Army National Guard
33	Fairway Drive	-	Private
21	Graham Hill	ended 2017	Private/Conservation Easement
40	Harkins Slough	grazing	Private/Conservation Easement
11	O'Neill/Tan/Anna Jean Cummings	-	County of Santa Cruz/Private
19	Porter Ranch	monitoring, grazing	Elkhorn Slough Foundation
41	Spring Hills Golf Course	-	Private

Occurrence Number	Location Name	Management	Ownership
34	Struve Slough / Tarplant Hill	monitoring, mowing	Watsonville Wetlands Watch
2	Twin Lakes State Beach	-	California Department of Parks and Recreation
9	Watsonville Airport	mowing, monitoring	City of Watsonville
46	Buena Vista Drive	-	Private
11	Santa Cruz Gardens/Winkle	monitoring, restoration	Private/Conservation Easement
28, 29, 30	Wildcat Canyon Regional Park (4 occurrences)	grazing, monitoring, (Introduced)	East Bay Regional Parks

Data from the De Laveaga (Santa Cruz Armory), Porter Ranch, Watsonville Airport, and Mezue occurrences suggest these populations are stable, although interannual variation in abundance can fluctuate significantly (>50 percent) around a mean population size (Table 2). The number of individuals at these locations range from hundreds to hundreds of thousands largely correlated with the area of the occurrence. However, years with many individuals have been observed at occurrences that are small in area, such as the Porter Ranch location in 2021. These very productive years at Porter Ranch produced a higher proportion of small individuals compared to larger individuals during years with abundances closer to an assumed mean population size (D. Dunkell 2022, pers. com). The larger, stable populations at De Laveaga (Santa Cruz Armory), Porter Ranch, Watsonville Airport, and Mezue differ from one another in relation to management strategy, interannual variability, and potentially climate. Mezue occurs in Contra Costa County, while the others are grouped relatively closer together in Santa Cruz and Monterey Counties. The common characteristic among these populations is some amount of remnant coastal prairie or coastal grassland habitat consisting of native grasses and forbs, as well as seasonally saturated soils. Additionally, although the management differs between locations, each site's management regime has been in place since at least 2014, with grazing at Porter Ranch and Mezue, mowing at the Watsonville Airport, and no management occurring at the De Laveaga (Santa Cruz Armory).

The populations at Arana Gulch, Santa Cruz Gardens, and Tarplant Hill have declined since 2014 despite management efforts to increase population sizes through weed control efforts. These areas have recently undergone restoration activities that include experimental management and/or introduction of Santa Cruz tarplant seed or juvenile plants. There are currently not enough years of data to evaluate whether the novel management or reintroductions have been successful.

Two additional occurrences within Wildcat Canyon Regional Park, Big Belgum and Upper Belgum, have monitoring data suggesting declining abundance. No restoration activities are planned for these locations.

The Apple Hill and Big Belgum West populations are no longer believed to support Santa Cruz tarplant based on multiple years of finding no individuals during surveys. The decline in abundance is presumed to be due to competition with non-native species. There is no management occurring at the Apple Hill location, and Big Belgum West is grazed as part of the general management of Wildcat Canyon Regional Park. The presence of a seed bank at either location is unknown.

The remaining populations have too little information to determine a trend in abundance but based on historical data and a lack of current management, the population numbers at those sites may be inferred to be low to zero. Because Santa Cruz tarplant establishes long term seed banks that may be present and undetected even though there are not observed germinated plants, we still consider these areas to have potential to support natural populations if habitat conditions improve (Service 2014, pp. 4-5).

In summary, the available data suggest that the most stable and abundant populations of Santa Cruz tarplant are those with consistent and long-standing management practices in areas with remnant or intact coastal prairie and grassland habitat with seasonally saturated soils. Only four of nineteen populations have data indicating stable populations. The remaining 15 populations are either undergoing restoration and have yet to demonstrate success, are in decline, or have no data from which to make an assessment.

