

**FINAL
SURVEY REPORT 2023
WILLOWY MONARDELLA CENSUS AND
MONITORING, MARINE CORPS AIR STATION
MIRAMAR, SAN DIEGO, CALIFORNIA**



**Naval Facilities Engineering Systems Command Southwest
Environmental Planning and Conservation**

750 Pacific Highway, Floor 12
San Diego, California 92132

Prepared for:

Environmental Management Department
Natural Resources Division
Marine Corps Air Station – Miramar
Building 6022
San Diego, California 92145

Contract N62473-20-D-0021, Task Order N6247323F4780

November 2024

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Vernadero Group Inc.

MARINE CORPS AIR STATION MIRAMAR, SAN DIEGO, CALIFORNIA

WILLOWY MONARDELLA (*MONARDELLA VIMINEA*)

CENSUS AND MONITORING

SAN DIEGO, CALIFORNIA

**Contract N6247320D0021,
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EXECUTIVE SUMMARY

Vernadero Group Inc. was contracted by Naval Facilities Engineering Systems Command Southwest on behalf of Marine Corps Air Station (MCAS) Miramar to conduct a Stationwide census for willowy monardella (*Monardella viminea*) and to monitor the species within long-term monitoring plots at MCAS Miramar in San Diego, California. We conducted willowy monardella surveys in 2023 following all census and monitoring methods described by the 2013 *Willowy Monardella (Monardella viminea) Field Protocol Manual* to ensure consistency with past and future willowy monardella surveys at MCAS Miramar. We surveyed and mapped all willowy monardella on MCAS Miramar, identifying adults, mature plants, juveniles, and seedlings. We used a standardized method to define and delineate clumps of willowy monardella during the census. We visited established monitoring plots and used standardized methods for measuring willowy monardella growth rates, determining clump health, and evaluating willowy monardella population expansion or contraction. We conducted census and monitoring activities at MCAS Miramar from 30 June 2023 through 12 August 2023.

A total of 776 living willowy monardella clumps were found during the 2023 census. While a much lower overall count of missing clumps was tallied during 2023 than during 2020, there was still an ongoing decrease in the number of living clumps found. Based on the count of dead clumps found, higher mortality was detected during 2023 than during 2020. Among the 776 living clumps found, 86 were new clumps that were not mapped during previous surveys. Many clumps that did not disappear due to mortality since 2020 stayed in the same clump count arrangement as during 2020, with both clump splitting and clump count decreases being comparatively low numbers during this time. Since recruitment was more prevalent than noted during 2020, there were more instances of younger size classes than during previous years. One seedling was identified during this time.

Clumps found in Spring and West Sycamore canyons were larger overall during 2023 than in other canyons. Clumps had lower height during 2023 than during 2020. Predictably, willowy monardella was generally found in secondary drainages in West Sycamore and Spring canyons, while these were mostly restricted to primary drainages in smaller canyons. During 2023, flood damage was the most frequently noted disturbance of willowy monardella. Clump count within monitoring plots decreased since 2020. The majority of monitoring plots, in fact, revealed decreased clump counts, and hence, higher mortality during 2023.

As with 2020, analysis of study plot data resulted in nonsignificant effects of habitat variables on willowy monardella elliptical area. This is a striking result, since willowy monardella clumps have been steadily disappearing since 2003. We found that since study plots are highly variable, that either the abundance of study plots should be increased, or that habitat condition variables monitored at study plots should be measured at all clump locations throughout MCAS Miramar. Monitoring plots experienced almost universal negative growth from 2020 to 2023, and they reflected declines in clump count seen outside of study plots during the period.

Outside of study plot locations, although overall willowy monardella clump abundance has steadily decreased since 2012; most of that decline has been restricted to San Clemente Canyon, and clump mortality in other canyons was mostly offset by willowy monardella recruitment since 2020. The highest number of dead clumps during 2023 willowy monardella monitoring was associated with nonnative grass and/or thatch accumulation, whereas flooding and erosion had the most negative effects on willowy monardella during 2017 and 2020.

Based solely on count data, and by performing a limited population viability analysis on count data, we predict that willowy monardella will be quasi-extinct at MCAS Miramar within 45 years if similar patterns persist. To avoid this outcome, we provide management and monitoring recommendations in this report that would be valuable for understanding the patterns, both past and predicted.

TABLE OF CONTENTS

1.0	INTRODUCTION	1-1
1.1	Marine Corps Air Station Miramar	1-1
1.2	Scope	1-1
1.3	Species Information.....	1-1
1.4	Precipitation Information.....	1-7
2.0	METHODS.....	2-1
2.1	Willowy Monardella Census	2-1
2.2	Willowy Monardella Monitoring.....	2-2
2.3	Data Analysis and Reporting.....	2-7
2.4	Geographic Information System.....	2-10
2.5	Access and Safety Coordination	2-10
3.0	RESULTS.....	3-1
3.1	2023 Willowy Monardella Census	3-1
3.2	2023 Willowy Monardella Plot Monitoring	3-13
4.0	OBSERVED TEMPORAL TRENDS.....	4-1
4.1	Census Temporal Observations.....	4-1
4.2	Monitoring Plot Temporal Observations	4-4
4.3	Willowy Monardella Clump Persistence Since 2017	4-11
5.0	DISCUSSION	5-1
6.0	MANAGEMENT IMPLICATIONS.....	6-1
6.1	Scour and Bank Erosion.....	6-1
6.2	Herbivory	6-1
6.3	Pollination Ecology.....	6-2
6.4	Nonnative Grasses.....	6-2
6.5	Habitat and Growth	6-3
7.0	MONITORING RECOMMENDATIONS.....	7-1
7.1	Population Viability Analysis.....	7-1
7.2	Comparison with Off-base Populations	7-3
8.0	REFERENCES	8-1

LIST OF FIGURES

Figure 1-1. Location of Marine Corps Air Station Miramar.....	1-2
Figure 1-2. Willowy Monardella Census Locations	1-5
Figure 1-3. Growing Season (July 1 – June 30) Precipitation (inches), and Mean, Minimum and Maximum Growing Season Temperature (degrees Fahrenheit) for MCAS Miramar 1993 – 2023	1-8
Figure 2-1. Location of Willowy Monardella Monitoring Plots at MCAS Miramar.....	2-5
Figure 3-1. Willowy Monardella Clumps in Elanus Canyon during 2023	3-3
Figure 3-2. Willowy Monardella Clumps in Murphy Canyon during 2023	3-4
Figure 3-3. Willowy Monardella Clumps in the Eastern Portion of San Clemente Canyon during 2023	3-5
Figure 3-4. Willowy Monardella Clumps in the Western Portion of San Clemente Canyon during 2023	3-6
Figure 3-5. Willowy Monardella Clumps in Spring Canyon during 2023.....	3-7
Figure 3-6. Willowy Monardella Clumps in Sycamore Canyon during 2023	3-8
Figure 3-7. Willowy Monardella Clumps in the Northern Portion of West Sycamore Canyon during 2023	3-9
Figure 3-8. Willowy Monardella Clumps in the Southern Portion of West Sycamore Canyon during 2023	3-10
Figure 4-1. Abundance of Willowy Monardella in MCAS Miramar Canyons and Overall, 2017 – 2023	4-1
Figure 4-2. Abundance of Willowy Monardella by Life Stage at MCAS Miramar, 2017 - 2023.	4-3
Figure 4-3. Probability of Willowy Monardella Quasi-Extinction (< 10 clumps) at MCAS Miramar within 50 years, with 95% Confidence Intervals.....	4-4
Figure 4-4. Abundance of Willowy Monardella in MCAS Miramar Monitoring Plots, 2017 – 2023	4-5
Figure 4-5. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Elanus Canyon.....	4-13
Figure 4-6. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Murphy Canyon.....	4-14
Figure 4-7. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Eastern Portion of San Clemente Canyon	4-15
Figure 4-8. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Western Portion of San Clemente Canyon	4-16

Figure 4-9. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Spring Canyon	4-17
Figure 4-10. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Sycamore Canyon	4-18
Figure 4-11. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Northern Portion of West Sycamore Canyon.....	4-19
Figure 4-12. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Southern Portion of West Sycamore Canyon	4-20

LIST OF TABLES

Table 2-1. Multiple Regression Variables	2-9
Table 3-1. Number of Willowy Monardella Clumps by Canyon Observed in 2023	3-1
Table 3-2. Life Stage of Willowy Monardella Clumps by Canyon 2017-2023	3-2
Table 3-3. Phenology Stage of Willowy Monardella Clumps by Canyon	3-2
Table 3-4. Mean Height, Length, and Width of Willowy Monardella Clumps by Canyon and Year	3-11
Table 3-5. Willowy Monardella Clump Occurrence by Drainage Type by Canyon	3-12
Table 3-6. Location in Drainage of Willowy Monardella Clumps by Canyon.....	3-12
Table 3-7. Frequency of Disturbances Observed Impacting Willowy Monardella.....	3-13
Table 3-8. Number of Living Willowy Monardella Clumps by Monitoring Plot.....	3-14
Table 3-9. Mean, Median, and Standard Deviation of 2023 Elliptical Area of Willowy Monardella Clumps by Monitoring Plot (see Table 3-8 for n).....	3-15
Table 3-10. Mean, Median, and Standard Deviation of 2023 Elliptical Volumes of Willowy Monardella Clumps by Monitoring Plot (see Table 3-8 for n)	3-16
Table 3-11. Drainage Depth, Soil Types, and Disturbances in Willowy Monardella Monitoring Plots	3-17
Table 3-12. Univariate Regression Results for Elliptical Area	3-18
Table 3-13. Univariate Regression Results for Elliptical Volume	3-19
Table 4-1. Willowy Monardella Life Stage and Disturbance by Year	4-2
Table 4-2. Willowy Monardella Growth Rates 2012 – 2023	4-5
Table 4-3. Generalized Linear Model of Willowy Monardella Survival Predicted by Clump Elliptical Area and Monitoring Year, with Monitoring Plot as a Random Effect	4-11

LIST OF APPENDICES

Appendix A. Monitoring Plot Photographs	A-1
Appendix B. Monitoring Plot Data Sheets	B-1

LIST OF ACRONYMS AND ABBREVIATIONS

aka	Also Known As
cm	Centimeter
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ID	Identification
MCAS	Marine Corps Air Station
mm	Millimeter
NA	Not Available
PVA	Population Viability Analysis
RDM	Residual Dry Matter
RTK	Real-Time Kinematic
USFWS	United States Fish and Wildlife Service
Vernadero	Vernadero Group Inc.

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1.0 INTRODUCTION

Vernadero Group Inc. (Vernadero) was contracted by Naval Facilities Engineering Systems Command Southwest on behalf of Marine Corps Air Station (MCAS) Miramar to conduct a Stationwide census for willow monardella (*Monardella viminea*) and monitor the species within long-term monitoring plots at MCAS Miramar in San Diego, California. Willow monardella surveys were conducted in 2020 to support natural resources planning and management activities by MCAS Miramar.

1.1 Marine Corps Air Station Miramar

MCAS Miramar is in San Diego County, approximately 13 miles north of downtown San Diego and 4 miles east of the Pacific Ocean (Figure 1-1). Suitable habitat for willow monardella occurs in drainage basins at MCAS Miramar. This includes portions of nine canyons: Rose, San Clemente, Elanus, Murphy, Oak, Spring, Quail, West Sycamore, and Sycamore. These drainage areas where suitable habitat is present compose the census area for willow monardella on the Station (Figure 1-2).

1.2 Scope

Vernadero conducted a Stationwide census for willow monardella during its flowering period in 2017, 2020, and during 2023. Each census followed the methods described by the *Willow Monardella (Monardella viminea) Field Protocol Manual* (MCAS Miramar 2013a; aka Field Protocol Manual). In addition to the Stationwide census, Vernadero supported the long-term monitoring of willow monardella at MCAS Miramar by collecting data in previously established monitoring plots, following the methods described in the Field Protocol Manual (MCAS Miramar 2013a). Lastly, Vernadero compared the results of the 2023 census and monitoring to the willow monardella census and monitoring data collected in 2012, 2017, and 2020.

1.3 Species Information

Willow monardella is a subshrub in the Lamiaceae (mint) family. It has erect stems, 25 to 50 centimeters (cm) in length, densely short-haired and appearing glaucous-green. Leaves are 20 to 40 millimeters (mm) in length, 2 to 4 mm wide, linear to narrowly lanceolate, minutely puberulent, and glaucous in appearance. There is typically one flower cluster per main stem, which is 20 to 30 mm wide with bracts that are 10 to 15 mm long and 5 to 9 mm wide. On rare occasions, there can be two to three flower clusters on a main stem. Flower corollas are white to rose in color. Willow monardella flowers from June through August and is typically found in rocky washes with cobbles at elevations below 1,200 feet (Jepson eFlora 2017).

Willow monardella is federally and state listed as endangered and has a California Native Plant Society ranking of 1B.1 (rare or endangered in California and elsewhere; severely endangered in California). There is a total of 30 known element occurrences of willow monardella, with 23 presumed extant, 6 possibly extirpated, and 1 presumed extirpated (California Native Plant Society 2023). All records of willow monardella are from San Diego County, California.

