

## Annual Report

### Population monitoring, seed collection and banking, and habitat assessment for the Paintbrush Hill occurrence of Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) January 2025

#### Background and Introduction

Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*; CAAFNE; State Threatened, Federally Endangered, CNPS RPR 1B.2) is a perennial root hemiparasite in the broomrape family (Orobanchaceae). It differs from its common sister taxon, *Castilleja affinis* ssp. *affinis* (CAAFAF), in having yellow to peach-colored floral bracts, rather than orange to red-colored, smaller inflorescences (15-25mm wide in CAAFNE vs. 30-50mm wide in CAAFAF), and in its habitat restriction to serpentine soils.

At the time of its listing as federally endangered in 1995 (USFWS 1995), only 1500 plants in six populations were known to exist, including one population in Santa Clara County (Paintbrush Hill, CNDDDB occurrence 7). Another nearby population, called Paintbrush Canyon, was subsequently discovered (2002, CNDDDB occurrence 9). Population sizes for this taxon range from 20 to 1000 plants depending on the occurrence (CNDDDB, Widener & Fant 2017), which suggests that a target population size of 2000 individuals (which is the non-taxon-specific recovery goal stated in the Santa Clara Valley Habitat Plan) may not be appropriate or attainable for this taxon and location.

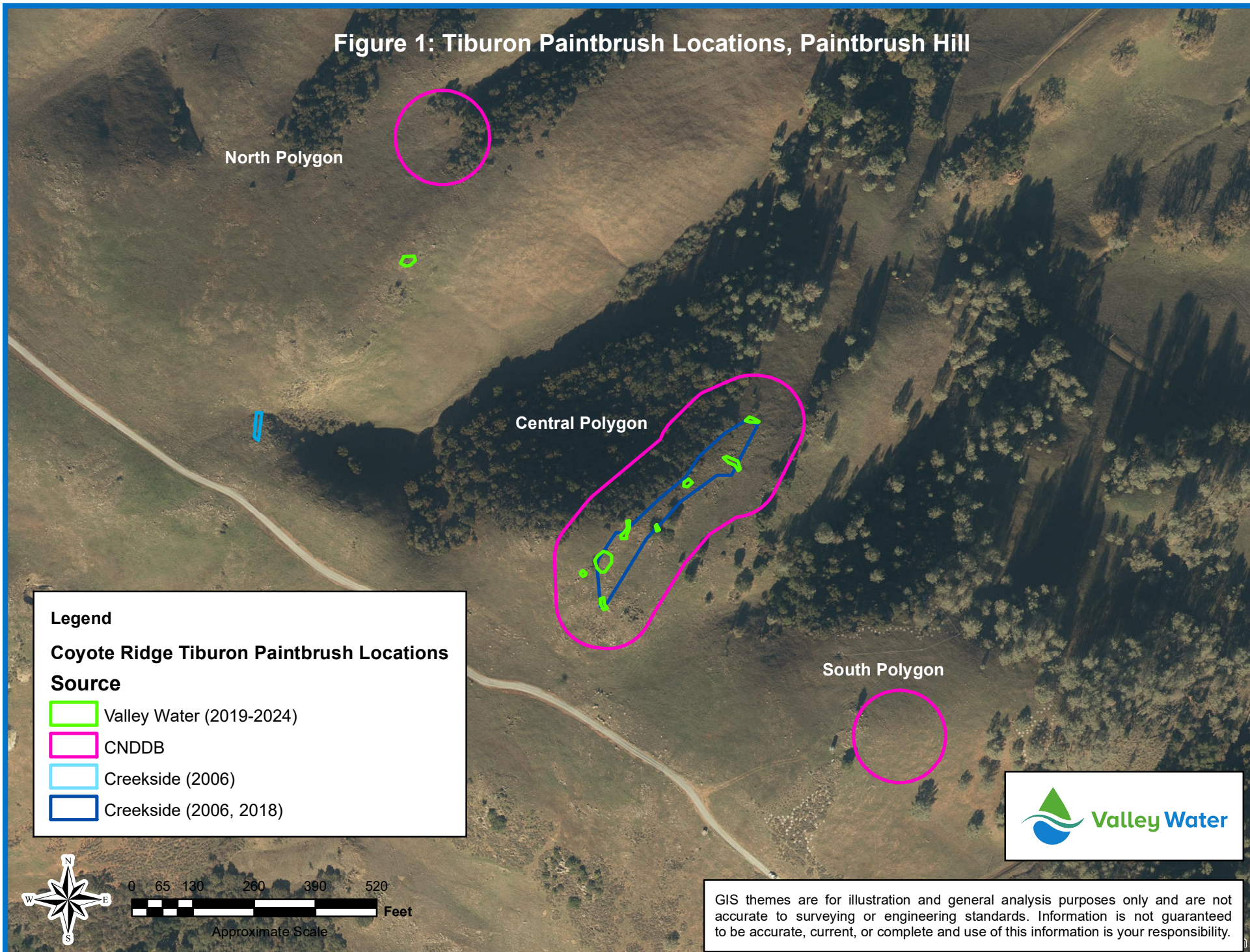
The Paintbrush Hill occurrence, located on property owned and managed by the Santa Clara Valley Water District (Valley Water), has historically been documented as three separate subpopulation clusters, or polygons (Figure 1). No plants were observed in the two smaller polygons (North and South) from 1997 and 1994, respectively (see Table 1), until 2019 when plants were rediscovered near the north polygon. The number of plants in the Paintbrush Hill occurrence has fluctuated over time, with the number of plants counted per year ranging from a low of 9 individuals in 1994 to 208 or 224 in 2018, depending on count method (Creekside Science 2018a). Concerns over the small population size at Paintbrush Hill, coupled with its inclusion as a covered, no-take species in the Santa Clara Valley Habitat Plan, a joint HCP/NCCP covering most of Santa Clara County, has led to increased focus on the development of recovery actions for the taxon and augmentation of the two known populations in Santa Clara County.