Table 2. Estimated annual abundance of Santa Cruz tarplant at each location from 2014 through 2021. Occ. # refers to the associated California Natural Diversity Database occurrence number if available. Hyphens (-) represent years where no data were available.

Location (Occ. #)	2014	2015	2016	2017	2018	2019	2020	2021
Apple Hill (5)	-	26	0	0	0	0	-	-
Arana Gulch (6)	4	0	35	0	267	-	17	16
Atkinson Lane (na)	-	-	-	-	-	-	-	-
De Laveaga (Santa Cruz Armory) (47)	1050	1060	1552	472	785	2465	-	4437
Fairway Drive (33)	-	-	-	-	-	-	-	-

Location (Occ. #)	2014	2015	2016	2017	2018	2019	2020	2021
Graham Hill (21)	625 to 725	-	975 to 1075	310 to 385	-	-	-	-
Harkins Slough (40)	-	-	-	-	-	224	-	50
O'Neill/Tan/Anna Jean Cummings (11)	-	-	-	-	-	-	-	-
Porter Ranch (19)	12000	10892	6300	-	-	16588	39166	205786
Spring Hills Golf Course (41)	-	-	-	-	-	-	-	-
Struve Slough / Tarplant Hill	3818	2239	406	<100	-	192 - 405	-	288
Twin Lakes State Beach (2)	-	-	-	-	-	-	-	-
Watsonville Airport (9)	705000	740000	772640	-	-	-	932000	-
Buena Vista Drive (46)	-	-	1500000	-	-	-	-	-
Santa Cruz Gardens/Winkle (11)	0	0	0	3	5	2	0	0
Big Belgum (28)	0	48	42	190	1	2	-	0
Big Belgum West (28)	-	0	0	0	-	-	-	-
Upper Belgum (29)	0	115	131	11	64	115	-	5
Mezue (30)	0	17030	20000	2150	-	74292	-	53912

Management Approaches

Santa Cruz tarplant abundance declines as invasive or non-native species abundance increases. Grazing (cattle), mowing, scraping, prescribed fire, and manual weed control have been utilized to control competition with invasive or non-native species depending on location, available

resources, and infrastructure. Each of these management approaches seeks to reduce competing biomass through an artificial disturbance to promote Santa Cruz tarplant germination, survival, and reproduction, and may be modified to control the intensity and timing of the disturbance as necessary to promote Santa Cruz tarplant.

The effectiveness of a specific management program is not uniform across occurrences. For example, Watsonville Airport has the largest and most consistently abundant population of Santa Cruz tarplant using only mowing at specific times of year, at specific heights depending on plant phenology, and at slow speed to reduce thatch accumulation (Salix 2020, pp. 4-6). No other locations have been able to maintain a stable population using only mowing to control non-native species. Conversely, grazing has been used at Arana Gulch, Porter Ranch, and Wildcat Canyon with various results (Beck and Woessner 2021, pp. 22-23; Dunkell 2022, pers. com.; M. Hammond 2022, pers. com.). Porter Ranch has a relatively stable and large population compared to Arana Gulch that has a population size near zero, although both have utilized grazing as the primary management tool. Wildcat Canyon consists of four areas with only one of the four areas consistently supporting large numbers of Santa Cruz tarplant despite all being managed with grazing. Scraping, prescribed fire, and manual weed control have been used at Arana Gulch and Tarplant Hill and appear effective in promoting Santa Cruz tarplant in the next growing season after the management action (Beck and Woessner 2021, pp. 22-23; J. Pilch 2022, pers. com.). However, these are not techniques that can be used continually to support both habitat and abundance of Santa Cruz tarplant within an occurrence because they rely on extreme levels of disturbance (scraping, burning), which may have negative effects on the associated habitat structure, or are impractical at large scales and with limited funds (manual labor).