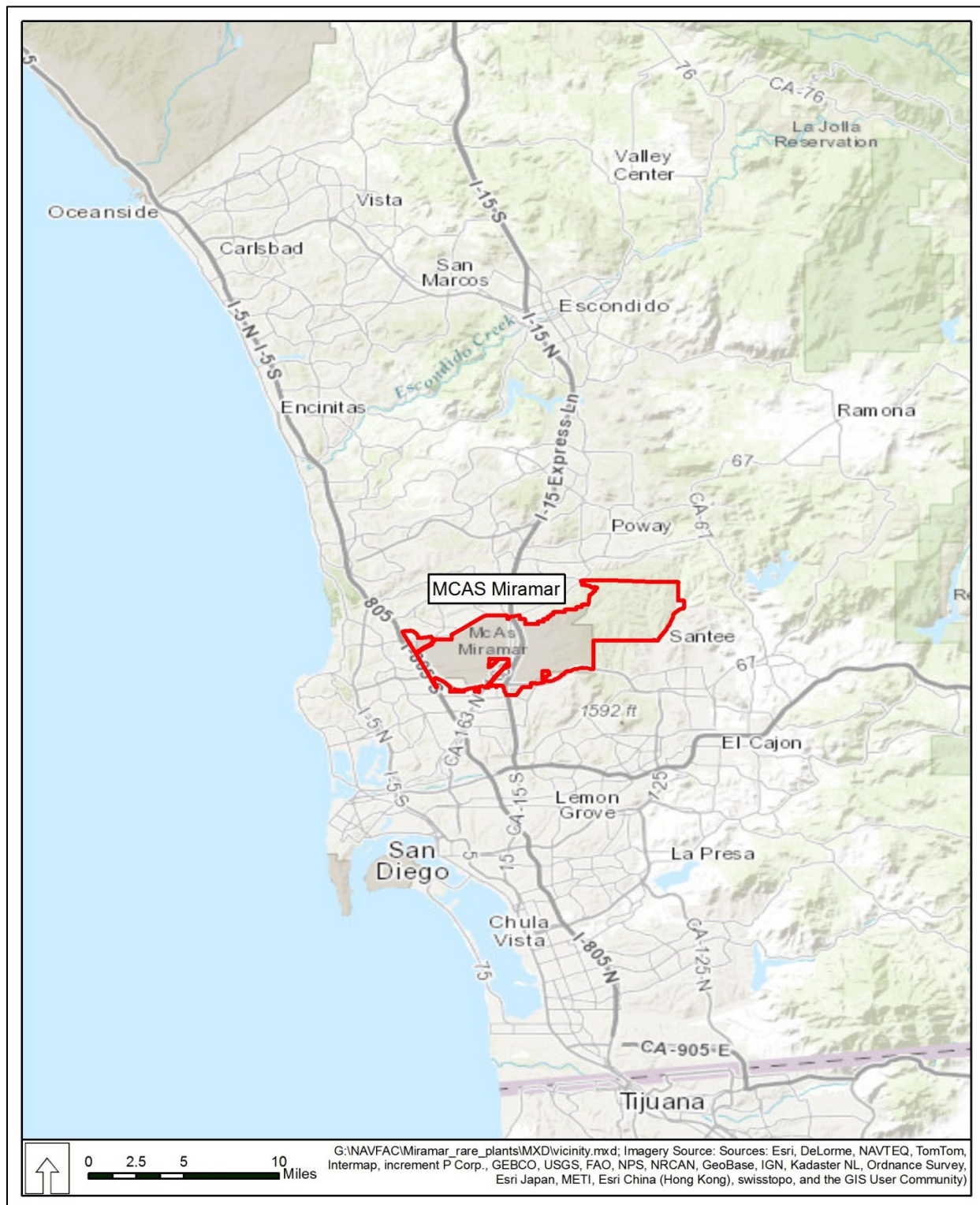


Figure 1-1. Location of Marine Corps Air Station Miramar

Willowy monardella is found in association with sandy washes, benches, and floodplains of streams and requires ephemeral watersheds with regular flooding regimes that periodically scour riparian vegetation (U.S. Fish and Wildlife Service [USFWS] 2008). Incidental observations noted that where willowy monardella was present within a sandy wash, bench, or floodplain, a layer of cobble was visible (due to a hydrological cut) approximately 6 inches below the soil surface. The USFWS indicates the narrow habitat conditions for willowy monardella are sustained “by natural processes and conditions of perennial streams and threatened by those factors that disrupt those processes and conditions” (USFWS 2008). The following have been causal mechanisms in the reduction of willowy monardella populations (USFWS 2008):

- Grazing/trampling
- Urban and residential development
- Various recreational activities
- Altered hydrological regimes
- Road construction
- Soil removal
- Sand and gravel mining
- Trash dumping
- Erosion
- Invasive plant species
- Fire
- Drought
- Reduction in gene flow

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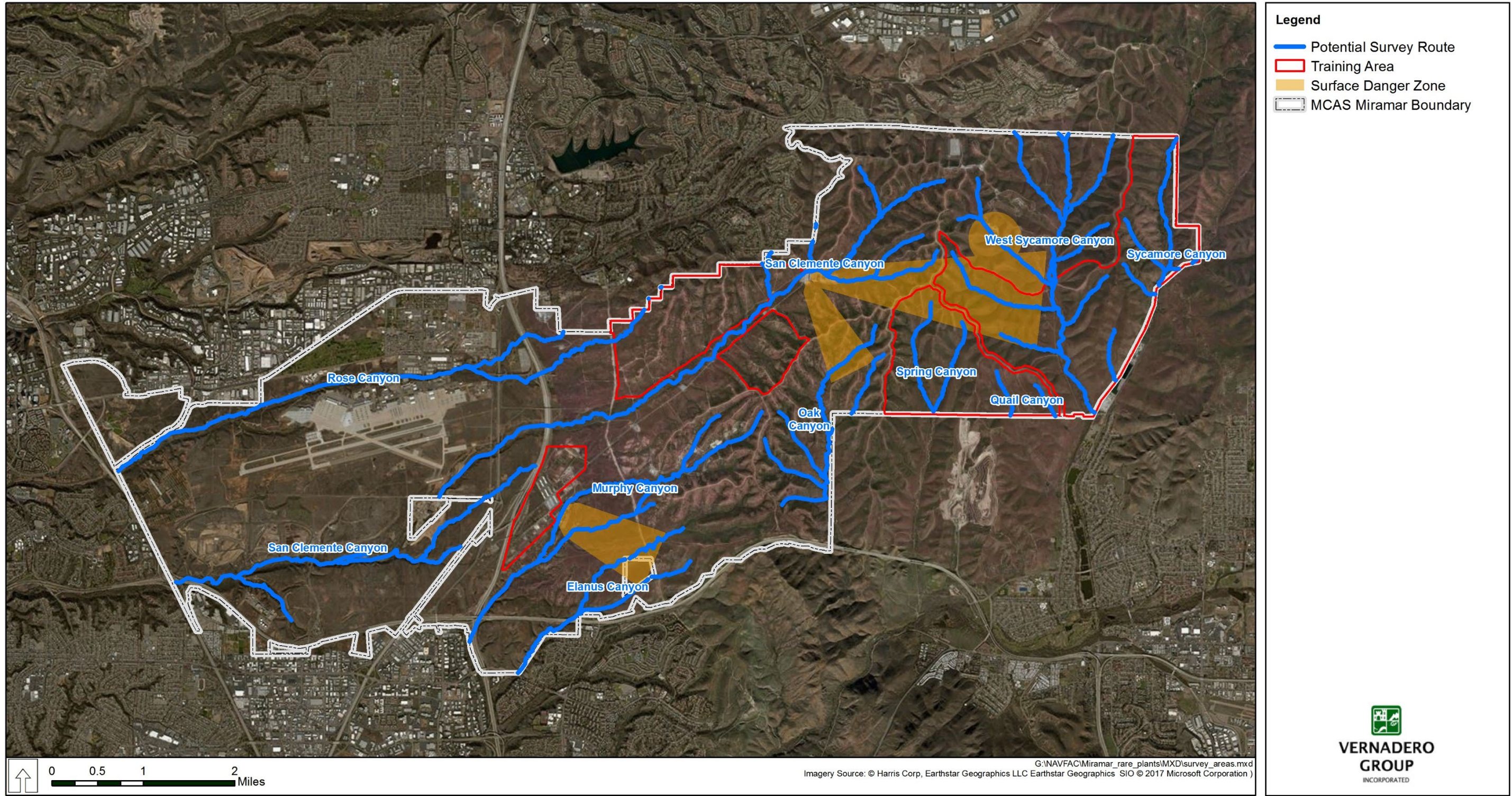


Figure 1-2. Willowy Monardella Census Locations

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1.4 Precipitation Information

Precipitation in San Diego County is annually variable, and precipitation's spatial distribution is influenced by many factors, including distance from the Pacific Ocean and topography. Because rainfall is critical for the growth of plant species and can lead to physical changes in stream channels due to scouring and biological changes such as the composition of plant species, it is useful to understand annual precipitation rates specific to the locations where willowy monardella is growing (USFWS 2008). Temperature influences evapotranspiration and impacts moisture availability.

Precipitation and temperature data centered on MCAS Miramar for the last 30 years were downloaded from the PRISM Climate Group (PRISM 2023). Severe, multiyear droughts have occurred at MCAS Miramar several times over the past 30 years. Record-breaking drought impacted the area between 2012 and 2015, followed by heavy rains in the 2016-2017 growing season, drought in 2018, heavy rains in the 2019 through 2020 growing seasons, and drought in 2021 and 2022 (Figure 1-3). There have been small temperature fluctuations since 1993, with cooler temperatures from 2017 through the present (Figure 1-3).

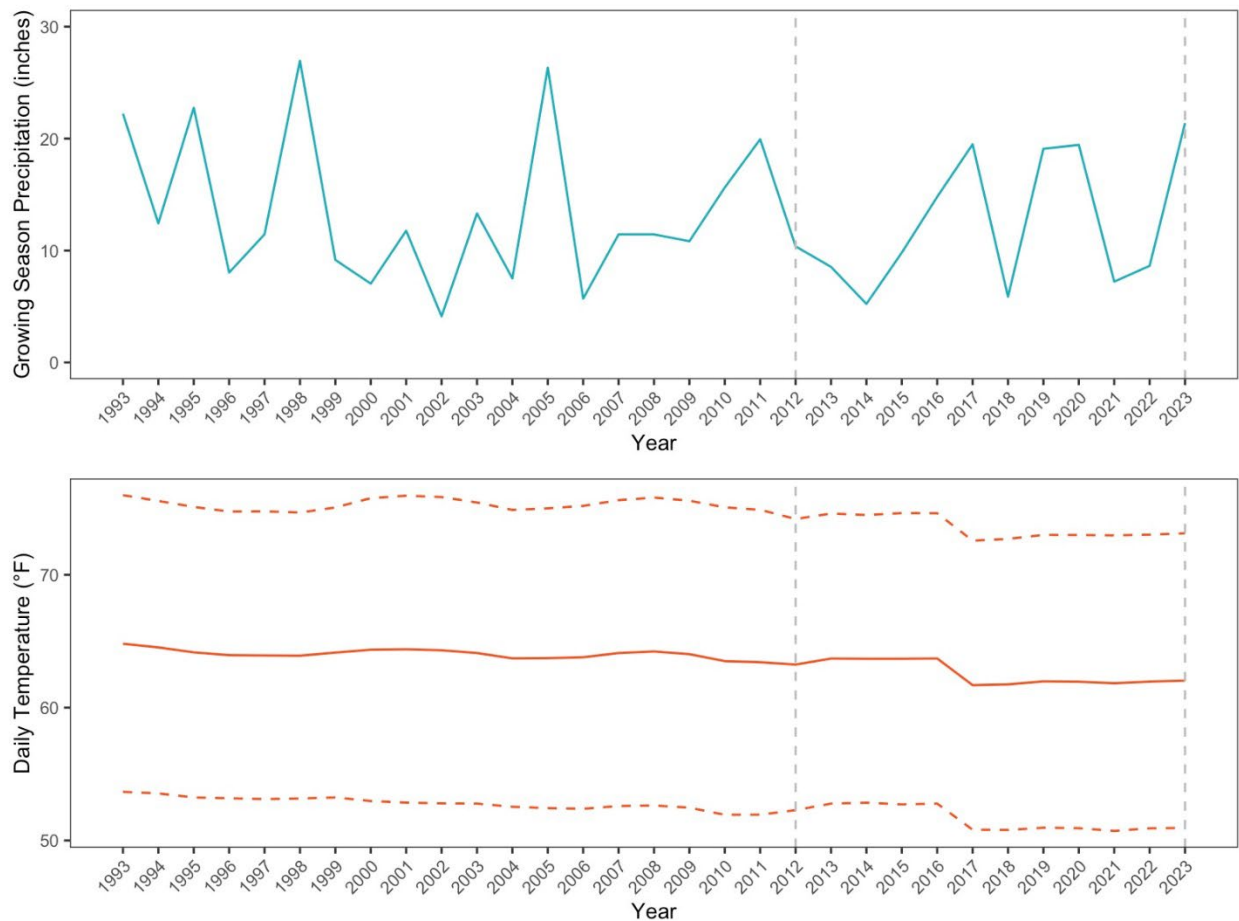


Figure 1-3. Growing Season (July 1 – June 30) Precipitation (inches), and Mean, Minimum and Maximum Growing Season Temperature (degrees Fahrenheit) for MCAS Miramar 1993 – 2023

The 2012 – 2017 monitoring period is delimited by dashed vertical lines. Source: PRISM 2023

2.0 METHODS

Vernadero followed all census and monitoring methods described by the Field Protocol Manual (MCAS Miramar 2013a) to ensure consistency with past and future willowy monardella surveys at MCAS Miramar. We surveyed and mapped all willowy monardella on MCAS Miramar identifying adults, mature plants, juveniles, and seedlings. We used a standardized method to define and delineate clumps of willowy monardella during the census. We visited established monitoring plots and used standardized methods to measure willowy monardella growth rates, determine clump health, and evaluate willowy monardella population expansion or contraction.

We conducted census and monitoring activities at MCAS Miramar from 30 June 2023 through 12 August 2023. Surveyors included Ms. Brianna Brambila, Ms. Nikki Gordon, Ms. Taylor Beaulac, Mr. Francis Coburn, and Mr. Arnaud Kerisit. Surveyors were well trained in the identification of willowy monardella and visited flowering willowy monardella prior to the start of surveys to ensure they understood the identifying characteristics. They were all provided a copy of the task order's Work Plan, Accident Prevention Plan, and the Field Protocol Manual (MCAS Miramar 2013a) to ensure consistency in data collection.

2.1 Willowy Monardella Census

Vernadero conducted a 100 percent coverage survey within all suitable habitat in Rose, San Clemente, Elanus, Murphy, Oak, Spring, Quail, West Sycamore, and Sycamore canyons on the Station. We examined ephemeral drainages, perennial drainages, and their associated floodplains for willowy monardella (see Figure 2-1). The identification and mapping of clumps were done according to the methods described in the Field Protocol Manual (MCAS Miramar 2013a). We identified a single clump as a willowy monardella plant(s) separated by more than 24 inches from another willowy monardella clump(s). We determined the separation between plants (living or presumed dead) by measuring between the two closest points of vegetation. We mapped and marked all seedlings regardless of the distance between the seedlings. We visited the locations of all previously identified willowy monardella plants to locate all of those willowy monardella clumps.

We identified all willowy monardella clumps with a plant tag following the methods described in the Field Protocol Manual (MCAS Miramar 2013a). Willowy monardella clumps mapped during previous surveys had a tag number, and we verified that the tags still existed and found them if necessary. Where plant tags were missing and a clump was observed, we installed a number tag and associated this tag number with the previous tag record. We placed a new plant tag on all newly identified clumps, and the plant tag number was recorded. We searched for all previously noted plant tags and recorded the status of each plant tag even if a tag and its associated clump could not be found. We mapped all plant tag locations with a global positioning system (GPS) unit with subfoot accuracy (Section 2.4).

The willowy monardella census collected the following information at every clump as described in the Field Protocol Manual (MCAS Miramar 2013a):

- Location (center point) of each clump with subfoot accuracy
- Plant tag number
- Plant tag numbers associated with clump expansion, splitting, or lost tags
- Phenology stage (vegetative, budding, flowering, fruiting, seeding, dormant/dead)
- Life stage (seeding, juvenile, mature, adult)
- Location of each clump within the drainage (in, at the edge, on a bench, or a combination)
- Drainage type (primary, secondary, tertiary)
- Residual dry matter (none, minimal, and dense thatch)
- Special observations such as disturbance or natural history

For life-stage data collection, surveyors defined seedlings as individuals that were less than 4 inches tall and lacked multiple stems, juveniles as lacking multiple stems but being more than 4 inches tall, mature as clumps with 20 or fewer stems, and adult as clumps with more than 20 stems.