<b>Polygon Location</b>	<b>1993</b>	<b>1994</b>	<b>1997</b>	<b>1999</b>	<b>2006</b>	<b>2009</b>	<b>2013</b>	<b>2018</b>
<i>North</i>	NA	4	27	NA	NA	NA	NA	NA
<i>Central</i>	17	NA	0	80	>140	103	~100	208/224
<i>South</i>	NA	5	0	0	NA	NA	NA	NA

Table 1. Historical reports of number of plants at Paintbrush Hill, 1993-2018. Data sources: CNDDDB (1993-2013), Creekside Science (2018)

Prior to developing any plan for population augmentation or recovery or drafting any prescriptive management actions, Valley Water and partners agreed to conduct a baseline assessment of the demography of and threats to the Paintbrush Hill occurrence (including 1. Population monitoring; 2. Limited seed collection and banking; 3. Basic assessment of habitat quality and threats). This was done by Valley Water between 2019 and 2023. The 2023 annual report summarized those five years of population monitoring and presented a list of future management actions for discussion and decision-making among the larger interest group. The most immediate recommendations were the instigation of

Figure 1: Tiburon Paintbrush Locations, Paintbrush Hill



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a concerted invasive plant removal effort in the immediate vicinity of the population, the implementation of some kind of fencing to protect the population from heavy current cattle impacts and potential pig impacts, and the potential addition of an associated reduced-effort follow up monitoring program to assess effectiveness and inform future decision making.

In April 2024, Valley Water convened a meeting with the Santa Clara Valley Habitat Agency and USFWS to discuss the results of our initial five years (2019-2023) of monitoring for Tiburon paintbrush at Paintbrush Hill and discuss future steps. The group decided to continue monitoring on a more streamlined basis than in the initial five years (to be performed by Valley Water) and implement some form of fencing as a habitat protection measure (to be implemented by Habitat Agency), and agreed that a concerted invasive plant removal effort was a good idea, but a final decision was not made regarding who would fund and implement this.

Fencing was not implemented this year but should be prioritized for 2025. A trial of three-strand electric fencing is currently underway at a different location in the Habitat Agency's reserve system, and results/lessons learned will be applied to this project as appropriate. An invasive plant reduction program is also recommended in the vicinity of the population, including both noxious weeds such as yellow star thistle (*Centaurea solstitialis*) and black mustard (*Brassica nigra*), which are encroaching from surrounding non-serpentine grassland, and annual non-native grasses which contribute to thatch and may suppress germination.

