

## **5-YEAR REVIEW**

### **Tiburon mariposa-lily (*Calochortus tiburonensis*)**

#### **GENERAL INFORMATION:**

**Species:** Tiburon mariposa-lily (*Calochortus tiburonensis*)

**Date listed:** February 3, 1995

**Federal Register (FR) citation:** 60 FR 6671

**Classification:** Threatened

#### **State Listing:**

The Tiburon mariposa-lily was listed by the State of California as threatened in 1987.

#### **BACKGROUND:**

##### **Most recent status review:**

U.S. Fish and Wildlife Service. 2011. *Calochortus tiburonensis* (Tiburon mariposa lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 13 pp.

##### **FR Notice citation announcing this status review:**

U.S. Fish and Wildlife Service. 2020. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 66 Species in California and Nevada. Federal Register 85:4692–4694.

We did not receive information from the public regarding the Tiburon mariposa lily in response to the notice.

#### **ASSESSMENT:**

##### **Information acquired since the last status review:**

This 5-year review was conducted by the U.S. Fish and Wildlife Service's (Service) Sacramento Field Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on January 27, 2020 (Service 2020, entire). We also contacted species experts, land managers, performed a literature search, and reviewed information from our own files, much of which was compiled during a recent recovery plan amendment for the species. The recovery plan amendment included quantitative criteria for delisting the species (Service 2019, pp. 34–36). New information has been incorporated into the relevant sections below.

##### **Species overview:**

The Tiburon mariposa lily is a bulbous perennial of the lily family (Liliaceae). Depending on climatic factors, the flowers bloom between May and late June, and are dependent on the bumblebee (*Bombus californicus*) for pollination. The species is only known from the open, rocky, serpentine derived soils of the serpentine bunchgrass community at Ring Mountain Preserve (Preserve) in southern Marin County, California. The status of the Tiburon mariposa lily has not changed substantially since it was listed in 1995; the population has remained relatively stable, with one potential recent decline (Service 2011, p. 10; Swope pers. comm.

2018; Marin County 2021a, entire; Marin County 2021b, p. 1). The species continues to be monitored within the Preserve (see the **Distribution** and **Abundance** sections below).

#### **New research:**

A long-term demography study was initiated in 2012 to assess basic biological and ecological characteristics of the Tiburon mariposa lily that will ultimately help inform a management plan (Marin County 2021c, p. 2). The primary purpose of the project was to identify the various Tiburon mariposa lily life stages, determine what life stages are most susceptible to various impacts (i.e., predation, mortality), and identify what life stages are driving population trends (Marin County 2021a, p. 12). Components of this study include: determining population dynamics using matrix models, determining life stage transitions, assessing whether pollen is limiting reproduction, and assessing whether colonies of Tiburon mariposa lily are locally adapted to the soil chemistry within that area (Swope 2013, p. 1; Swope 2014, p. 1; Swope 2015, p. 1; Swope 2016, p. 1).

#### Demography study

The demography study began in the fall of 2012 and continued through the summer of 2016. During the initial year of the study, life stages were identified and transition rates were estimated; however, it was noted that transition rates were likely to vary in response to environmental conditions (Swope 2013, pp. 1–2). A total of seven Tiburon mariposa lily life stage transition states were identified: seed, small vegetative, large vegetative, small flowering, large flowering, dormant, bulbil (Swope 2013, pp. 2–3, Table 1). After the second year of study and one full year of transition was recorded, at least 60% of the individual lilies monitored remained dormant or reverted to a smaller life stage, which was thought to be a response to drought conditions the area was experiencing (Swope 2014, p. 1). Previous observations suggest this dormancy can persist for at least three years when environmental conditions are unfavorable (Swope 2014, p. 2). Over the entire study period, in which drought conditions persisted every year, 70% of tracked lilies went dormant at least once and 23% were dormant for over a year (Swope 2016, p. 2). Furthermore, it appears the species also responds to unfavorable conditions by producing, on average, fewer flowers per plant (Swope 2014, p. 2). Over the four-year study, 49.7% of tracked individuals flowered at least once, but 50.3% never flowered at all (Swope 2016, p. 2).