2.2 Willowy Monardella Monitoring

Seventeen monitoring plots were established in 2002 and 2003, and those monitoring plots were labeled A through Q. However, due to the lack of willowy monardella clumps in some of the monitoring plots during the 2012 monitoring event, six originally established monitoring plots were eliminated (B, D, E, F, K, and M) and six new monitoring plots were added (R, S, T, U, V, and W).

We conducted habitat and clump-size monitoring at the 17 preestablished long-term monitoring plots labeled A, C, G, H, I, J, L, N, O, P, Q, R, S, T, U, V, and W (Figure 2-1). We identified each clump in the long-term monitoring plots and collected the following data on clumps as described by the methods in the Field Protocol Manual (MCAS Miramar 2013a):

- Individual clump diameter measured at the widest point of each clump
- Individual clump width measured at the widest point perpendicular to the clump's diameter
- Individual clump height measured at the highest point
- Relative cover within variable-sized concentric, elliptical quadrats over the center point of the clump for willowy monardella, bare ground, nonnative and native grasses, unidentifiable grasses, native herbs, nonnative herbs, shrubs, and trees.

We also collected the following habitat data at each monitoring plot as described by the methods in the Field Protocol Manual (MCAS Miramar 2013a):

- Observations of disturbances (e.g., fire, erosion)
- Dominant plant species and percent plant cover (recorded for all plant species with greater than 10 percent relative cover)
- Estimated average depth of the drainage associated with the monitoring plot
- Mapping of the outer extent of all rocky drainages within each plot

Photograph locations were previously established at each of the monitoring plots. We collected digital photographs at each of the preestablished photograph locations. While collecting new photographs, we referenced the photographs collected in 2012 and 2017 to ensure the direction and field of view matched the previous photographs to the extent practicable.

We checked the rebar stakes marking the four corners of each plot and replaced the stakes if needed. We also collected a GPS point at all four corners of each monitoring plot during the monitoring event. We painted all replacement monitoring plot stakes blue and repainted previously installed stakes blue as needed.

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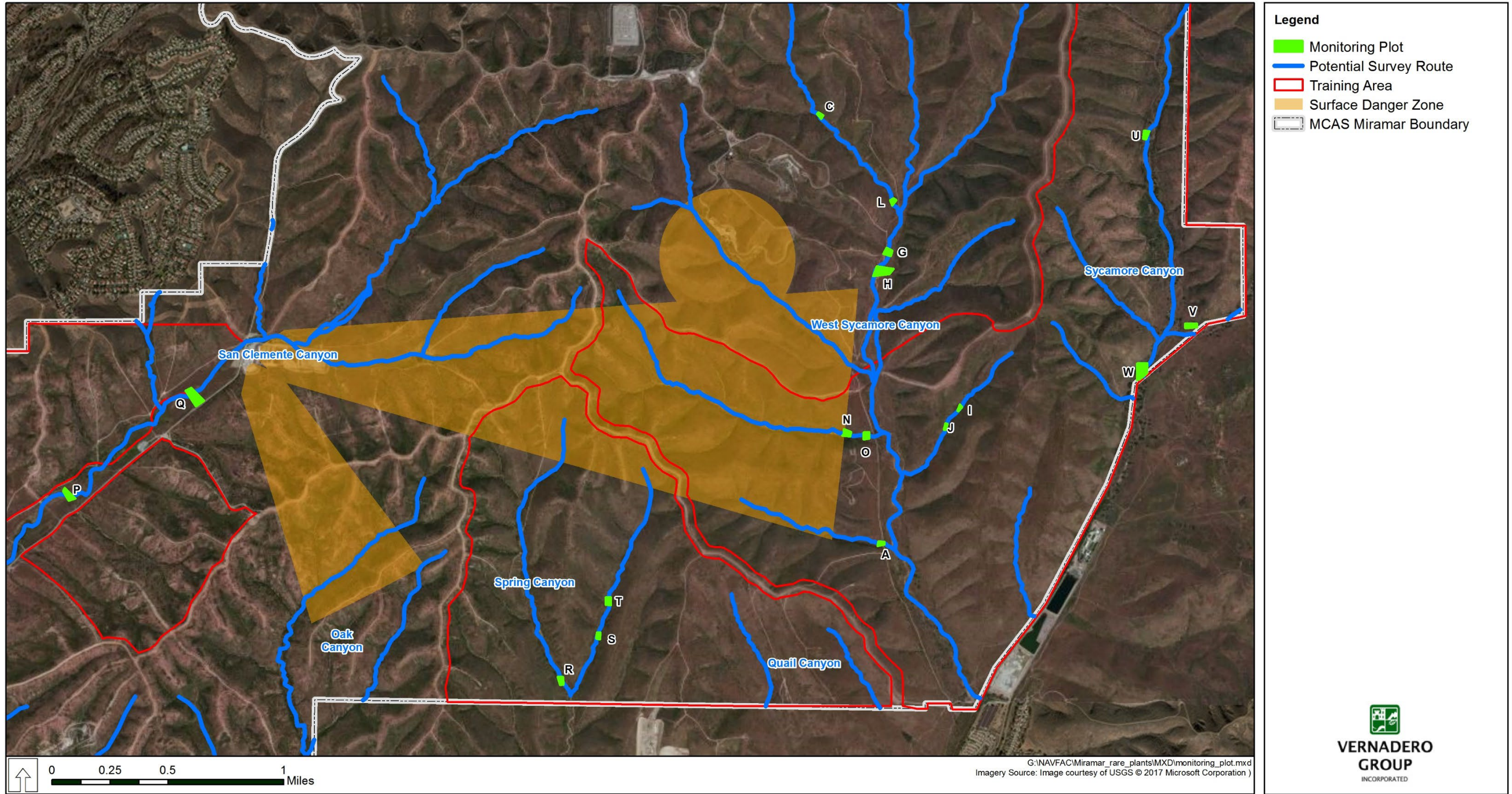


Figure 2-1. Location of Willowy Monardella Monitoring Plots at MCAS Miramar

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2.3 Data Analysis and Reporting

Vernadero analyzed all data collected from the census and monitoring fieldwork according to modified methods provided in the Field Protocol Manual (MCAS Miramar 2013a). For the census data, clumps were evaluated according to their distribution, phenology and life stages, changes in life stages between survey events, position of clumps relative to drainage areas, and additional observations (MCAS Miramar 2013a). For the analysis of monitoring plot data, changes in elliptical area, volume, and growth rate were calculated for all clumps. Elliptical area (in units of square cm) was calculated using the following formula from the Field Protocol Manual:

$$\text{Elliptical Area} = \pi * \left(\frac{1}{2} \text{ of the Clump Diameter}\right) * \left(\frac{1}{2} \text{ of the Clump Width}\right)$$

Elliptical volume (in units of cubic cm) was then calculated using the following formula from the Field Protocol Manual:

$$\text{Elliptical Volume} = \text{Elliptical Area} * \text{Clump Height}$$

Growth rate was determined by evaluating the change in elliptical area and elliptical volume for willowy monardella clumps in monitoring plots between monitoring events. Clump growth rate was calculated according to the methods provided in the Field Protocol Manual (MCAS Miramar 2013a) using the following formula for each willowy monardella clump that was monitored in 2012, 2017, and 2020:

$$\text{Clump Growth Rate} = \left(\frac{\text{Time 2 Elliptical Area or Elliptical Volume}}{\text{Time 1 Elliptical Area or Elliptical Volume}}\right) - 1$$

The result is a positive or negative rate of growth for each willowy monardella clump.

The multiple regression approach to examine the effects of habitat features associated with willowy monardella clump size (elliptical area and volume) as described in the Field Protocol Manual (MCAS Miramar 2013a) was modified to improve statistical validity. Issues with the approach that was followed include:

- **Pseudoreplication.** Clumps within monitoring plots are spatially correlated. That is, they do not represent independent samples and to treat them as independent samples in a statistical model violates assumptions of independence of errors, which inflates the degrees of freedom and can lead to overinflation of significance and/or obscure meaningful relationships (Crawley 2013).
- **Collinearity.** Explanatory variables that are correlated with one another (collinearity) should not both be included in a model as this can lead to unstable parameter estimates and lead to spurious conclusions (Crawley 2013). For example, total plant cover and total herbaceous cover would be expected to positively correlate with invasive grass cover, and bare ground negatively correlated with invasive grass cover.

- **Parsimony.** Statistical models should be based on the principle of parsimony, with the simplest model that best fits the data (Crawley 2013). Pseudoreplication was addressed by using mixed effect models with a random effect of monitoring plot. Mixed effect models account for nonindependence of errors by modelling the covariance structure of observations grouped within the random effect variable (Crawley 2013). Collinearity and parsimony were addressed by first inspecting the data for correlations between habitat variables and relationships between habitat variables and response variables (elliptical area or elliptical volume) with graphs, then modelling the effect of each habitat variable in a univariate mixed effect model to identify the strongest relationships.

If relationships were apparent, then multiple combinations of habitat variables would have been used in multiple regression, with the most parsimonious model selected using Akeake's Information Criterion; however, as there were no relationships between habitat variables and elliptical area or volume, there was no need to build multiple regression models. We tested whether there were significant differences among monitoring years in terms of plant size and growth by using a mixed effect model with monitoring plot and individual plant as random effects and year as a fixed effect, and tested whether there were differences in plant size and growth among monitoring plots by using a general linear model with monitoring plot as a fixed effect.

The habitat characteristics collected as part of willowy monardella monitoring were included as independent variables in univariate regression, with monitoring plot ID as a random effect (Table 2-1).

Table 2-1. Multiple Regression Variables

Variable	Independent Variable	Scale	Codes for Regression
X_1	Herbivory	Yes or No	1 = Yes, 0 = No
X_2	Percent cover nonnative grasses	1 to 100 percent to closest 5 percent	As continuous variable
X_3	Percent cover native herbs	1 to 100 percent to closest 5 percent	As continuous variable
X_4	Percent cover nonnative herbs	1 to 100 percent to closest 5 percent	As continuous variable
X_5	Percent cover shrub species	1 to 100 percent to closest 5 percent	As continuous variable
X_6	Percent cover tree canopy	1 to 100 percent to closest 5 percent	As continuous variable
X_7	Percent cover bare ground	1 to 100 percent to closest 5 percent	As continuous variable
X_8	Drainage type	Primary, secondary, or tertiary	1 = primary, 2 = secondary, 3 = tertiary (Coded as categorical values)
X_9 and X_{10}	RDM	Level 1 = no RDM Level 2 = minimal RDM Level 3 = dense thatch	As dummy variables by adding two separate dichotomous independent variables: $B_9 = 1$ if RDM level is 1, 0 otherwise; $B_{10} = 1$ if RDM level 2, 0 otherwise. (Only two dummy variables are required because if both B_8 and B_9 are 0, then the RDM level must be 3.)

Source: MCAS Miramar 2013a

RDM – residual dry matter

We used the Stationwide census data from 2002 to 2023 to build count-based population viability analysis (e.g., Dennis et al. 1991; Morris and Doak 2003; Elder et al. 2003) to calculate population growth rates and to model quasi-extinction probabilities. Population growth was calculated from changes in cumulative abundance from one monitoring event to the next using the formula:

$$\text{Growth}_{t \text{ to } t+1} = \ln(N_{t+1}/N_t)$$

$\ln$ is the natural log, and N_t is the abundance at the initial census, and $t+1$ is the abundance at the second census

If growth is above zero, the population is growing, if below zero the population is in decline, and 0 is no change. Population growth was calculated for each monitoring event pair in the dataset, i.e., from 2002 to 2012, 2012 to 2017, 2017 to 2020 and 2020 to 2023. To model stochastic population growth models that account for environmental variation, the mean (μ) and variance (σ^2) of growth were calculated from the dataset. The probability of quasi-extinction (defined as 10 or fewer clumps remaining) with bootstrapped confidence intervals were estimated using the

function `countCDFxt` from the `popbio` package in RStudio (Stubbin and Milligan 2007). This function plots the cumulative probabilities of quasi-extinction through time with 95 percent confidence intervals, using the estimated value of μ , σ , the number of transitions in the dataset, the current population size, the quasi-extinction threshold, and the length of the census in years.

Photographs taken during the 2023 monitoring period and previous monitoring efforts were visually compared for noticeable changes in plant growth form and structure.

2.4 Geographic Information System

All GPS data were collected using EOS Positioning System's Arrow 200® Global Navigation Satellite System Real-Time Kinematic (RTK) subfoot-accurate units. The Arrow 200® RTK units were connected via Bluetooth® with Android® and iOS® mobile phones or tablets. The locations of census-area boundaries, willowy monardella clumps, plant tag locations, monitoring plot corners, and other observed resources of interest were collected in ArcGIS Collector. For all fieldwork, geographic information system (GIS) data were collected using data dictionaries provided by MCAS Miramar. All data collected were compatible with Spatial Data Standards for Facilities Infrastructure and Environment version 3.0 and contained complete metadata based on MCAS Miramar's metadata requirements.

2.5 Access and Safety Coordination

All range safety was coordinated through Mr. A. J. Ward, MCAS Miramar Range Control. Mr. Ward was notified when the field team required access to the far eastern part of MCAS Miramar. Additional coordination was required for access to various other points, and Vernadero interacted with the Padre Dam Municipal Water District and Mr. Ronald Clark, MCAS Miramar, for those access requirements.

3.0 RESULTS

3.1 2023 Willowy Monardella Census

The 2023 survey observed 865 total willowy monardella clumps, with 776 living willowy monardella clumps and 93 dead willowy monardella clumps (Figures 3-1 through 3-8; Table 3-1). A total of 39 clumps that had been observed and tagged during previous surveys were not relocated (Table 3-1). Of the living willowy monardella clumps, 86 were new clumps not mapped during previous surveys (Table 3-1), 18 clumps were previously mapped as multiple clumps and were merged into a single clump, and 14 clumps were previously mapped as a single clump and were split into multiple clumps.

Table 3-1. Number of Willowy Monardella Clumps by Canyon Observed in 2023

Canyon	Number of Living Clumps	Number of New Clumps in 2023	Number of Dead Clumps	Previously Mapped but Not Relocated
Elanus	9	0	0	0
Murphy	1	0	0	0
San Clemente	224	16	48	19
Spring	175	6	10	4
Sycamore	128	38	11	2
West Sycamore	239	29	20	14
Oak	0	0	0	0
Quail	0	0	0	0
Rose	0	0	0	0
Total	776	89	89	39

As in 2020, the majority of all the willowy monardella clumps observed during the 2023 surveys were adults (652 clumps). More smaller size classes were observed in 2023 than in previous years, with 95 mature clumps, 22 clumps categorized as juvenile (versus 3 in 2020), and one seedling (Table 3-2). The 2023 seedling was the first seedling observation in since 2017. Although smaller plants were more frequently observed during 2023, apparent mortality also continued by 2023, and the rate of recruitment has not outstripped mortality during this time (Table 3-2).