Comparisons between occurrences with similar general management approaches (e.g. grazing, mowing) should be done carefully and only when the details of the management are known. For example, the grazing regime at Wildcat Canyon is different than that at Arana Gulch or Porter Ranch. Additionally, the occurrence characteristics such as habitat productivity, soil moisture, shade, and vegetation composition may affect the realized intensity of the grazing even if stocking rates are similar between locations. Similarly, multiple locations may utilize mowing to reduce competition from non-native species, but the timing, frequency, height of cut, and type of mower all may affect how Santa Cruz tarplant responds to the mowing. Historical land use further complicates comparisons between locations by affecting the density and viability of a seedbank, soil characteristics, hydrology, and current vegetation composition.

Future management would benefit from regular data collection that facilitates comparisons between occurrences. Current management goals are to reduce the amount of non-native species (competing biomass) that inhibit Santa Cruz tarplant germination, survival, and reproduction. Estimation of the total non-Santa Cruz tarplant herbaceous biomass produced in a growing season, compared to the end of season non-Santa Cruz tarplant herbaceous biomass would allow the intensity, or reduction in biomass, of each management approach to be calculated. Stocking rates and timing should be recorded for areas grazed and type of mower, timing of mowing, height of mowing, and any thatch removal or management should be recorded for areas that are mowed. Regularly collecting these kinds of data between occurrences could potentially describe why not all grazing and/or mowing efforts have similar responses and could provide the information needed to determine best management practices for the species.

Active Reintroduction Efforts

Active reintroduction efforts are in progress at Arana Gulch and Santa Cruz Gardens (K. Lyons 2022, pers. com., D. Rogers 2021, pers. com.; Stanton 2021, entire). Both populations have declined to zero or near zero in recent years (Table 1). Habitat management at both locations failed to improve germination of a seed bank, prompting active reintroduction efforts. At Santa Cruz Gardens, partners are broadcasting seed. At Arana Gulch, partners are outplanting individuals within weed control treatment plots (Stanton 2021, entire). Novel introductions (introductions at areas where the species has previously not been known to occur) of Santa Cruz tarplant have been attempted in the past without success (Holl and Hayes 2006, entire). Current plans to reintroduce the species into sites formerly occupied with high abundance (reintroduction) may have greater success than introductions to locations with apparent suitable habitat but have not been historically occupied.

Evaluation of Threats

Habitat loss from development, habitat degradation from invasive species and grazing, small preserve sizes, ineffective management and restoration, and stochastic events were all considered threats at the time of listing (Service 2000, p. 14899). While we consider each of these threats separately, it is important to note that they are all linked, and changes in one can result in changes in the others. Climate change was also considered a threat in the previous 5-year review (Service 2014, p. 29). Each of these threats remain and are discussed below.

Habitat Loss

The rate of direct habitat loss due to development has slowed since Santa Cruz tarplant was listed. The Service is not aware of any new development projects that have resulted in direct and permanent loss of Santa Cruz tarplant since the 2014 5-year review. Prior loss of habitat has resulted in fragmented populations that are isolated by surrounding urbanization, and inhibiting gene flow between populations (Service 2014, pp. 17-18).

Arana Gulch, Fairway Drive, Graham Hill, Santa Cruz Gardens, and Wildcat Canyon represent populations that have been placed into conservation easements or are managed for the benefit of Santa Cruz tarplant as mitigation for development. Arana Gulch and Santa Cruz Gardens have each had significant declines in abundance to zero or near zero, suggesting that these occurrences have failed to offset any loss of individuals and habitat that resulted from associated development. There were originally eight introductions of Santa Cruz tarplant within Wildcat Canyon, only three of which are considered extant, and only one has greater than 1,000 individuals, with the remaining two populations ranging between 10 and 200 individuals (Table 2). Abundance reporting for the Fairway Drive population ceased in 2005 with the last abundance estimate indicating a decline since listing. Monitoring of the Graham Hill occurrence ceased in 2017 after a low abundance year that was within the observed historical range in fluctuation. Taken together, the available information suggests that the permanent loss of individuals and habitat of Santa Cruz tarplant that has occurred from development has not been offset by mitigation and that the resulting fragmented populations have continued to decline and are likely to continue to decline in the absence of successful long-term management. This observation mirrors the results of an unsuccessful attempt to experimentally introduce Santa Cruz tarplant to multiple locations (Holl and Hayes 2006, pp. 1128-1130).