In 2015, results were provided for two of the colonies that were being monitored, which are referred to as the “Nursery” and “Burn” sites. These colonies are the largest and most dense of the monitored colonies, and about 20–35% of the individuals within these colonies remained dormant over the study. The Burn colony grew in 2013–2014 and again in 2014–2015, but only half of the plants flowered in 2015 compared to the previous three seasons. In contrast, the Nursery colony showed declines over the same survey years; in addition, flowering plants within the colony decreased to about half their previous abundance (Swope 2015, p. 2). These results suggest mature plant survival has the greatest influence on colony growth rate (Swope 2015, p. 2). Plants that survive to flowering within the Nursery colony contribute 3.6–4.5 times more to future growth rate compared to seedlings within that colony. Within the Burn colony, flowering individuals contribute 1.9–2.5 times more to future growth rate than seedlings within that colony. These results suggest the Nursery colony is more vulnerable demographically because its persistence is dependent on a single life stage (Swope 2015, p. 2).

To help determine each colony's growth rate over the study period, a mixed stage and age-based model was developed. A total of four of the five colonies studied showed declines in the last year of monitoring (2015–2016), some of which were severe (22% decline). Although each colony showed a rapid increase in growth at least once over the study period, the mean growth rate for each colony was less than one (Swope 2016, pp. 1–2). Somewhat surprisingly, this study showed growth rates varied widely across the different transition stages for all five study colonies, which was not expected for a perennial with a long lifespan (Swope 2016, p. 2).

### Pollination Ecology

The discovery of several Tiburon mariposa lily individuals with various mutations (i.e., petals missing hairs, lack of pigmentation, four petals and sepals instead of three, seven stamens instead of six) within the same small colony suggested these isolated colonies may be experiencing inbreeding or a loss of genetic diversity, and prompted the pollination experiments described here (pp. 12, 15, Photos 2 and 3). For the first year of the pollination study, a total of 30 plants were selected from a small, isolated colony and separated into one of three treatment groups to determine whether the species was experiencing insufficient pollen receipt that result in lower seed set. The first group received natural levels of pollination (“open pollination”), the second group received supplemental pollen from donors within the same small colony, and the third group received supplemental pollen from donor plants from the largest, most dense colony located 0.62 kilometers (0.39 miles) away (Swope 2013, p. 2). Results show individuals that receive supplemental pollen from donors within the same colony set seed >3 times more on average compared to plants that received open pollination, suggesting individuals are currently not receiving sufficient amounts of pollen (Swope 2013, p. 2).

For subsequent years, the researcher wanted to assess whether gene flow between colonies enhances or restricts local adaptation to soil characteristics within each colony. To test this, Swope (2014, p. 2; Swope 2015, p. 3) worked in two large, high density colonies with different soil characteristics and hand pollinated individual plants with donors from either the same colony or from the other colony. The soil at the Burn site colony has high heavy metal concentrations and low nutrient concentrations, with these characteristics being consistent across the site. In contrast, the soil at the Nursery site colony generally had lower heavy metal and nutrient concentrations, but these characteristics were not consistent across the site and were variable across short distances (Swope 2014, p. 2; Swope 2015, p. 3). Individuals from the Burn site that were pollinated by donors from the Burn site had 2.5 times more seed production than when the donor pollen came from the Nursery site. Conversely, individuals from the Nursery site that were pollinated by donors from the Burn site produced 2.5 times more seed than those pollinated by donors from the same colony. These results suggest that within the Burn site gene flow interferes with local adaptation and within the Nursery site the introduction of novel genetic alleles increases fitness and genetic diversity. These findings compliment the findings from the demography studies which show a lower flowering rate in the Nursery colony and suggest this lower rate may indicate a loss of genetic diversity within that colony (Swope 2014, p. 2). Another part of this experiment included an assessment of whether the amount of pollen was limiting seed set in these larger colonies. This was done by hand-pollinating individuals using donors within the same colony and comparing them to plants that were open pollinated. Unlike the initial pollination experiment which showed a small, isolated population had lower seed set likely due to insufficient pollen receipt, this experiment within the larger colonies did not provide evidence that pollen was limiting seed set (Swope 2013, p. 2; Swope 2015, p. 4).