## Methods

### Population Monitoring

As in prior years (2019-2023), CAAFNE individuals were identified based on the best available information for each plant. Factors taken into account included growth pattern, morphology, and distance from other plants.

*Growth pattern:* Plants that are close together can sometimes be distinguished because the stems all radiate from separate common centers or root crowns. Stems that angle towards a common center, even if the exact center point is obscured by rocks, can be inferred as belonging to a single plant.

*Morphology:* Often different plants may have different phenology (one is blooming slightly later than the other), stature (one may be taller), or coloration (plants may display differences in leaf or flower color). When plants have more than one flowering stem, those stems tend to be more like one another than stems from separate plants.

After counting, plants were marked with durable metal plant markers and assigned a number, to facilitate tracking of individual plants across years to the extent possible.

Seedlings were defined as single unflowering stems less than 10cm tall. Seedlings were tallied only (no other metrics measured).

In addition to the plant count, additional information was collected during the population monitoring for all flowering CAAFNE plants. Information collected included:

- number of stems per plant
- number of inflorescences (flowering stalks) per plant
- maximum plant height (in cm)
- qualitative observations of threats as appropriate (severe herbivory, other disturbances)

For reference, the elements of baseline study that are no longer included going forward are:

- width of inflorescences (in cm)
- dominant flower color (3 categories: pale peach/yellow, moderate orange-red, bright red)
- potential host plant species within 12 inches
- more detailed observation of herbivory on inflorescences (present/absent, putative vector if available (e.g., insect, cattle, rabbit))

Spring field work took place on May 21, 2024, capturing peak flower. After peak flower, monitoring visits occurred approximately every three to four weeks to assess fruiting phenology and determine the best time for collection of fruiting information. Summer field work took place on June 27 and July 18, 2024.

Fruiting information collected included:

- number of infructescences per plant
- number of inflorescences remaining per plant on that date, if any
- number of capsules per infructescence

These are the same elements as were collected between 2019 and 2023.

### Seed Collection and Banking

Seeds were not collected in 2024 and are not planned for collection in future. The seeds from the five-year-long (2019-2023) collection effort will remain at the California Botanic Garden (CBG, formerly Rancho Santa Ana Botanical Garden) seed storage facility. A backup sample has been deposited by CBG with the National Laboratory for Genetic Resources Preservation in Fort Collins, CO. The seeds collected by Valley Water will not be combined with the seed collection made by Creekside Science in 2018.

## **Results**

### 2024 Population Monitoring

This year 116 adult plants and 74 seedlings between 1 and 10 cm were observed, for a total 2024 population size of 190 individuals, up from 105 in 2023, 118 in 2022, 130 in 2021, and 139 in 2020 but fewer than the 222 observed in 2019. This included 107 adult plants and 74 seedlings in the main (central) polygon, and 9 adult plants in the northern polygon (Figure 1). Only 65 plants flowered and 32 plants set fruit this year.

Population summary statistics (average plant height, average number of stems, inflorescences, and infructescences per flowering/fruitlet individual, average number of capsules per infructescence) are listed in Table 2 (seedlings are excluded from these metrics because they are defined as single non-flowering stems less than 10cm tall). Average height per plant in 2024 was 19.6cm (n=109), with an average number of stems per plant of 7.1 and average number of inflorescences per flowering plant of 2.1 (n=65). 2024 plants were shorter, more branched, and had fewer inflorescences per plant than 2023 plants.

Average number of infructescences per fruiting plant was 2.7 (n=32), though only 0.7 per plant if all adult plants are included (4.8 for plants inside enclosures), and the average number of capsules per infructescence was 4.5 (6.7 for plants inside enclosures). These numbers are lower than in 2023. See Table 2 for comparison with 2019-2023 baseline data.