Although the rate of habitat loss from development has decreased, there are multiple populations on properties owned by entities that may develop the land in the future. These populations are at risk of habitat loss if development occurs and mitigation to offset development is unsuccessful. The lack of success of past mitigation suggests that any future development of currently occupied land would result in further permanent reduction in Santa Cruz tarplant suitable habitat and abundance.

Invasive Species

Invasive species are currently the primary threat contributing to population declines and habitat degradation of Santa Cruz tarplant and control of invasive species is the primary goal of management (Beck and Woessner 2021, pp. 21-33; L. Kummerer 2022, pers. com.; Service 2014, p. 19; Wallace 2013, p. 2). Santa Cruz tarplant occurs in areas that were historically disturbed, typically by cattle grazing, but the frequency and intensity of disturbance that best promotes Santa Cruz tarplant is not known. In the absence of this disturbance (release from grazing), invasive species increased with resulting decreases in Santa Cruz tarplant abundance (Service 2014, pp. 19-20). Commonly associated invasive plant species include ryegrass (*Festuca perennis*), cat's ear (*Hypochaeris* spp.), English plantain (*Plantago lanceolata*), velvet grass (*Holcus lanatus*), nut sedge (*Cyperus* sp.), rattlesnake grass (*Briza maxima*), and white clover (*Trifolium repens*) (Lyons 2019, pp. 1, 4; Patten 2021, p. 1).

Invasive species are managed at multiple Santa Cruz tarplant locations using grazing or mowing to reduce the biomass, litter, and canopy height of invasive species (despite differences, mowing may be considered a partial substitute for grazing) (Beck and Woessner 2021, pp. 21-33; L. Kummerer 2022, pers. com.; Service 2014, p. 19; Wallace 2013, p. 2). The response of Santa Cruz tarplant has been variable between sites and management techniques. For example, at Arana gulch there is near complete cover of non-native forbs and grasses despite recent grazing and mowing, as well as history of grazing, mowing, scraping, and burning to stimulate Santa Cruz tarplant while reducing invasive species cover. Even with long term management of invasive species, the total annual abundance of Santa Cruz tarplant has remained near zero since 2014 (Table 2). Conversely, the mowing regime at the Watsonville Airport has been mostly successful at maintaining a large population of Santa Cruz tarplant and associated coastal prairie, while also keeping invasive species to densities that do not appear to impede the reproductive cycle of Santa Cruz tarplant (Salix 2020, pp. 4-6, 10-13). An important difference between the sites is that the management at the Watsonville airport is designed to maintain an existing large population, while the management at Arana Gulch is attempting to stimulate a population in decline. The difference in responses between the two locations suggests that invasive species may be managed successfully where an existing large population of Santa Cruz tarplant already occurs, but invasive species management alone may not be enough to improve populations that were historically large but are currently near zero.

We assume that locations that are unmanaged, for which no data are available, have high levels of invasive species cover, and that habitat that was once suitable may no longer be suitable due to competition. It is likely that invasive species will continue to be a persistent threat to both Santa Cruz tarplant and its habitat until successful management techniques are refined and uniformly applied.

Grazing

Grazing is considered a threat to Santa Cruz tarplant because it is a primary factor in the historical degradation of Santa Cruz tarplant habitat by facilitating the introduction and establishment of non-native plant species within coastal prairie and coastal grasslands (Service 2000, pp. 14901-14907). All populations have been exposed to some form of grazing, with the possible exception of the De Laveaga (Santa Cruz Armory) occurrence, and all populations are either dominated by non-native species or have significant amounts of non-native species present that require management to maintain existing Santa Cruz tarplant habitat. All known habitat for Santa Cruz tarplant is believed to have been historically degraded prior to listing through the introduction and subsequent dominance of non-native plants species.