A reciprocal transplant experiment using seedlings is currently planned to further test these findings (Swope 2015, p. 4; Swope 2016, p. 3). Reciprocal transplant experiments using seeds were attempted; however, these experiments were not successful as seed germination was too low (Swope 2016, p. 3). Furthermore, future genetic studies will also provide insight into differentiation between colonies, relatedness within each colony, and how genetic diversity is correlated with colony growth or decline (Swope 2015, p. 4).

### Soil Analysis

Soil analyses initiated at the beginning of the study show the species is restricted to soils with extremely low Ca/Mg ratios, much lower ratios than what is typically measured for other serpentine soils (Swope 2013, p. 2; Marin County 2021a, pp. 16–17). Even in areas where the habitat seems suitable and is within dispersal distance of known occurrences, if the soils had higher Ca/Mg ratios the species was not found there (Swope 2013, p. 2). The restricted distribution of colonies seen throughout the Preserve could be explained by the variation of serpentine soil characteristics, which is creating microhabitats that limit the species to areas with low Ca/Mg ratios. It is also possible the presence of native perennial grasses is excluding Tiburon mariposa lily from areas with these higher Ca/Mg ratios (Swope 2013, p. 2; Marin County 2021a, pp. 16–17).

### **Distribution:**

The Tiburon mariposa lily has only been known to occur at the approximately 160-hectare (400-acre) Preserve on the Tiburon Peninsula in southern Marin County, California (Service 1995, p. 6673; Service 2011, p. 4; Service 2019, p. 5). The final listing rule described the species as a single population but does not mention how the population was distributed (Service 1995, p. 6673). However, the 1998 recovery plan described the single population as distributed in three major colonies (Service 1998, p. II-19). The previous 5-year review described the perimeters of nine distinct colonies totaling approximately 16 hectares (40 acres) and ranging in size from approximately 0.1 to 13 hectares (0.25 to 32 acres) (LSA Associates, Inc. 2007, Figure 2; Service 2011, p. 4; Swope pers. comm. 2018). A recent mapping effort documented a total of 12 Tiburon mariposa lily colonies, totaling approximately 46.6 acres (Marin County Parks 2020a). This is an increase in both acreage and number of colonies compared to previous mapping efforts.

### **Abundance:**

Different protocols have been used to monitor the population of Tiburon mariposa lily at the Preserve, and therefore, the different data sets cannot be compared directly. The final listing rule described an estimated population size of 40,000 individuals in 1991 (Serpa pers. comm. 1992 *in* Service 1995, p. 6673) and the 2011 5-year review provides four years of monitoring data (2007–2008 and 2010–2011) from what was originally 25 plots (only 24 have been monitored after 2007), but only the number of plants within the plot was recorded and not an overall estimated population size (Service 2011, pp. 4–5; Marin County 2021a, p. 2). Monitoring has continued within those same plots, with a modification to the monitoring protocol in 2011 to collect data on a larger portion of life stages and an additional modification in 2015 to help analyze both short- and long-term trends for certain variables (Marin County 2021a, pp. 4, 28). Data collected from 2007 to 2020 within the established plots is summarized in Table 1.

It is hard to determine what the species' population trend is with such large fluctuations in numbers from year to year; however, it appears the population has remained relatively stable or

has experienced a recent decline (Service 2011, p. 10; Swope pers. comm. 2018; Marin County 2021a, pp. 6–7). Monitoring data still needs to undergo statistical analysis and a preliminary trend analysis suggests specialized software may be needed to better understand population trends (Marin County 2021a, p. 32; Marin County 2021c, p. 3).