In enclosure?	2019-2023 Baseline			2024		
	All <sup>†</sup>	In	Out	All <sup>†</sup>	In	Out
<b>Average height per plant (cm)</b>	18.8	<b>*24.5</b>	*17.6	19.6	<b>21.5</b>	19.1
<b>Average # of stems per plant</b>	6.4	6.1	<b>6.4</b>	7.1	6.8	<b>7.2</b>
<b>Average # of inflorescences per plant<sup>††</sup></b>	2.5	<b>*3.7</b>	*2.2	2.1	<b>2.6</b>	2.0
<b>Average # of infructescences per plant<sup>††</sup></b>	1.5	<b>*3.3</b>	*1.1	2.7	<b>4.8</b>	2.2
<b>Average # of capsules per infructescence<sup>††</sup></b>	4.2	<b>*5.4</b>	*3.4	4.5	<b>6.7</b>	3.3

Table 2: Population summary statistics of CAAFNE at Paintbrush Hill in 2024 as compared to 2019-2023 baseline

<sup>†</sup> Reproductive plants only; seedlings not included

<sup>††</sup> Calculated for plants with reproductive structures

\* p-value for the difference between in/out of enclosure is significant at  $p < 0.01$  (Welch's t-test). Tests not done for individual years.

Note: Higher value for in/out of enclosure is bold in each set of three columns

## Discussion

### Number of Plants

The number of CAAFNE reported at Paintbrush Hill over time is illustrated in Figure 2. Please note that survey methods and locations have not been consistent throughout the entire period for which data are available (i.e. multiple people collected data over the period 1993-2018, followed by consistent data collection 2019-2024). Although the available population numbers show for the most part a relatively stable population size, the declining counts in 2020 – 2023, coupled with usually low numbers of seedlings observed, highlight that this small population may need additional protection if it is to persist or increase in size (Figure 2). Results from 2024 include a high number of seedlings (74) but their survival rate is unknown until 2025 field work.

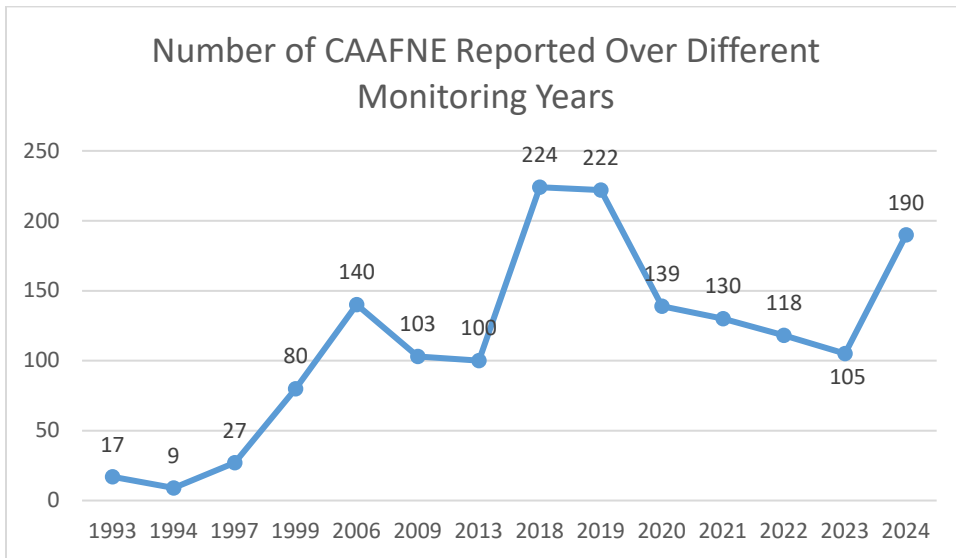


Figure 2. Number of CAAFNE plants at Paintbrush Hill, 1993-2023. Data sources: CNDDDB (1993-2013), Creekside Science (2018), Valley Water (2019-2024)

### Number of Plants Inside Enclosures

The number of plants observed inside cages declined over the first three years of our observations, increased in 2022 and 2023, and declined again in 2024 (Figure 3). The proportion of the total population within enclosures has remained within a close range, between 14% in 2021 and 22% in 2024.

Of the five existing enclosures, only two have consistently supported Tiburon paintbrush plants during the period of Valley Water’s population monitoring effort. Two have been empty since the start of the monitoring effort. A third was empty until 2022, when four plants reappeared. They did not return in 2024. The size, extent of branching and high number of inflorescences present on most plants inside enclosures suggest that these plants are dormant during monitoring years when not observed, which is an important life history consideration for the population. These enclosures were assessed carefully each year, so although it’s possible some non-flowering above-ground plant material was missed, it is more likely there was underground root mass but no visible shoots in the intervening years, which is possible due to the plants’ hemiparasitic life form.