Currently, grazing may either be a continued threat to Santa Cruz tarplant, or a benefit. Grazing may be a threat if it results in continued degradation of habitat by promoting invasive species or through direct mortality of Santa Cruz tarplant. Grazing may be a benefit if the grazing regime decreases the cover of invasive species, thereby facilitating Santa Cruz tarplant germination, survival, and reproduction. Both scenarios have been observed. The listing rule noted that occurrences that supported Santa Cruz tarplant declined in abundance following grazing release (Service 2000, pp. 14902-14904). Conversely, the population at Porter Ranch has been relatively stable under the existing grazing regime, while also maintaining a high amount of native cover and remnant coastal prairie habitat (Table 2, Motamed 2022, pers. com.). The grazing program at Wildcat Canyon Regional Park has had varying degrees of success with the introduced populations. Of the original eight introductions, only three regularly have plants and only one of those with abundance consistently greater than 1,000 plants (Table 2).

Grazing was reintroduced to Arana Gulch with the goal of improving habitat conditions by reducing non-native species cover, increasing the amount of bare ground, and stimulating the seed bank (Beck and Woessner 2021, pp. 21-33). Population numbers had decreased to historically low abundance and in some years no individuals were observed. The reintroduced grazing regime did not succeed in increasing Santa Cruz tarplant abundance, although bare ground increased and non-native species cover and canopy height decreased. Native species cover did not increase as non-native species cover decreased and despite decreases in non-native species cover, non-native species remain near 100 percent relative cover.

The lack of success at Arana Gulch, variable results at Wildcat Canyon, and successful management at Porter Ranch highlight the difficulty in categorizing grazing as either a threat or a benefit to Santa Cruz tarplant. The term grazing is used interchangeably between locations despite significant practical differences in stocking rates, grazing infrastructure, active grazing management, animal species, and grazing intensity. Typical grazing metrics such as residual dry matter are not recorded (or not reported) at most locations making comparisons of grazing intensity between occurrences difficult. Grazing may be viewed as an attractive management tool since it may be cost effective for controlling non-native species across large areas and can be compatible with Santa Cruz tarplant. However, areas where grazing is not already occurring likely lack the infrastructure to introduce cattle, and many areas where Santa Cruz tarplant occurs are located on parcels with too little acreage for a permanent herd, necessitating the movement of cattle to and from an occurrence depending on forage levels and Santa Cruz tarplant phenology. The required movement of small numbers of cattle increases the difficulty of

implementing an effective grazing program in areas within urban interfaces and on small acreages. A potential solution for small occurrences within urban interfaces is to use mowing as a substitute for grazing. This has been done successfully at the Watsonville Airport. However, mowing has been attempted at Arana Gulch and Tarplant Hill with less success, again highlighting the need to identify the conditions and techniques under which mowing may be used effectively.

Preserve Size and Management

The majority of existing Santa Cruz tarplant occurrences occur on small properties, the majority of which have no active management programs specific to Santa Cruz tarplant. The smaller occurrences are also generally located within an urban framework that isolates occurrences from one another. Santa Cruz tarplant is self-incompatible, requiring pollen from other individuals to produce viable seed (67 FR 63968). Small and isolated populations are less likely to be connected to the larger metapopulation if pollinator pathways are obstructed by large distances and urbanization. The effects of small occurrence sizes are exacerbated by lack of management, allowing non-native plant species to outcompete Santa Cruz tarplant, resulting in decreased abundance and degraded habitat. Populations with small acreages within urbanized areas that lack management are likely to experience continued declines and become increasingly unsuitable for Santa Cruz tarplant unless habitat is improved through appropriate management actions.

Stochastic Events

The threat from stochastic events increases as the number of occurrences, and the number of individuals within an occurrence, decrease. Eight of the nineteen occurrences have no abundance information or regularly have fewer than 10 individuals based on periodic monitoring. Six occurrences frequently have between 100 and 500 individuals. The remaining five occurrences regularly have larger abundances. With 14 of 19 occurrences having low numbers of individuals, Santa Cruz tarplant is very susceptible to loss of occurrences due to stochastic events. Because populations are fragmented and separated by large distances, the remaining large populations are unlikely to act as sources to naturally recolonize populations following loss of occurrences due to stochastic events. Establishing new populations or reintroducing seed or juvenile plants to declining areas has proven difficult, suggesting that loss of any single occurrence is not likely to be easily restored to self-sustaining conditions (Beck and Woessner 2021, pp. 27-28, Holl and Hayes 2006, entire).