Table 3-2. Life Stage of Willowy Monardella Clumps by Canyon 2017-2023

Monitoring Year	Location	Life Stage				
		Seedling	Juvenile	Adult	Mature	Dead or Not Found
2017	Elanus Canyon	0	0	10	0	1
	Murphy Canyon	0	0	1	0	0
	San Clemente Canyon	0	0	344	16	38
	Spring Canyon	1	2	180	8	55
	Sycamore Canyon	0	0	111	5	85
	West Sycamore Canyon	0	1	257	16	92
	Total	1	3	903	45	271
2020	Elanus Canyon	0	0	9	0	2
	Murphy Canyon	0	0	2	0	1
	San Clemente Canyon	0	1	297	16	129
	Spring Canyon	0	1	168	7	1
	Sycamore Canyon	0	0	128	8	98
	West Sycamore Canyon	0	1	240	14	131
	Total	0	3	844	45	362
2023	Elanus Canyon	0	0	8	1	0
	Murphy Canyon	0	0	1	0	0
	San Clemente Canyon	1	4	203	40	61
	Spring Canyon	0	7	123	16	14
	Sycamore Canyon	0	3	111	15	13
	West Sycamore Canyon	0	7	218	26	34
Total		1	21	664	98	122

The phenology of the vast majority of clumps found during the 2023 census were in the flowering stage (Table 3-3). Clumps not flowering were typically either vegetative or budding, with only two clumps observed to be in the seeding stage or senescent (Table 3-3).

Table 3-3. Phenology Stage of Willowy Monardella Clumps by Canyon

Canyon	Phenology Stage					
	Vegetative	Budding	Flowering	Fruiting	Seeding	Senescent
Elanus	1	0	8	0	1	0
Murphy	0	0	1	0	0	0
San Clemente	11	8	202	0	0	1
Spring	2	0	171	0	1	0
Sycamore	0	0	93	0	0	0
West Sycamore	7	9	113	0	0	0
Total	21	17	588	0	2	1



Figure 3-1. Willowy Monardella Clumps in Elanus Canyon during 2023

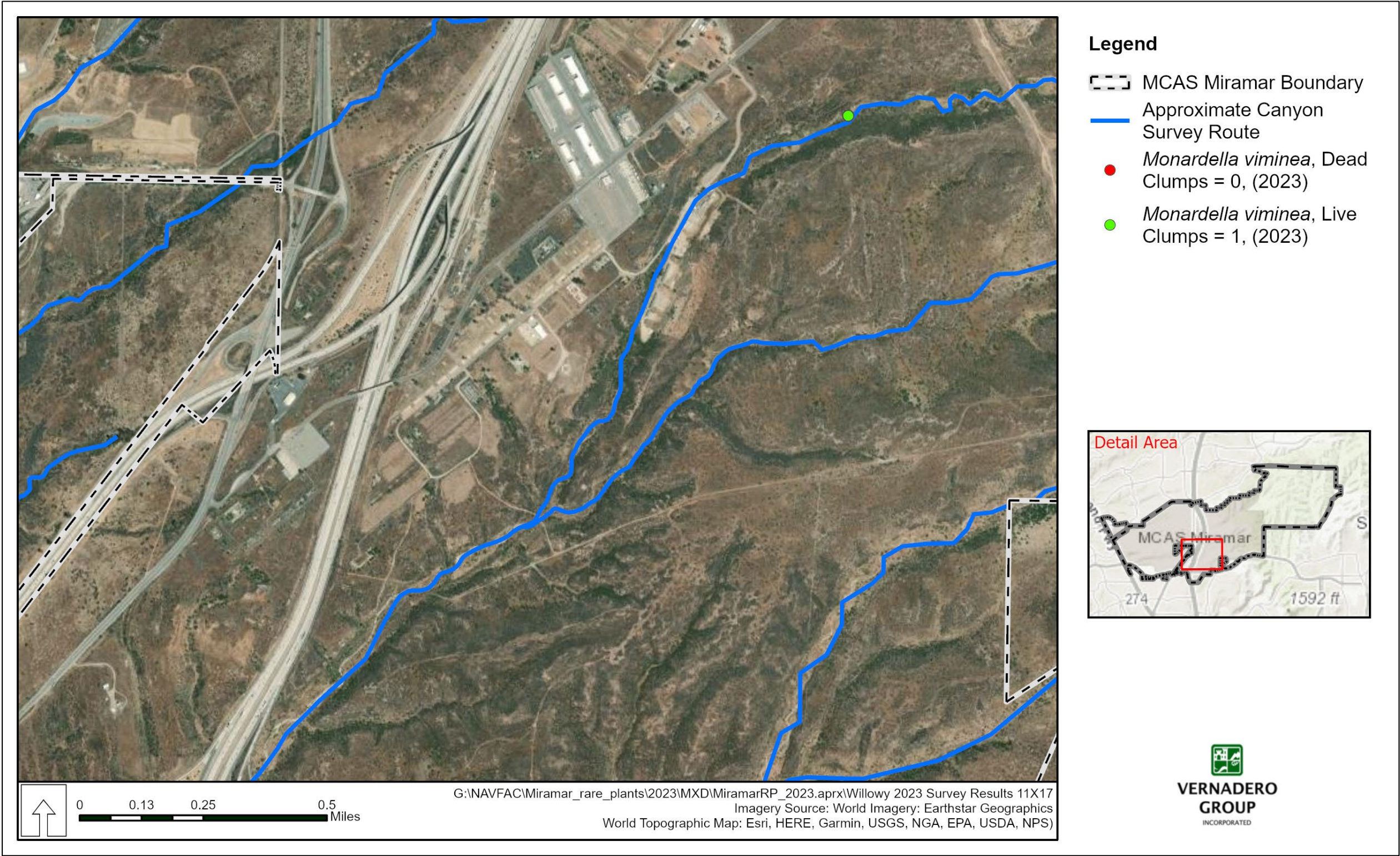


Figure 3-2. Willowy Monardella Clumps in Murphy Canyon during 2023

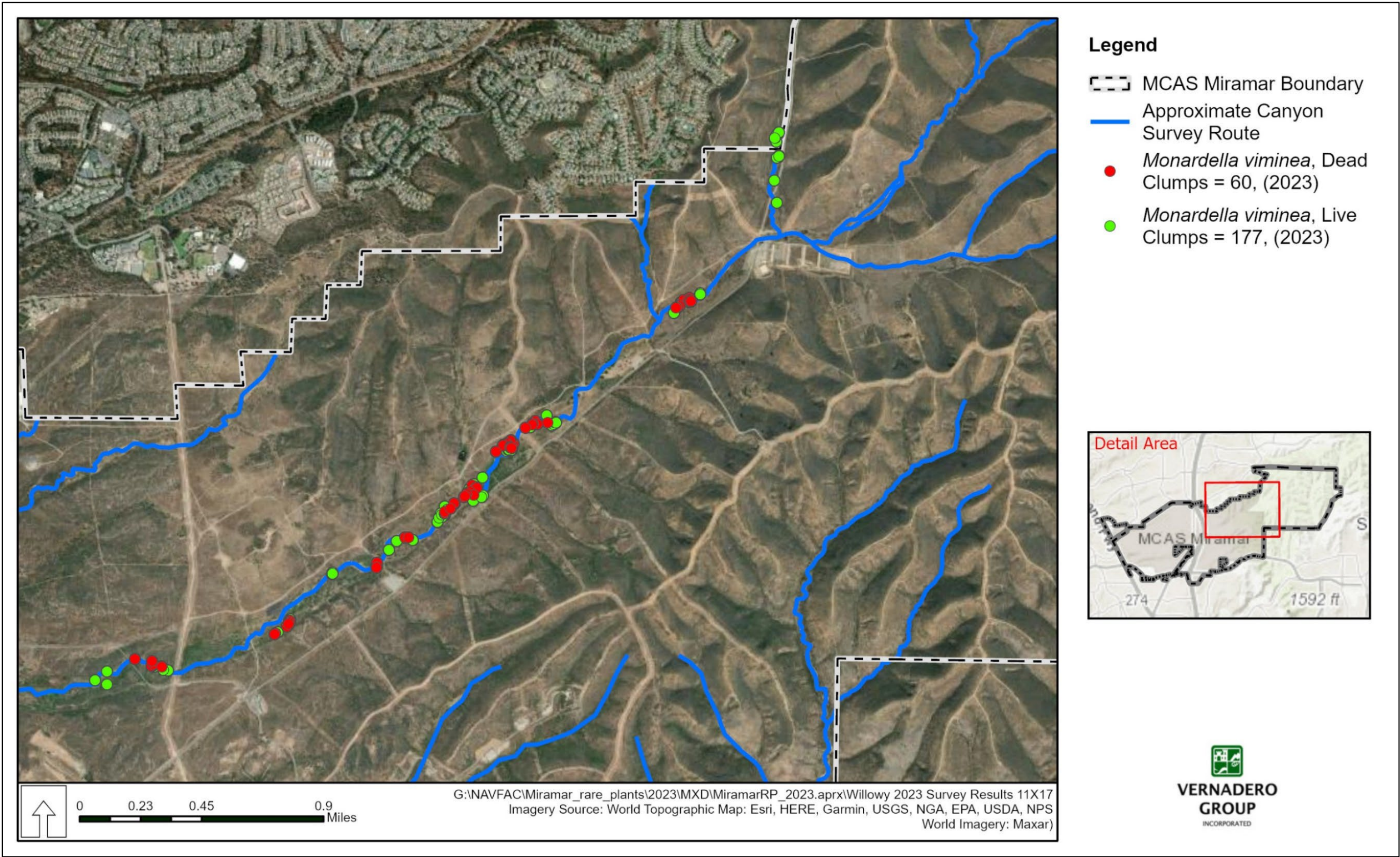


Figure 3-3. Willowy Monardella Clumps in the Eastern Portion of San Clemente Canyon during 2023

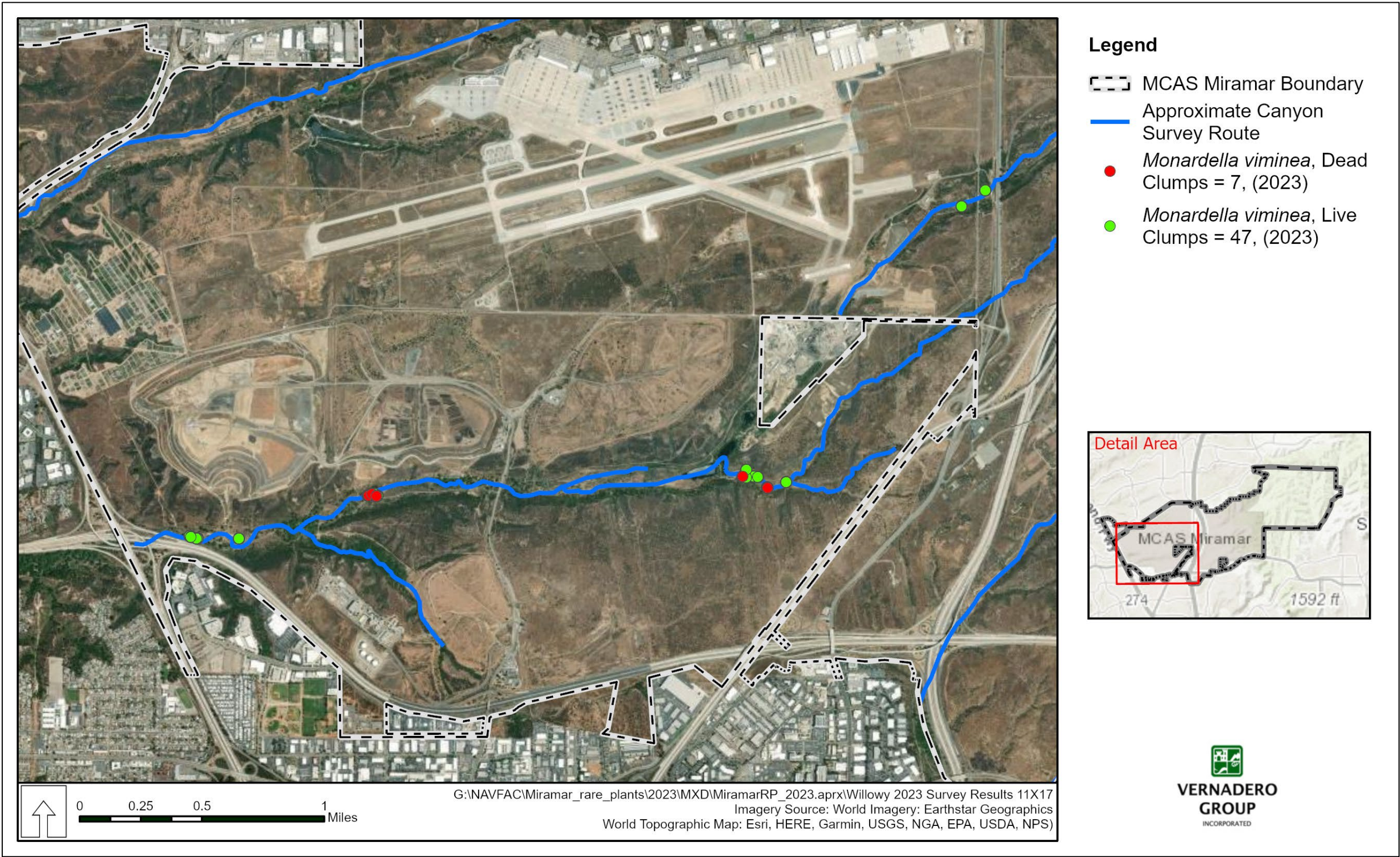


Figure 3-4. Willowy Monardella Clumps in the Western Portion of San Clemente Canyon during 2023