Plants inside enclosures continue to provide a high proportion of the functional reproductive output of this population (with 6 plants, 3% of population, responsible for 195 capsules, or 51% of total) but at this time only a little less than 20% of the population is protected in this way.

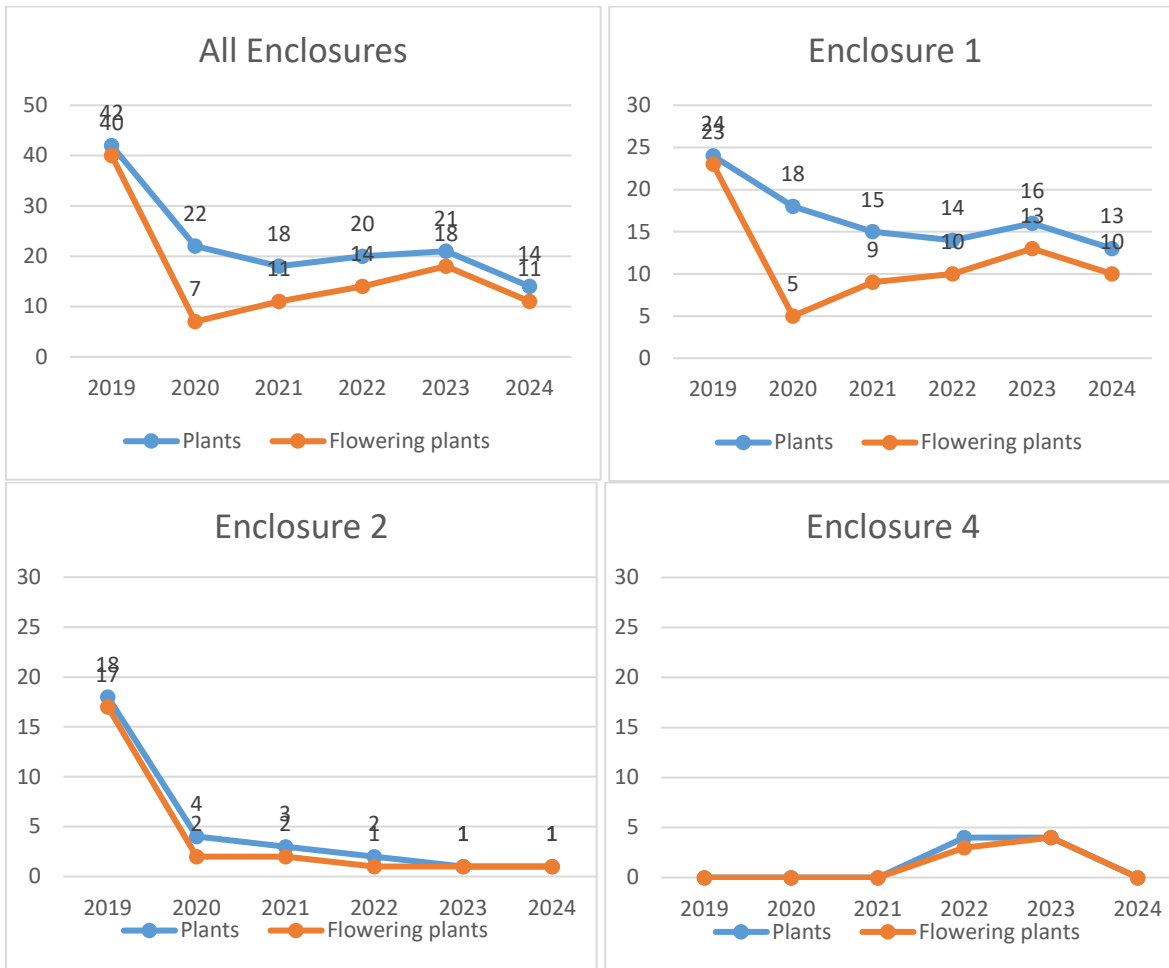


Figure 3. Number of Tiburon paintbrush plants observed inside protective cages from 2019-2024.