*Table 1. Data collected from 2007 to 2020 within established plots at Ring Mountain Preserve*

Year	# of plants	# of flowers	# of plants without flowers	# of flower stalks nibbled	# of leaves nibbled	# of mature capsules	# of plants with capsules
2007 <sup>1</sup>	226	229	145	9	50	56	29
2008 <sup>1</sup>	178	62	139	6	117	--	--
2010 <sup>1</sup>	262	176	153	10	112	63	43
2011 <sup>1</sup>	197	137	24	24	80	91	--
2012 <sup>2</sup>	196	89	36	121	66	--	--
2013	240	30	37	--	40	74	--
2014	270	77	45	--	138	92	--
2015	240	205	162	6	127	107	--
2016	240	184	150	44	142	79	45
2017	182	108	119	12	125	46	35
2018	74	66	40	3	55	26	16
2019	245	121	124	13	109	97	55
2020	93	39	67	14	51	38	21

### **Threats:**

Threats noted in the final listing rule include recreational activities, potential overuse and vandalism of the Preserve, non-native invasive plant species, restricted habitat and range, and small population size (Service 1995, pp. 6677–6682). We noted that the occurrence of this plant in a single population, its proximity to human population centers, and intensive development activities renders it vulnerable to catastrophic events such as fire, disease or pest outbreak, severe drought, or other natural or human caused disasters (Service 1995, pp. 6673, 6681). We also mentioned the species is protected from urban development and was fenced to prevent off-road vehicle use (Service 1995, pp. 6678). The previous 5-year review noted the same threats as the final listing rule, but also included mammalian herbivory and climate change (Service 2011, pp. 6–9). The threats described at listing and in the previous 5-year review continue to impact the species and no additional threats were noted in the recovery plan amendment (Service 2019, p. 6); however, as mentioned above (see Pollination Ecology) inbreeding depression could potentially be a threat.

In 2012 a wildfire burned through Preserve, impacting approximately 14 acres of serpentine grassland habitat in areas where the Tiburon mariposa lily is known to occur (Marin County 2021c, p. 2). The fire occurred during the blooming period for the species, so all individuals within the fire footprint were unable to set seed that year (Marin County 2021a, p. 7). A total of 612 Tiburon mariposa lily plants were identified within the burn footprint, although this is likely an underestimate since some individuals were likely burned beyond identification (Marin County 2021a, p. 9; Marin County 2021c, p. 2). Because the fire was low intensity and burned quickly

<sup>1</sup> Surveys during these years were not always consistent for all variables.

<sup>2</sup> A wildfire occurred on June 14<sup>th</sup>, 2012, prior to completing the monitoring effort.

through the area, it is unlikely to have affected underground plant structures such as bulbs or seeds (the species is a perennial bulb that maintains a seed bank). About 5 months after the wildfire, leaf emergence from bulbs within the burn footprint were observed, further suggesting these underground structures were not impacted (Marin County 2021a, p. 9).

Herbivory of flowering stems primarily by jackrabbits was documented over multiple years of the demography study (see Table 1 above), but was especially high during the 2013–14 season. Over that season, approximately 40–80% of flowering stems in 2014 were lost to herbivory, resulting in an 80–100% reduction in seed production per plant (Swope 2014, pp. 2, 3; Swope 2105, p. 3; Swope 2016, p. 2). This heavy herbivory, which reduces the number of individuals contributing seed, can have genetic consequences even if the colony appears large and healthy (Swope 2014, p. 3); however, it does not have a noticeable effect on colony growth rate since the likelihood of a seed becoming a mature plant is so low (Swope 2015, p. 3). Furthermore, when the model was run with a simulated elimination of herbivory, the growth rate only slightly increased (Swope 2015, p. 3; Swope 2016, p. 2). In order to assess whether a genetic bottleneck is occurring within any of the colonies, plant tissue has been collected and a grant awarded to conduct future genetic analyses (Swope 2014, p. 3; Swope 2015, p. 3; Swope 2016, p. 3).