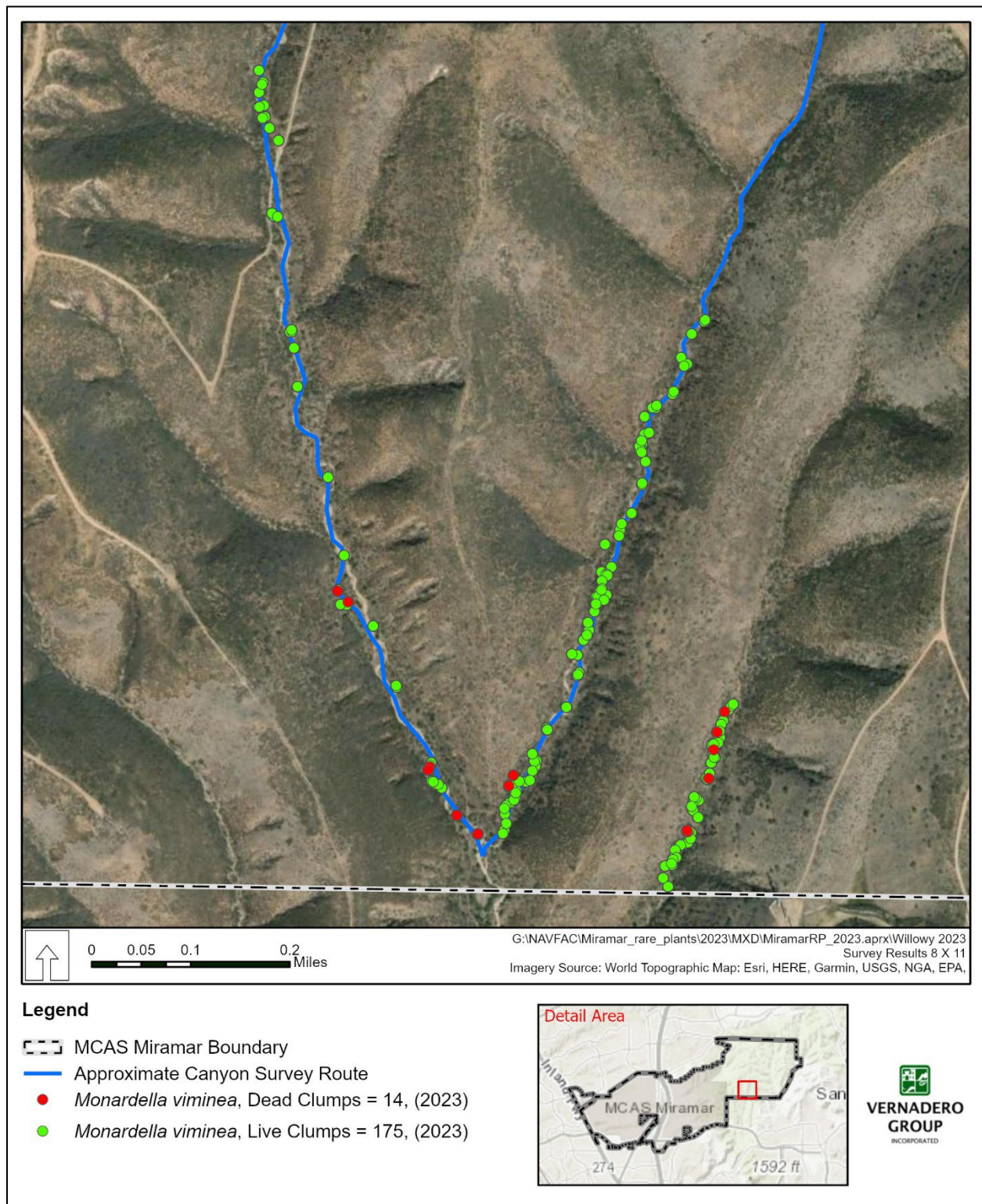


Figure 3-5. Willowy Monardella Clumps in Spring Canyon during 2023

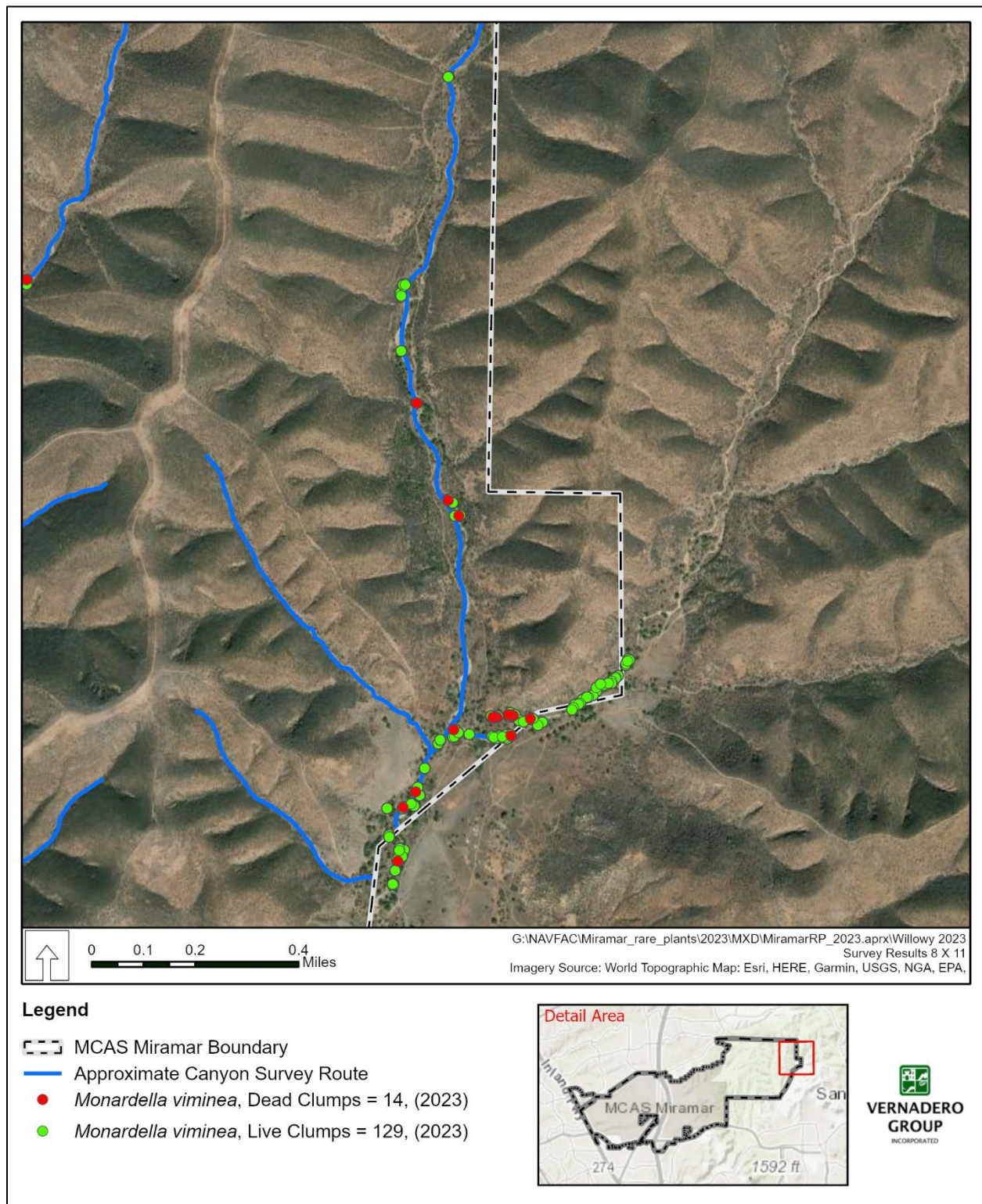


Figure 3-6. Willowy Monardella Clumps in Sycamore Canyon during 2023

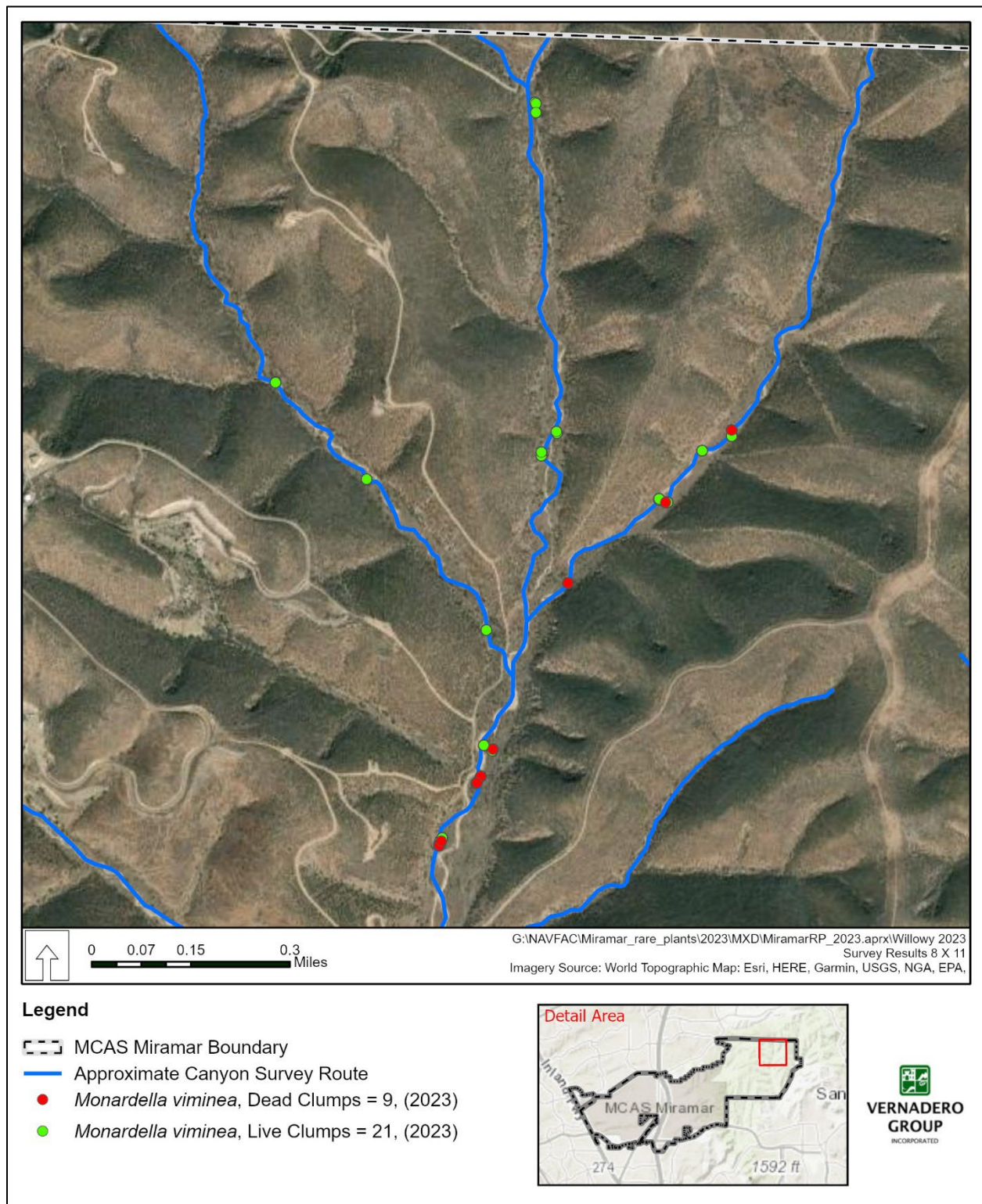


Figure 3-7. Willowy Monardella Clumps in the Northern Portion of West Sycamore Canyon during 2023

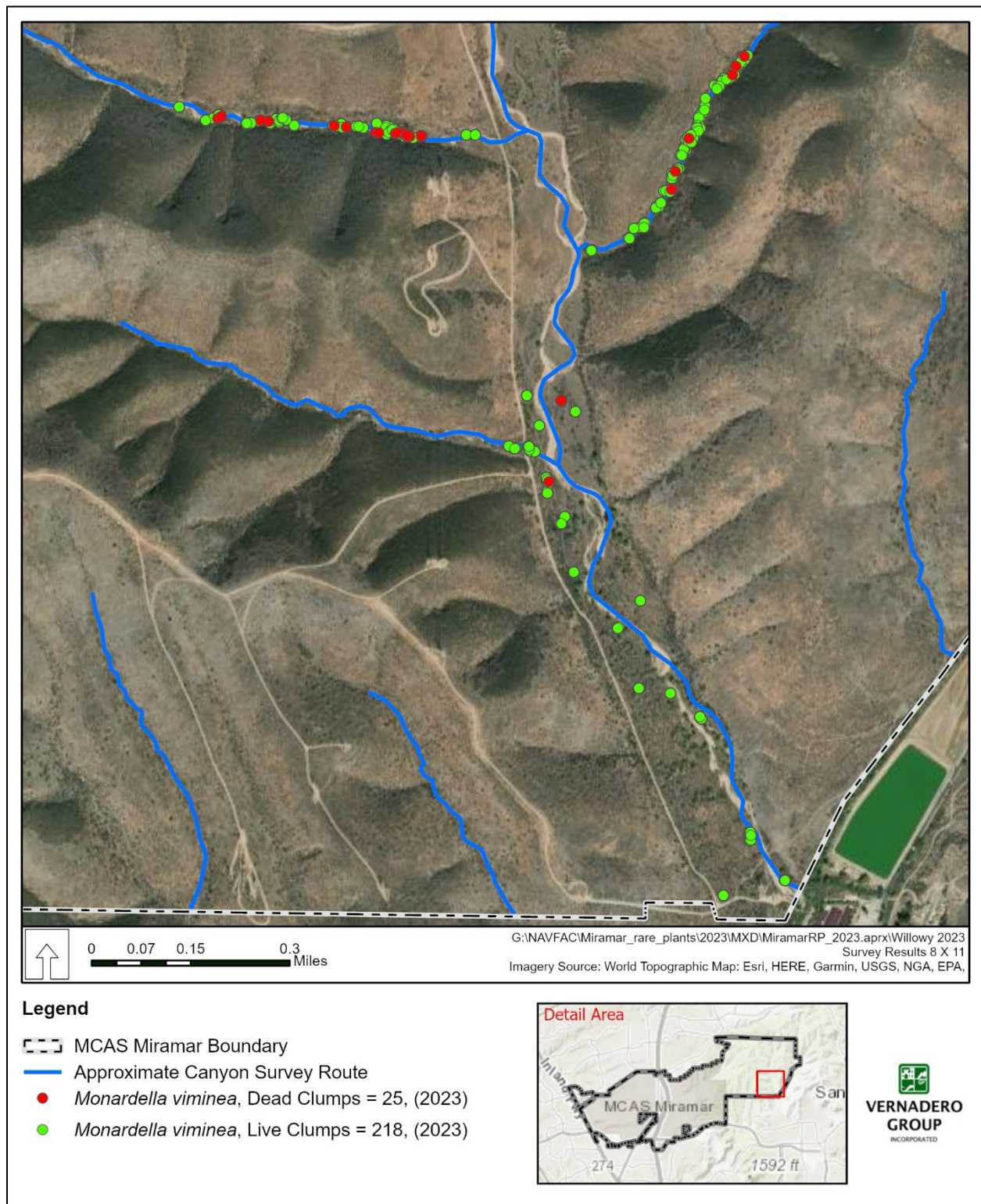


Figure 3-8. Willowy Monardella Clumps in the Southern Portion of West Sycamore Canyon during 2023

Although the Field Monitoring Protocol (MCAS Miramar 2013a) methods only require the measurement of clump size for willow monardella clumps occurring in monitoring plots, these data were collected for all clumps during the 2020 and 2023 censuses. While clump sizes were similar across canyons, clumps in Spring Canyon and West Sycamore Canyon, where willow monardella is most abundant, were larger, with differences between other drainages not statistically significant (Table 3-4). Clumps were significantly smaller in terms of plant height and width in 2023 relative to 2020, but differences in plant length were not significant (Table 3-4).

Table 3-4. Mean Height, Length, and Width of Willowy Monardella Clumps by Canyon and Year

Canyon	Mean Height (cm)*		Mean Length (cm) ^{ns}		Mean Width (cm)**	
	2020	2023	2020	2023	2020	2023
Elanus (n=9 2020, 2023)	40	44	120	113	70	66
Murphy (n=1 2020, 2023)	45	38	108	37	77	5
San Clemente (n=289 2020, n=291 2023)	45	49	120	98	82	67
Spring (n=189 2020, 2023)	52	50**	159	156	117	99*
Sycamore (n=107 2020, n=141 2023)	51	42	157	128	112	86
West Sycamore (n=233 2020, n=273 2023)	55	51***	173	167*	119	112**
Overall Mean (n=822 2020, 2=866 2023)	50	49	148	137	106	91
Minimum	8	6	1	1	1	1
Maximum	155	97	1,200	1,310	874	878

cm – centimeter

*= p < 0.01

**= p < 0.001

Results of general linear model with the effect of year and drainage of the canyon on plant height, length, and width:
ns = not significant (p > 0.05),

We recorded the drainage type (primary or secondary) and geomorphological location of willow monardella clumps along drainage channels. In Spring and West Sycamore canyons, willow monardella was exclusively or predominately found along secondary drainages, while within other canyons it was more likely to occur along primary drainages (Table 3-5). Most clumps were found in alluvial benches or flats (596 clumps) along drainage channels, with 153 clumps found on the inside curve or edge of meandering channels and 117 clumps found within a main drainage (Table 3-6).