Climate Change

Santa Cruz tarplant may be affected by climate change most directly through changes in magnitude and variability of precipitation, minimum temperature, and maximum temperature. Average precipitation is projected to increase by 2.5 to 9.8 inches by 2099 throughout Contra Costa, Santa Cruz, and Monterey Counties. This range includes the projected change in annual precipitation for climate models using both medium and high carbon futures (Ackerly et al. 2018, pp. 17-25, Langridge 2018, pp. 12-17). Despite the increase in precipitation, the areas occupied by Santa Cruz tarplant may experience fewer total days of precipitation relative to historical averages because of an associated increase in precipitation variability and timing. Current climate models suggest that there will be fewer days of higher-than-average precipitation, leading to increased number of dry days between precipitation events (Langridge et al. 2018, p. 16). Because timing of precipitation impacts germination and survivorship, the changes in

variability and timing are likely to have a greater impact on the recovery of Santa Cruz tarplant than the change in the amount of precipitation.

Average maximum and minimum temperatures are also projected to increase throughout the range of Santa Cruz tarplant. The greatest change in temperatures will occur at areas inland, outside of coastal influence and the amount of temperature increase will vary depending global emissions relative to the modeled medium and high carbon futures (Ackerly et al. 2018, pp. 13-16; Langridge 2018, pp. 13-15).

Santa Cruz tarplant is closely associated with coastal prairie and coastal grassland vegetation types. These vegetation types may have some resilience to climate change due to the moderating effects of the ocean and the presence of coastal fog, as well as being comprised of species that have evolved within a landscape of high inter-annual variability in precipitation and drought (Langridge 2018, p. 40-41). However, if the amount of fog decreases, the future environment may favor non-native annual species commonly associated with interior grasslands. In either case, the specific effects of climate change to Santa Cruz tarplant may be variable but are expected to be detrimental.

Summary of Threats

Habitat loss from development was the primary threat that led to the listing of Santa Cruz tarplant. Historical habitat loss resulted in populations that generally have low abundance, small acreages, and are isolated from one another by surrounding urbanization, reducing gene flow and increasing the threat of extirpation from stochastic events. Development on unprotected properties still threatens Santa Cruz tarplant and its habitat despite many locations being protected from direct development. The current primary threat is the continued degradation of habitat that supports or could support Santa Cruz tarplant. The most common cause of habitat degradation is the loss of native coastal prairie and grassland species due to increases in invasive or non-native vegetation. Non-native vegetation has historically increased at sites that support Santa Cruz tarplant, typically due to historic grazing and subsequent grazing release that allowed non-native species to expand. At most locations, non-native vegetation management is either not occurring or has been ineffective at facilitating the reestablishment of native species and increasing Santa Cruz tarplant abundance. Climate change will likely exacerbate all other threats by further reducing habitat suitability due to increases in the length and severity of drought.

RECOVERY CRITERIA

A recovery plan for Santa Cruz tarplant has not been completed, and therefore recovery criteria have not been established. Recovery actions that will benefit the species are listed in the recommendations section of this review.

CONCLUSION

The evaluation of threats affecting the species under the factors in 4(a)(1) of the Act and current understanding of population trends were conducted using the best available scientific information. Habitat loss from development, habitat degradation from invasive species and grazing, small preserve sizes, ineffective management and restoration, stochastic events, and

climate change all remain threats to Santa Cruz tarplant. The abundance of Santa Cruz tarplant appears stable at four of 19 populations with the remaining populations declining in abundance or lacking data with which to assess population trends. Therefore, we conclude that Santa Cruz tarplant remains a threatened species.

RECOMMENDATIONS FOR FUTURE ACTIONS

1. Identify techniques for successful reintroduction and management.
2. Secure funding for management at currently unmanaged locations.
3. Include habitat restoration as part of reintroduction efforts.
4. Identify mechanisms to promote and preserve Santa Cruz tarplant on properties susceptible to development.