**Recovery criteria:**

Recovery criteria for delisting the Tiburon mariposa lily are described in the Recovery Plan Amendment for Serpentine Soil Species of the San Francisco Bay Area (Service 2019, pp. 34–36). Delisting criteria for Tiburon mariposa lily have not been met (Table 2).

*Table 2. Delisting criteria for the Tiburon mariposa lily.*

Delisting criteria	Has criterion been met?
Population at Ring Mountain Preserve is fully protected and managed with the primary intention of preserving the population in perpetuity.	This criterion has been met. The Ring Mountain Preserve is owned and managed by Marin County Parks and Open Space, and is currently protected.
Management plan approved and implemented for the population at Ring Mountain Preserve and any other location the species may be discovered.	This criterion has been met. Marin County Parks and Open Space is implementing the Ring Mountain Open Space Preserve Management, Stewardship, and Restoration Program Three-Year work plan (March 2021-March 2024) (Marin County Parks 2020b, entire) and the Vegetation and Biodiversity Management Plan (Marin County 2015, entire). These plans build on the approved Ring Mountain Preserve Sensitive Resources Monitoring and Enhancement Strategy (LSA Associates, Inc. 2007, entire), and includes continued monitoring within established transects, management of nonnative plants, and management of off-trail/unofficial trail use.

Delisting criteria	Has criterion been met?
Monitoring shows stable or increasing trends over a period of 20 years.	This criterion has not been met. Trends appear to show a stable or recently declining population; however, monitoring data still needs to undergo statistical analysis and may require specialized software to better understand trends.
All protected colonies contain at least 1,000 individuals containing reproductive, self-regenerating adults.	This criterion has not been met. Monitoring reports provide a total number of individuals counted within the established transects; however, abundance estimates for each colony are not provided. Furthermore, the total number of individuals counted within the transects have not come close to 1,000, the highest count was from 2014 when 270 individuals were documented (Marin County 2021b, p. 1).
Seeds stored in at least two facilities certified by the Center for Plant Conservation, and reliable germination and propagation techniques understood.	This criterion has not been met. We are not aware of Tiburon mariposa lily seed being stored in a certified facility or whether propagation and germination techniques are understood.

**Conclusion:**

After reviewing the best available scientific information, we conclude that the Tiburon mariposa lily remains a threatened species. The evaluation of threats affecting the species under the factors in 4(a)(1) of the Endangered Species Act and analysis of the status of the species in our 2011 status review (Service 2011) remains an accurate reflection of the species’ current status.

**RECOMMENDATIONS FOR FUTURE ACTIONS:**

Here we propose several recommendations which will aid in the recovery and conservation of the Tiburon mariposa lily. These recommendations have already been discussed in previous recovery documents (Service 2011, p. 10; Service 2019, p. 48) and remain valid.

1. Continue annual monitoring and non-native invasive plant control efforts. Data collected from monitoring efforts should be statistically analyzed to determine population trends. If specialized software is needed to better understand trends, then that software should be identified and utilized to analyze the data.
2. Continue efforts to minimize off-trail use within the Preserve. Continue to educate visitors about the Preserve’s sensitive resources and the effects off-trail use has on rare plants.
3. Store seeds in at least two Center for Plant Conservation certified facilities. Unless storage techniques and/or research show otherwise, replenish seed stock every 10 years to ensure seed viability. Research germination and propagation techniques.
4. Conduct genetic analyses on existing collected plant tissue to determine whether a genetic bottleneck is occurring within any colonies.

**Field Supervisor, Sacramento Fish and Wildlife Office**

**Approve** \_\_\_\_\_ **Date** \_\_\_\_\_

## Literature Cited

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Personal Communication

Swope, Sarah. 2018. Assistant Professor of Biology and Botanic Garden Director, Mills College, Oakland, California. Telephone conversation with Amber Aguilera of the Sacramento Fish and Wildlife Office, July 27, 2018. Subject: Status updates and overviews of biology and ecology for Tiburon mariposa lily and for Tiburon jewelflower.