**Table 3-5. Willowy Monardella Clump Occurrence
by Drainage Type by Canyon**

Canyon	Drainage Type	
	Primary	Secondary
Elanus	9	0
Murphy	1	0
San Clemente	269	16
Spring	0	189
Sycamore	127	14
West Sycamore	42	231
Total	448	450

Table 3-6. Location in Drainage of Willowy Monardella Clumps by Canyon

Canyon	Drainage Location		
	Alluvial Bench or Flats	Inside Edge of Curve in Meandering Drainage	Main Drainage
Elanus	7	2	0
Murphy	0	1	0
San Clemente	233	16	23
Spring	106	44	35
Sycamore	93	35	11
West Sycamore	157	55	48
Total	596	153	117

No disturbance was observed for most occurrences of willowy monardella (Table 3-7). Flooding and associated erosion were the most frequent disturbances noted during 2023, with annual grass and thatch encroachment also frequently observed (Table 3-7). Rodent soil disturbance was noted at 1 percent of all occurrences. Other disturbances, including herbivory, tree and shrub shading, treefall, and location near a bike patch or transmission line together impacted 1 percent of occurrences (Table 3-7).

**Table 3-7. Frequency of Disturbances
Observed Impacting Willowy Monardella**

Disturbance type	Percent occurrence (n=904)
No Disturbance	65%
Erosion/Flooding	16%
Annual Grasses/Thatch	13%
Rodent Soil Disturbance	1%
Other*	1%

* Other disturbances include herbivory, tree and shrub shading, treefall, and location near a bike path or transmission line. Multiple disturbances may be observed at a single occurrence, and occurrences include sites where willowy monardella was observed and where it was missing or dead in 2023.

A number of potential pollinators were observed on willowy monardella flowers in 2023, with bees (bumblebees [*Bombus* spp.] and honeybees [*Apis* spp.]) most frequently observed with 100 total observations. Moths and butterflies (fiery skipper [*Hylephila phyleus*], tiger swallowtail [*Papilio glaucus*], dusky wing butterfly [*Erynnis* spp.], pale swallowtail [*Papilio eurymedon*], and Monarch butterfly [*Danaus plexippus*]) were observed 36 times. Wasps, hornets, flies and stinkbugs (Pentatomidae) were infrequently observed.

3.2 2023 Willowy Monardella Plot Monitoring

A total of 113 living willowy monardella clumps were recorded during 2023 in the 17 monitoring plots, a decline of 12 clumps from 2020 (Table 3-8). Abundance declined in 10 plots during 2023, there was no change in four plots, abundance was stable in four plots, and abundance increased in four plots (Table 3-8). Plot G lost its two remaining willowy monardella clumps (Table 3-8).

Table 3-8. Number of Living Willowy Monardella Clumps by Monitoring Plot

Monitoring Plot	2023 Number of Willowy Monardella Clumps (2020 Number)*	Drainage Location	Survey Date 2023
A	3 (5)	West Sycamore Canyon	15 July 2023
C	2 (1)	West Sycamore Canyon	21 July 2023
G	0 (2)	West Sycamore Canyon	21 July 2023
H	3 (4)	West Sycamore Canyon	21 July 2023
I	18 (16)	West Sycamore Canyon	8 July 2023
J	8 (9)	West Sycamore Canyon	8 July 2023
L	1 (1)	West Sycamore Canyon	21 July 2023
N	3 (4)	West Sycamore Canyon	14 July 2023
O	1 (1)	West Sycamore Canyon	15 July 2023
P	7 (8)	San Clemente Canyon	6 July 2023
Q	7 (12)	San Clemente Canyon	5 July 2023
R	5 (4)	Spring Canyon	23 July 2023
S	12 (14)	Spring Canyon	23 July 2023
T	8 (7)	Spring Canyon	22 July 2023
U	9 (9)	Sycamore Canyon	19 July 2023
V	19 (19)	Sycamore Canyon	23 July 2020
W	7 (9)	Sycamore Canyon	13 July 2020

* The total includes only living clumps. One dead clump was observed in Plots P and W; two dead clumps were observed in Plots G, I, N and S; three dead clumps were observed in Plots H and V; and seven dead clumps were observed in Plot Q.

Willowy monardella elliptical area and volume were highly variable within and among monitoring plots (Tables 3-9 and 3-10). Plots I and J in West Sycamore Canyon had the largest individuals in terms of area and volume, matching the census results.

Table 3-9. Mean, Median, and Standard Deviation of 2023 Elliptical Area of Willowy Monardella Clumps by Monitoring Plot (see Table 3-8 for n)

Monitoring Plot	Mean Elliptical Area (square meters)	Median Elliptical Area (square meters)	Standard Deviation (square meters)
A	4.01	3.00	4.43
C	0.36	0.36	0.17
G	0.00	0.00	NA
H	0.52	0.73	0.42
I	4.79	1.10	7.39
J	1.82	1.53	1.34
L	4.33	4.33	NA
N	2.20	1.90	2.28
O	0.01	0.01	NA
P	0.44	0.40	0.41
Q	0.62	0.19	0.67
R	1.41	1.20	1.21
S	1.32	1.35	1.09
T	1.35	0.67	1.53
U	0.66	0.56	0.50
V	1.32	0.45	2.16
W	1.17	1.64	0.78
Overall	1.83	0.80	3.50

Table 3-10. Mean, Median, and Standard Deviation of 2023 Elliptical Volumes of Willowy Monardella Clumps by Monitoring Plot (see Table 3-8 for n)

Monitoring Plot	Mean Elliptical Volume (cubic meters)	Median Elliptical Volume (cubic meters)	Standard Deviation (cubic meters)
A	2.34	1.12	2.45
C	0.18	0.18	0.06
G	0.00	0.00	NA
H	0.27	0.39	0.22
I	2.43	0.58	3.96
J	0.95	0.70	0.71
L	3.07	3.07	NA
N	1.17	0.97	1.24
O	0.00	0.00	NA
P	0.25	0.24	0.22
Q	0.47	0.09	0.53
R	0.66	0.37	0.69
S	0.69	0.54	0.74
T	0.55	0.32	0.60
U	0.31	0.24	0.32
V	0.64	0.18	1.08
W	0.50	0.54	0.40
Overall	0.94	0.38	1.87

Some level of disturbance was present at most of the monitoring plots. The most common disturbances were flooding, with associated erosion, heavy invasive grass, and thatch cover (Table 3-11). The average drainage depth at the monitoring plots was 51 cm (Table 3-11). Only four soil types were recorded in the 17 monitoring plots, with Redding cobbly loam being the most common type (Table 3-11). Native species were dominant in 9 of the 17 monitoring plots, with nonnative species dominant in 5 plots. Natives and nonnatives were codominant in three plots (Table 3-11).

**Table 3-11. Drainage Depth, Soil Types, and Disturbances
in Willowy Monardella Monitoring Plots**

Monitoring Plot	Drainage Depth (cm)	Soil Type	Native (Nonnative) Dominant Plant Species Percent Cover	Disturbance Notes
A	30	SvE, RfF	60 (40)	Flooding, high cover of annual grasses in some areas, road runs through plot.
C	56	RfF, SvE	40 (60)	Heavy thatch on benches.
G	120	SvE, RfF	60 (40)	Flooding, erosion of main channel. High thatch cover throughout half of plot.
H	61	SvE, RfF	30 (70)	Road/trail runs through plot. Recent fire ca. 50 meters south of plot. High cover of thatch over half of plot.
I	52	RfF	63 (37)	None
J	33	RfF	63 (23)	None
L	36	SvE, RfF	15 (65)	Flooding and bank erosion, high thatch cover on benches.
N	60	SvE, RfF	35 (65)	Flooding, high erosion of banks, high thatch and annual grass cover on alluvial terraces.
O	65	SvE, RfF	30 (65)	High amount of flooding, bank erosion, high cover of thatch and annual grasses.
P	NA	VbB	40 (40)	High cover of annual grasses
Q	60	VbB	37 (57)	NA
R	60	RfF	55 (45)	High amount of flooding, bank erosion. High annual grass and thatch cover on terraces.
S	52	SvE, RfF	67 (39)	Channel undercutting/downcutting and erosion. Small trail through plot. Dense thatch over portions of plot.
T	27	SvE, RfF	70 (30)	Flooding, high cover of thatch in some areas.
U	20	SvE, RfF	60 (40)	High thatch cover over large portion of plot.
V	33	SvE	50 (50)	High cover of exotics, extensive ground disturbance by rodents.
W	NA	SvE, DaE	55 (50)	High floods moved through washes. Much of plot covered in dense annual grass thatch.

cm – centimeter; NA – not applicable

Key to Soil Types

SvE – stony land; **RfF** – Redding cobbly loam, dissected, 15 to 50 percent slopes; **VbB** – Visalia gravelly sandy loam, 2 to 5 percent slopes; **DaE** – Diablo clay, 15 to 30 percent slopes

The overall average relative cover of plants associated with willowy monardella clumps was 60 percent, and the average bare-ground relative cover was 26 percent. The relative cover of grasses and forbs was 22 percent and 9 percent, respectively; all grasses and nearly all forbs identified in the quadrats at the willowy monardella clumps were nonnative. The averages for tree and shrub cover were 5 percent and 24 percent, respectively.

Scatter plots of explanatory habitat variables using the paired function in R showed that bare ground was negatively correlated with plant cover. Similarly, willowy monardella elliptical area and volume were negatively correlated with bare ground and invasive grass cover but did not exhibit clear trends with other plant cover types. Univariate models of elliptical area and volume predicted by each habitat variable showed no significant effects (Tables 3-12 and 3-13). Since no relationships were identified at the univariate level, multiple regression was not necessary.

Table 3-12. Univariate Regression Results for Elliptical Area

Habitat Feature	Estimate	Mean Standard Error	Z Value	Probability (> Z)
Bare Ground	-0.01973	0.0197	-1.001	0.317
Nonnative Grasses	-0.02049	0.02129	-0.962	0.340
Native Herbs	0.08522	0.07603	1.121	0.262
Nonnative Herbs	0.08476	0.10083	0.841	0.401
Shrub Cover	-0.04136	0.0273	-1.515	0.130
Tree Cover	-0.008224	0.026231	-0.314	0.754
Bare Ground	-0.024	33.221	1.457	0.230
Total Cover	-0.01542	0.01445	-1.068	0.286
Total Herbaceous Cover	-0.01688	0.02077	-0.813	0.416
RDM – Dense Thatch	0.7499	1.0384	0.722	0.470
RDM – Minimal	1.3891	1.1242	1.236	0.217
RDM – None	0.1177	1.3929	0.084	0.933
Drainage Type – Primary	0.9225	0.6495	1.420	0.155
Drainage Type – Secondary	1.338	0.8227	1.626	0.104

RDM – residual dry matter

Table 3-13. Univariate Regression Results for Elliptical Volume

Habitat Feature	Estimate*	Mean Standard Error	Z Value	Probability (> Z)
Bare Ground	0.00	0.00	-0.99	0.320
Nonnative Grasses	0.00	0.00	-0.93	0.350
Native Herbs	0.00	0.00	0.98	0.330
Nonnative Herbs	0.00	0.00	0.45	0.650
Shrub Cover	0.00	0.00	-1.36	0.170
Tree Cover	0.00	0.00	-0.190	0.850
Bare Ground	0.00	0.00	-0.985	0.324
Total Cover	0.00	0.00	-1.136	0.256
Total Herbaceous Cover	0.00	0.00	-0.796	0.426
RDM – Dense Thatch	0.00	0.00	0.657	0.511
RDM – Minimal	0.00	0.00	1.214	0.225
RDM – None	0.00	0.00	0.123	0.902
Drainage Type – Primary	0.00	0.00	1.390	0.165
Drainage Type – Secondary	0.00	0.00	1.583	0.113

RDM – residual dry matter

* Note that estimates are not zero, but such small numbers that they are effectively zero in terms of the size of the effect.

These regression models calculate a Z-statistic that tests the significance of the relationship between the independent variables (habitat variables) and the dependent variable (elliptical area or elliptical volume). Larger Z-statistics are associated with a greater likelihood of a relationship, and P is equal to the probability that a given Z-statistic will be arrived at randomly (i.e., in the absence of a relationship). Significance was assessed at $p \leq 0.05$. If the Z value is negative, then the relationship is negative (e.g., more nonnative grasses is significantly related to a smaller elliptical area for clumps). If the Z value is positive, then the relationship between the elliptical area or elliptical volume of the habitat variable is positive.

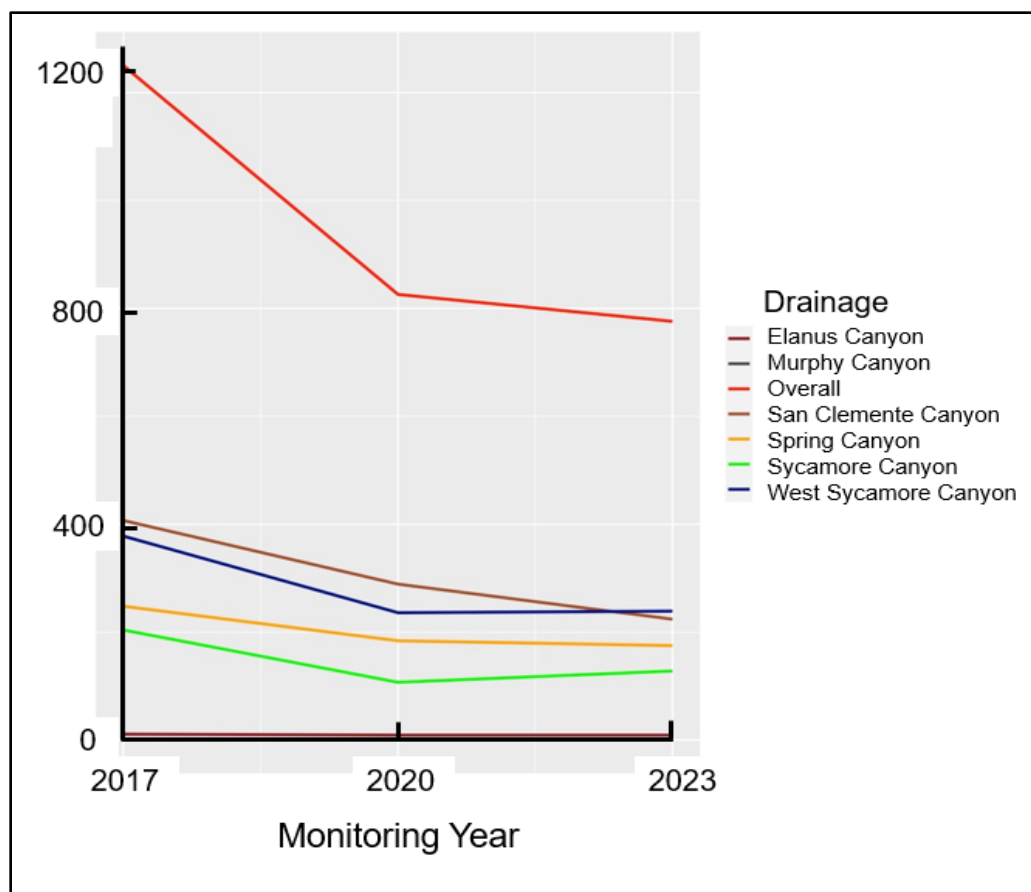
The data indicate that there may be relationships between elliptical area and some habitat variables, with smaller plants associated with higher levels of bare ground, invasive plants, and shrub cover. Larger plants are associated with higher levels of native herb cover, as well as with secondary drainages. However, high variability in plant size and a small sample size means that statistical significance is obscured.