### Phenology

Year	Peak Flowering Date	Fruit Maturity Date
2019	May 9	June 12
2020	May 5	July 6
2021	April 19	July 15
2022	April 13	July 6
2023	May 11	July 17-Aug 17
2024	May 21	June 27-July 18

Table 3. Key phenological dates for Paintbrush Hill Tiburon paintbrush population over time.

### Damage and fencing

Over several years of monitoring, herbivory and trampling have been documented to be significant threats to the Tiburon paintbrush (CAAFNE) population. Herbivory and trampling from cattle have caused visible damage to plants, particularly to their brittle inflorescences, reducing reproductive success. A more minor contribution was documented of herbivory from rabbits and insects, as well as burrowing by small mammals and intermittent pig rooting. Damage varied from cleanly nibbled stalks or broken or missing inflorescences to disappearance of entire plants, leading to a decrease in mature

seed production and potential long-term population decline. Fencing is a crucial measure to protect the population from these ongoing threats. Cattle trampling during sensitive periods of plant and fruit development (e.g., Feb-July) has been particularly detrimental. Fencing would help mitigate these pressures, particularly in areas with the highest herbivore activity (flat portion of site at top of slope, near road). Although challenges such as chapparal habitat disruption and the steepness of the site need to be addressed, targeted fencing strategies, such as temporary electric fencing or repositioning existing enclosures, would effectively safeguard the plants without causing undue harm to the surrounding ecosystem. A site visit with representatives from the Habitat Agency to explore fencing alternatives took place in April 2022, and at the April 2024 meeting the Habitat Agency agreed to implement some sort of fencing. The successful implementation of fencing could be key to sustaining and potentially increasing the population of CAAFNE, with the aim of ensuring its long-term survival.

### Invasive Plant Species

Invasive plant species of concern include non-native grasses, both annual (soft chess [*Bromus hordeaceus*], foxtail chess [*Bromus madritensis*], and wild oat [*Avena fatua*]) and perennial (Italian rye grass, *Festuca perennis*), which are currently in contact with the paintbrush population and have increased in frequency since 2020, and several noxious weeds which are present in the surrounding grasslands and encroaching nearer to the paintbrush plants over time, notably including yellow star thistle, black mustard, and (in the northern polygon) tocalote (*Centaurea melitensis*).

A limited number of yellow star thistle, tocalote and black mustard plants in the immediate vicinity of the CAAFNE patches have been removed during population monitoring activities as time allowed, but a concerted effort over time is recommended in order to prevent the spread and increase in density of these plants and their encroachment into the core CAAFNE area.

Future funding for this effort is likely to be available through Valley Water's Anderson Dam/Ogier Ponds mitigation funds, but funding opportunities until then are unknown.

### **Conclusions and Next Steps**

Fluctuations in number are normal for plant populations, but 2020 - 2023 were unencouraging years for the Paintbrush Hill population. The region has suffered from multiple drought years recently, including severe drought conditions between 2014 and 2016 and again between 2020 and 2023. Pressure on the population from trampling and herbivory appear significant. 2022, with decreased trampling and grazing pressure from cattle, but continued drought conditions, appeared to have provided a small respite for the habitat. The growing season of 2023, with its significant rain events, could have presented an opportunity for a population rebound, but this did not occur. One can conclude that rainfall alone does not appear to tightly control the population's numbers.

The habitat quality in the central polygon has declined over the last several years, likely due to a number of factors including environmental conditions (drought, depositional N), compaction, erosion, grazing and trampling from cattle and game, and encroachment by non-native plant species. Protecting this population from further habitat deterioration should be a high priority.

Given our observations over the last six years, we recommend the following to improve conditions for the Paintbrush Hill CAAFNE population:

1. Continue to pursue protecting this population via fencing. **In 2025 a pilot electric fencing option is recommended.** Other possibilities include adjusting the current aging small

enclosures to better protect the current distribution of plants and habitat or an eventual complete fencing option.

2. Invasive plant control:

- a. Develop and implement a long-term vegetation management plan for the area that takes into account encroaching invasive species such as yellow star thistle and black mustard as well as invasive grasses such as soft chess and wild oat whose cover is increasing at the site and may degrade habitat quality over time.
- b. In 2025, before long-term planning and funding are available, begin management activities with any available resources.

## Literature Cited

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