APPROVAL

Lead Field Supervisor, Fish and Wildlife Service

Approved _____ Date 7/19/2022
Acting for Stephen P. Henry, Field Supervisor

REFERENCES

- Ackerly, D., A. Jones, M. Stacey, B. Riordan. (University of California, Berkeley). 2018. *San Francisco Bay Area Summary Report*. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.
- Beck, T., and B. Woessner. 2021. Arana Gulch Habitat Management Plan City of Santa Cruz Year 7 (2020) Annual Report. City of Santa Cruz Department of Parks and Recreation. 101 pp.
- [CNDDDB] California Natural Diversity Database. 2022. State and Federally Listed Endangered, Threatened, and Rare Plants of California. California Department of Fish and Wildlife. Sacramento, CA. April 2022. 25 pp.
- [CNDDDB] California Natural Diversity Database. 2022. Element occurrence reports of *Chorizanthe pungens* var. *hartwegiana*. California Department of Fish and Game, Biogeographic Data Branch. Accessed January 2022.
- Dunkell, D. 2022 Email from Dash Dunkell to Todd Lemein regarding population abundance of Santa Cruz tarplant at Porter Ranch. April 2022.
- Hammond, M. 2022. Email from Michele Hammond to Todd Lemein regarding population abundance and management of Santa Cruz tarplant. June 2022.
- 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*. 20:4, 1121-1131.
- Kummerer, L. 2022. Email from Laura Kummerer to Todd Lemein regarding Santa Cruz tarplant abundance at Harkins Slough. June 2022.
- Langridge, R. (University of California, Santa Cruz). 2018. Central Coast Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-006.
- Lyons, K. 2019. Arana Gulch Greenbelt Summary of Santa Cruz Tarplant Census July – September 2019. 4 pp.
- Lyons, K. 2022. Email from Kathy Lyons to Todd Lemein regarding abundance and introduction of Santa Cruz tarplant at Santa Cruz Gardens. May 2022.
- Motamed, K. 2022. Email from Kaveh Motamed to Todd Lemein regarding observations of habitat characteristics of stable populations of Santa Cruz tarplant. May 2022.
- Patten, A. 2021. CNPS Rare Plant Treasure Hunt Field Survey Form completed for Santa Cruz Armory. 1 pp.
- Pilch, J. 2022. Email from Jonathan Pilch to Todd Lemein regarding Santa Cruz tarplant abundance and recent management actions. June 2022.

- Rogers, D. 2021. Letter from Deborah Rogers to Cat Darst regarding the status of Santa Cruz tarplant (*Holocarpha macradenia*) at Santa Cruz Gardens managed by the Center for Natural Lands Management. July 19, 2021.
- Salix Consulting Inc. 2020. 2020 Santa Cruz Tarplant Population Assessment for the +/-291-Acre Watsonville Municipal Airport Study Area. Prepared for: City of Watsonville Water Operations Division. 30 pp.
- [Service] U.S. Fish and Wildlife Service. 2000. Endangered and Threatened Wildlife and Plants; Threatened Status for *Holocarpha macradenia* (Santa Cruz tarplant). 65 FR 14898-14909.
- [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). 67 FR 63968-64007.
- [Service] U.S. Fish and Wildlife Service. 2014. *Holocarpha macradenia* (Santa Cruz tarplant) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office. 48 pp.
- [Service] U.S. Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 76 species in California and Nevada. (86 FR 27462), May 20, 2021.
- Stanton, A. E. 2021. Arana Gulch 2021 Experimental SCT Planting Program. Prepared for the City of Santa Cruz Parks and Recreation. 8 pp.
- Wallace, J. 2013. Management Practices for the Santa Cruz Tarplant on the Watsonville Municipal Airport – For Submission to the California Department of Fish and Wildlife. Memorandum from Jim Wallace to Rayvon Williams. Wallace Environmental Consulting, Inc. 4 pp.