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4.0 OBSERVED TEMPORAL TRENDS

4.1 Census Temporal Observations

The overall abundance of willowy monardella clumps at MCAS Miramar has declined every year since 2012 (Figure 4-1; 2012 data not shown). Willowy monardella declined within all drainages between 2012 and 2017, but between 2020 and 2023 overall declines were driven by mortality in San Clemente Canyon. Although mortality was also significant in West Sycamore Canyon, and occurred to a lesser extent in Spring and Sycamore canyons over this time period, the discovery of new monardella clumps in these canyons offset the overall change in abundance (Figure 4-1).



**Figure 4-1. Abundance of Willowy Monardella
in MCAS Miramar Canyons and Overall, 2017 – 2023**

Dense annual grasses and thatch were associated with the greatest number of dead willowy monardella clumps during 2023 (Table 4-1). Although flooding and erosion were noted as impacting many clumps of willowy monardella in 2023, there were relatively few flood-related mortality events. However, flooding and erosion were attributed to many deaths in 2017 and 2020 (Table 4-1). Herbivory, rodent activity, and heavy shrub cover were associated with some mortality in 2023 (Table 4-1).

Table 4-1. Willowy Monardella Life Stage and Disturbance by Year

Life Stage	Erosion/ Flooding	Disturbance					
		Grass/ Thatch	Herbivory	Other	None	Rodents	Shrub Cover
2023							
Adult	94	78	2	3	455	8	12
Dead	9	10	0	2	107	2	1
Juvenile	5	1	0	0	16	0	0
Mature	26	8	0	0	63	1	0
Seedling	1	0	0	0	0	0	0
2020							
Adult	7	0	3	3	753	7	8
Dead	19	6	0	2	407	1	1
Juvenile	0	0	0	0	3	0	0
Mature	0	0	0	0	45	0	0
Seedling	0	0	0	0	0	0	0
2017							
Adult	41	1	82	5	753	0	0
Dead	52	1	4	0	263	0	0
Juvenile	0	0	0	0	3	0	0
Mature	3	0	3	0	39	0	0
Seedling	0	0	0	0	0	0	0

The number of clumps in the adult life stage declined the most over the monitoring period, with the proportion of individuals in mature and juvenile life stages increasing between 2020 and 2023 (Figure 4-2). A change in the abundance of clumps in different life stages could result from regression of larger life stages to smaller life stages, mortality, and the addition of newly observed clumps: changes would likely be a combination of all of these. The 2023 census added 89 previously unmapped clumps to the total census, which included 1 seedling, 7 juveniles, and 24 mature clumps. This was the first time a seedling has been observed since 2017. All of these younger plants (juveniles and mature plants) likely represent relatively recent recruits, which may have been difficult to detect during 2020. At least three mature plants were planted by the California Native Plant Society.

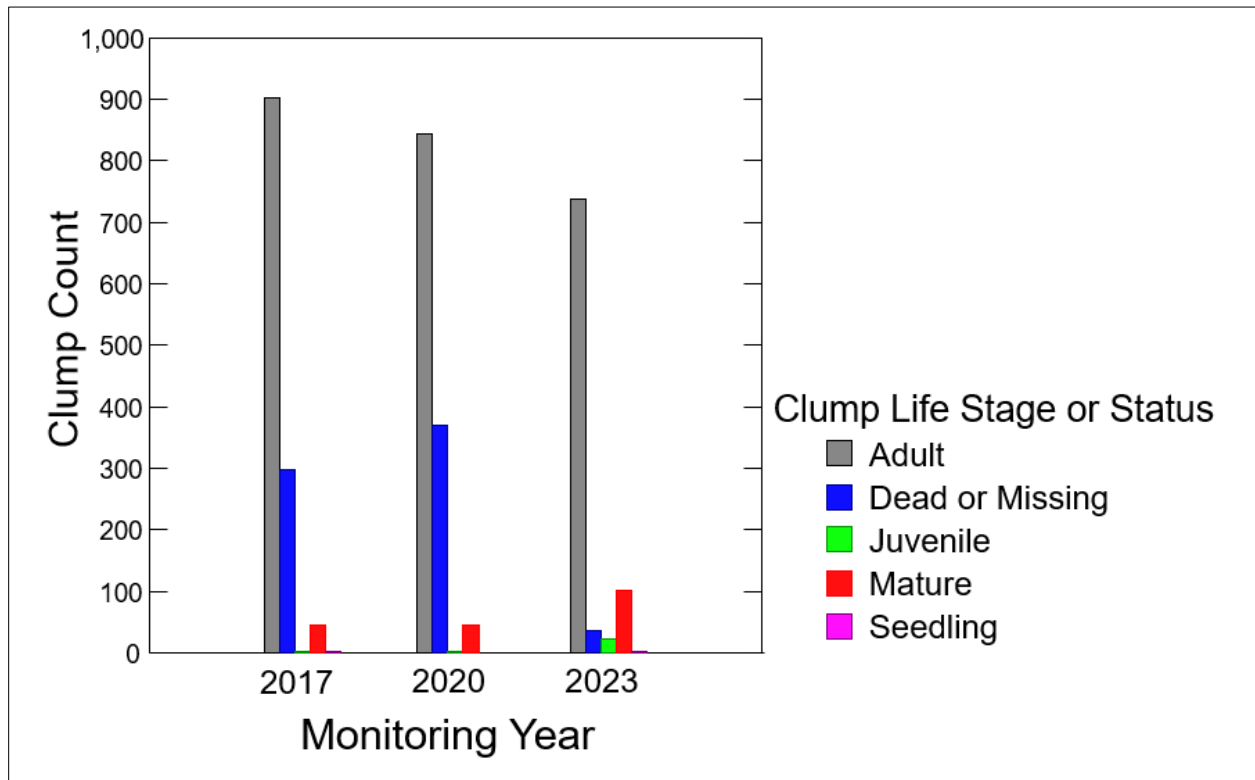


Figure 4-2. Abundance of Willowy Monardella by Life Stage at MCAS Miramar, 2017 - 2023

Population growth, based on a Stationwide census, has been negative for every monitoring interval. While the rate of decline has slowed with time, count-based population viability analysis projects a 100 percent probability of quasi-extinction of willowy monardella at MCAS Miramar within approximately 45 years if similar patterns continue (Figure 4-3).

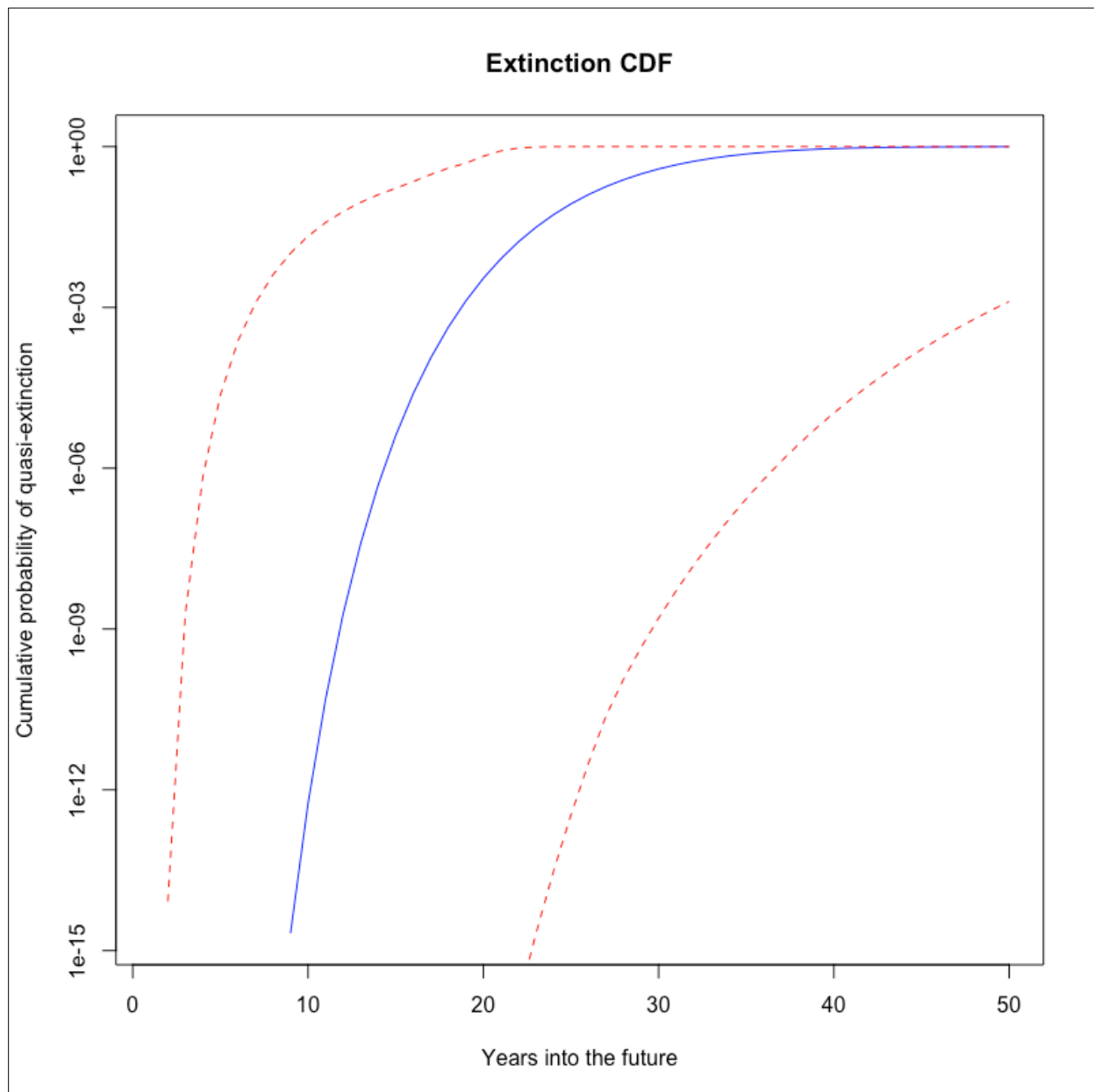


Figure 4-3. Probability of Willowy Monardella Quasi-Extinction (< 10 clumps) at MCAS Miramar within 50 years, with 95% Confidence Intervals

4.2 Monitoring Plot Temporal Observations

Abundance of willowy monardella has also declined in monitoring plots since 2017; abundance in most monitoring plots matches the census trends, with steeper declines observed between 2017 and 2020 than between 2020 and 2023 (Figure 4-4). Several monitoring plots showed no clump abundance decrease since 2020, and monitoring plots I and R appeared to increase in clump abundance since a drop during 2020 (Figure 4-4).

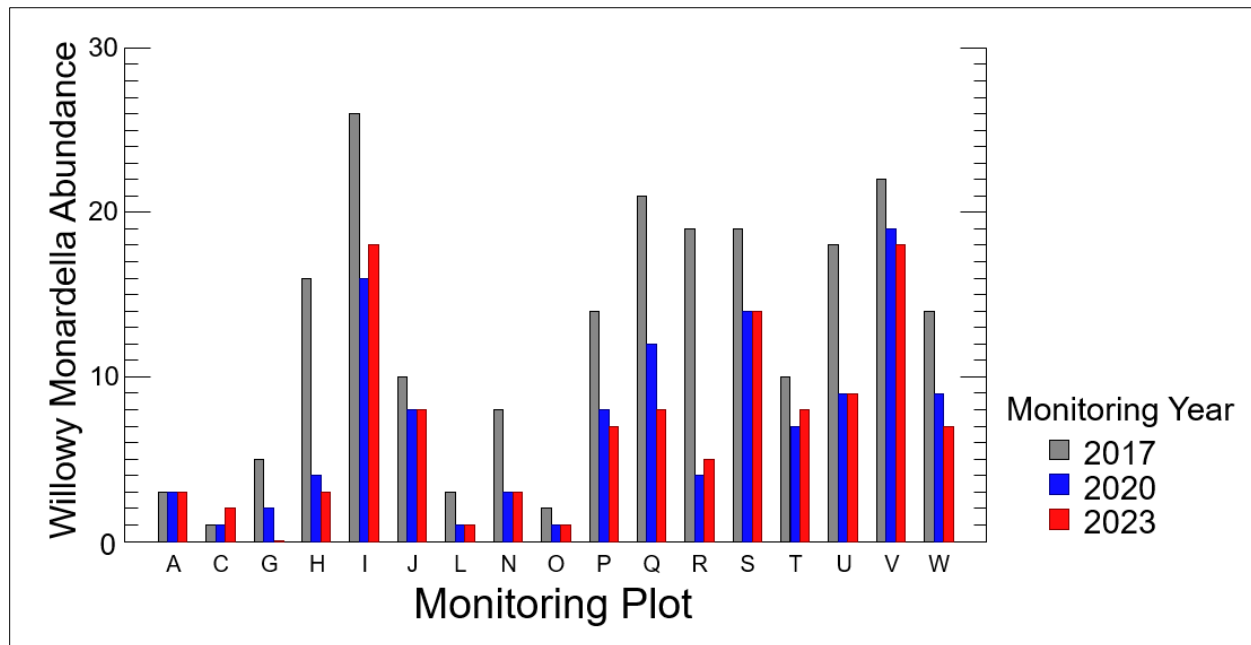


Figure 4-4. Abundance of Willowy Monardella in MCAS Miramar Monitoring Plots, 2017 – 2023

Average growth rates in terms of clump elliptical area and volume increased for most plots between 2017 and 2023. However, most clumps experienced negative growth between 2020 and 2023 (Table 4-2). Although Monitoring Plots P and Q had a mean positive clump growth rate, this was driven by large growth in one individual; with that outlier individual removed, average clump growth was negative. Only Monitoring Plot A had a truly positive clump growth rate (Table 4-2).

Table 4-2. Willowy Monardella Growth Rates 2012 – 2023

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
Monitoring Plot A						
461	-	-	-0.06	-0.01	0.32	0.45
870	-	-	1.22	1.84	0.17	-0.20
1607	-	-	0.11	0.29	-0.88	-0.89
1636	-	-	-0.23	-0.03	0.43	0.35
1656	-	-	7.52	7.52	0.21	0.46
Mean Plot A	-	-	1.71	1.92	0.05	0.034
Monitoring Plot C						
375	0.48	0.32	0.62	0.80	-0.88	-0.92

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
Monitoring Plot G						
373	-	-	-0.74	-0.84	-	-
1770	1.44	2.41	0.31	0.21	-	-
Mean Plot G	1.44	2.41	-0.22	-0.32	-	-
Monitoring Plot H						
1521	0.07	-0.12	-	-	-	-
1524	0.21	0.21	-0.35	-0.57	-0.52	-0.52
1530	-0.94	-0.97	-	-	-	-
1761	-0.86	-0.85	1.99	1.30	-	-
1772	-0.17	0.06	-	-	-	-
1774	1.50	1.04	-0.20	-0.33	-0.86	-0.87
1778	-0.68	-0.85	-	-	-	-
1780	-0.26	0.27	0.04	0.10	0.50	0.42
Mean Plot H	-0.14	-0.15	0.37	0.12	-0.29	-0.32
Monitoring Plot I						
390	-	-	1.14	1.29	-0.21	-0.30
398	-	-	2.95	4.99	0.47	0.14
946	-	-	35.63	85.45	0.13	-0.21
1230	0.63	2.21	1.71	1.39	-	-
1231	4.49	7.53	-	-	-	-
1232	-0.60	-0.69	13.45	18.82	-0.84	-0.83
1233	-0.20	-0.02	-	-	-	-
1236	-0.99	-1.00	-	-	-	-
1237	1.67	1.54	0.21	0.08	-0.49	-0.46
1244	-	-	1.53	0.41	-0.51	-0.46
1246	-0.22	0.34	-	-	-	-
1250	7.23	7.67	1.93	1.25	-0.18	-0.26
1252	1.10	1.27	1.37	2.01	-0.19	-0.30
1253	-0.58	-0.79	-0.95	-0.96	0.39	-0.07
1256	-0.33	-0.27	3.81	3.81	-0.67	-0.73
1257	0.65	0.71	1.32	1.09	-0.73	-0.73
1268	0.03	-0.36	0.46	0.39	-0.48	-0.46
1273	-0.05	-0.22	0.41	0.25	0.09	-0.03
1286	2.37	1.20	-	-	-	-

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
1293	1.07	0.93	1.70	1.37	-	-
1836	-	-	9.60	12.12	0.71	0.91
Mean Plot I	1.02	1.25	4.77	8.36	-0.21	-0.26
Monitoring Plot J						
516	-	-	1.90	2.42	-0.08	-0.30
1050	-	-	28.97	24.69	-0.78	-0.65
1173	-0.33	-0.44	1.73	1.61	-0.44	-0.50
1174	0.36	0.14	-0.14	-0.12	0.03	-0.01
1176	3.25	3.52	-	-	-	-
1179	1.61	3.21	0.72	0.56	-0.27	-0.32
1182	-0.12	-0.17	-	-	-	-
1187	-	-	0.35	0.67	-0.53	-0.69
1629	-	-	0.14	0.23	0.00	-0.23
1733	255.25	609.12			-	-
1837	-	-	-0.16	0.31	0.67	0.48
Mean Plot J	45.34	102.56	4.19	6.75	-0.18	-0.28
Monitoring Plot L						
495	-	-	6.95	8.65	-0.04	0.34
Monitoring Plot N						
51	-	-	-0.95	-0.99	-	-
693	-	-	0.33	0.43	0.62	0.49
1302	-	-	-0.46	-0.51	-0.75	-0.78
Mean Plot N	-	-	-0.36	-	-0.07	-0.15
Monitoring Plot O						
1522	-	-	-0.72	-0.70	-	-
Monitoring Plot P						
905	-0.26	-0.51	-0.98	-0.98	1.97	2.61
919	-0.62	-0.80	-	-	-	-
920	-0.67	-0.69	-	-	-	-
921	-0.56	-0.70	-0.51	-0.30	0.18	0.32
924	-0.27	-0.46	-	-	-	-
925	-0.55	-0.66	-0.63	-0.66	-0.47	-0.45
927	-0.87	-0.93	-	-	-	-
931	-0.31	-0.51	1.07	2.23	0.08	-0.02

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
932	-0.46	-0.65	-0.11	0.19	-0.07	-0.06
934	0.32	0.22	-0.11	-0.24	-0.22	0.43
935	-0.23	-0.40	0.04	0.20	-	-
Mean Plot P	-0.41	-0.55	-0.18	0.06	0.25	0.47
Monitoring Plot Q						
852	-0.90	-0.94	-	-	-	--
855	1.28	1.28	-0.60	-0.70	-	
856	-0.78	-0.81	2.03	3.08	-0.78	-0.84
857	-0.51	-0.67	-0.18	0.30	-0.33	-0.44
859	-0.05	-0.43	-0.59	-0.42	-	-
861	0.79	0.65	0.35	0.64	-0.73	-0.74
865	-0.37	-0.40	-0.81	-0.80	-0.32	-0.39
866	-0.74	-0.82	0.00	0.35	-	-
867	-0.24	-0.47	-0.47	-0.30	-	-
872	0.87	0.57	-	-	-	-
873	1.46	1.25	-	-	-	-
874	-0.93	-0.95	0.56	0.77	-0.79	-0.83
875	-	-	-1.00	-1.00	-	-
876 (151)	0.19	-0.09	0.36	0.81	-0.72	-0.72
879	-0.91	-0.95	0.87	1.62	-	-
Mean Plot Q	-0.06	0.60	0.04	0.36	-0.61	-0.66
Monitoring Plot R						
1388	-	-	0.59	0.57	-	-
1440	-	-	0.87	0.65	-	-
1584	-	-	0.58	1.14	-	-
1611	-	-	1.47	3.54	1.84	1.49
Mean Plot R	-	-	0.88	1.47	1.84	1.49
Monitoring Plot S						
206	-	-	1.02	2.74	5.87	8.25
211	-	-	0.68	2.51	0.64	0.13
237	-	-	5.19	8.12	-	-
238	-	-	2.14	3.66	0.83	0.43
239	-	-	1.07	2.27	1.52	1.66
241	-	-	1.11	3.21	-	-

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
243	-	-	0.56	0.78	0.13	0.08
244	-	-	0.43	0.60	-0.16	-0.32
249	-	-	0.00	0.20	-0.10	-0.12
317	-	-	0.64	2.22	-0.35	-0.40
356	-	-	3.48	17.73	-	-
1762	-	-	-0.16	0.97	-0.61	-0.65
Mean Plot S	-	-	1.35	3.75	0.86	1.01
Monitoring Plot T						
173	-	-	0.25	0.54	-0.12	-0.59
187	-	-	0.04	0.67	0.05	0.00
189	-	-	0.87	0.69	-0.95	-0.94
190	-	-	3.82	3.38	-0.21	-0.29
192	-	-	0.31	0.35	-	-
199	-	-	15.03	32.45	0.42	0.36
204	-	-	-0.06	0.37	0.21	-0.05
Mean Plot T	-	-	2.89	5.49	-0.10	-0.25
Monitoring Plot U						
319	-	-	0.01	0.27	-0.17	-0.28
326	-	-	0.56	1.84	-0.16	-0.16
331	-	-	0.24	1.03	0.46	0.16
335	-	-	0.19	0.81	-0.06	0.15
339	-	-	0.88	1.33	-0.44	-0.36
449	-	-	25.76	45.22	0.60	0.15
1461	-	-	-0.92	-0.89	-0.28	-0.67
1809	-	-	5.08	7.26	-0.36	-0.60
Mean Plot U	-	-	3.97	7.11	-0.05	-0.20
Monitoring Plot V						
48	-	-	0.15	0.06	-0.49	-0.57
52	-	-	-0.12	-0.17	-	-
59	-	-	-0.49	-0.42	-0.56	-0.62
63	-	-	-0.31	-0.35	-0.24	-0.36
68	-	-	-0.86	-0.91	-0.56	-0.49
70	-	-	-0.50	-0.52	-0.39	-0.33
71	-	-	0.44	0.21	-0.32	-0.42

Clump ID	2012–2017 Elliptical Area Growth Rate*	2012–2017 Elliptical Volume Growth Rate*	2017–2020 Elliptical Area Growth Rate*	2017–2020 Elliptical Volume Growth Rate*	2020–2023 Elliptical Area Growth Rate*	2020–2023 Elliptical Volume Growth Rate*
72	-	-	-0.06	-0.18	0.62	0.24
73	-	-	-0.20	-0.59	-	-
76	-	-	0.51	0.31	-0.30	-0.52
77	-	-	-0.26	-0.26	0.22	0.09
99	-	-	0.03	0.10	-0.69	-0.72
100	-	-	-0.13	-0.23	-0.43	-0.55
119	-	-	-0.73	-0.78	-	-
122	-	-	-0.09	-0.36	-	-
127	-	-	-0.42	-0.68	-	-
128	-	-	-0.51	-0.54	-0.81	-0.78
1500	-	-	0.38	0.52	-0.09	-0.44
Mean Plot V	-	-	-0.18	-0.27	-0.31	-0.42
Monitoring Plot W						
105	-	-	-0.64	-0.65	0.15	0.30
517	-	-	1.67	2.83	0.14	-0.10
565	-	-	5.27	9.66	-	-
979	-	-	6.39	12.44	-0.30	-0.54
1589	-	-	0.17	0.23	-0.47	-0.60
1614	-	-	-0.71	-0.70	-	-
1857	-	-	0.33	0.72	-0.35	-0.58
1901	-	-	0.21	0.25	-0.35	-0.58
1990	-	-	0.73	1.30	-	-
Mean Plot W	-	-	1.49	2.90	-0.27	-0.48

ID – identification number

* Growth rates for the elliptical area and elliptical volume generate a normalized relationship among clumps; however, these growth rates lack units (i.e., they are not converted to percentages of change). The growth rate formula used is provided in Section 2.3 of this report and follows the requirements provided in Section 4.2.2 of the Field Protocol Manual (MCAS Miramar 2013a).

Larger clumps of willowy monardella were more likely to survive within monitoring plots, with the best-fitting model of survival including year and elliptical area as fixed effects and monitoring plots as a random effect (Table 4-3).

**Table 4-3. Generalized Linear Model of Willowy Monardella
Survival Predicted by Clump Elliptical Area
and Monitoring Year, with Monitoring Plot as a Random Effect**

Predictor	Coefficient	SE	z	Pr(> z)
Intercept	413.1	221.4	1.866	0.063
Elliptical Area	0.0000415	0.0000195	2.122	0.0339
Year	-0.2	0.11	-1.855	0.0635

A component of the long-term monitoring of willowy monardella includes the collection of photographs at fixed locations at the monitoring plots (Appendix A). The most discernable pattern observed during the review of the photographs at the monitoring plots was the increase in nonnative grasses and other herbaceous (i.e., nonwoody) plants within the monitoring plots from 2012 to 2017 and to 2023. Data sheets from monitoring plot data collected in 2023 are provided in Appendix B.

4.3 Willowy Monardella Clump Persistence Since 2017

Figures 4-5 through 4-12 further the notion that willowy monardella clumps are in overall decline at MCAS Miramar since at least 2017.

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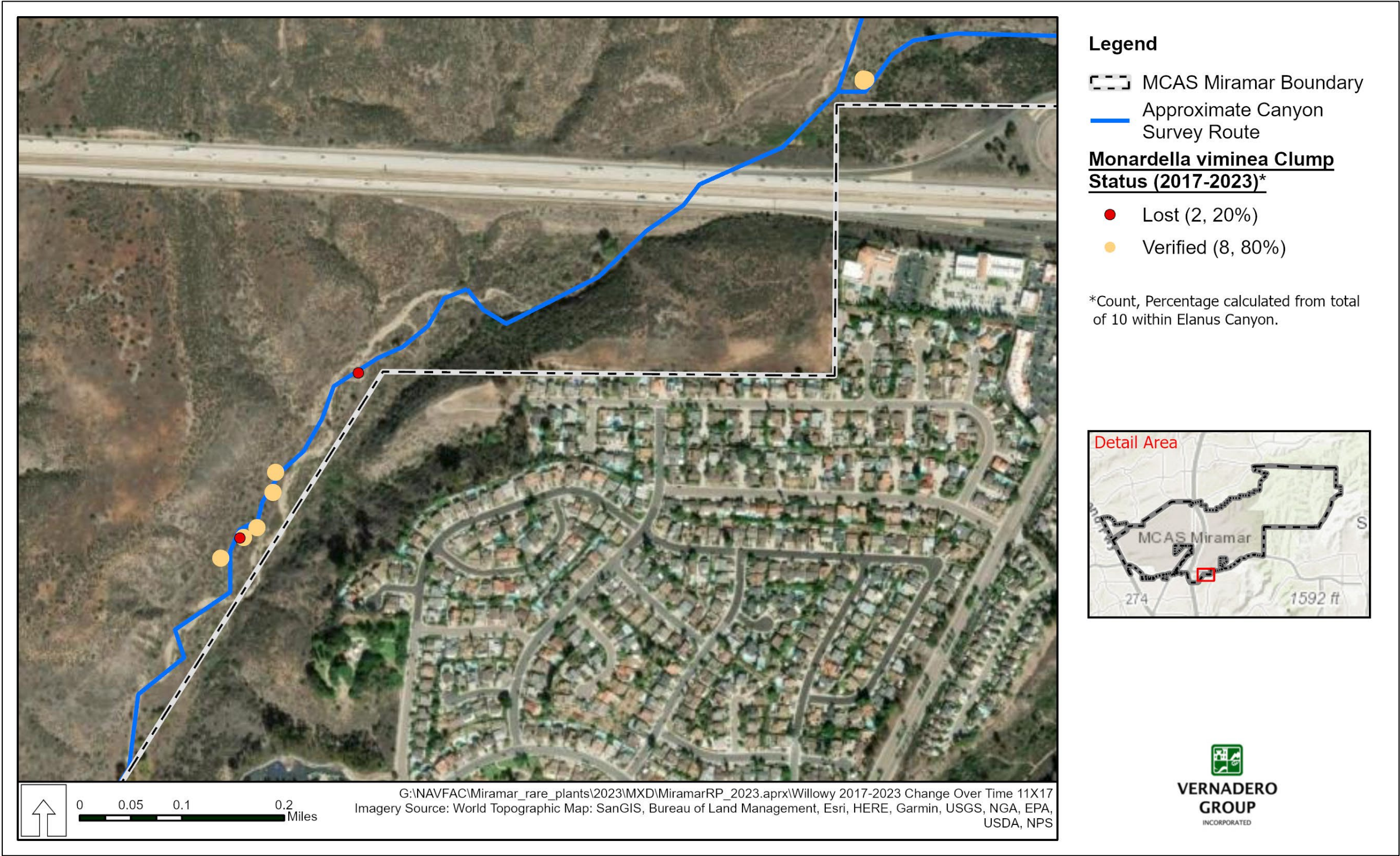


Figure 4-5. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Elanus Canyon

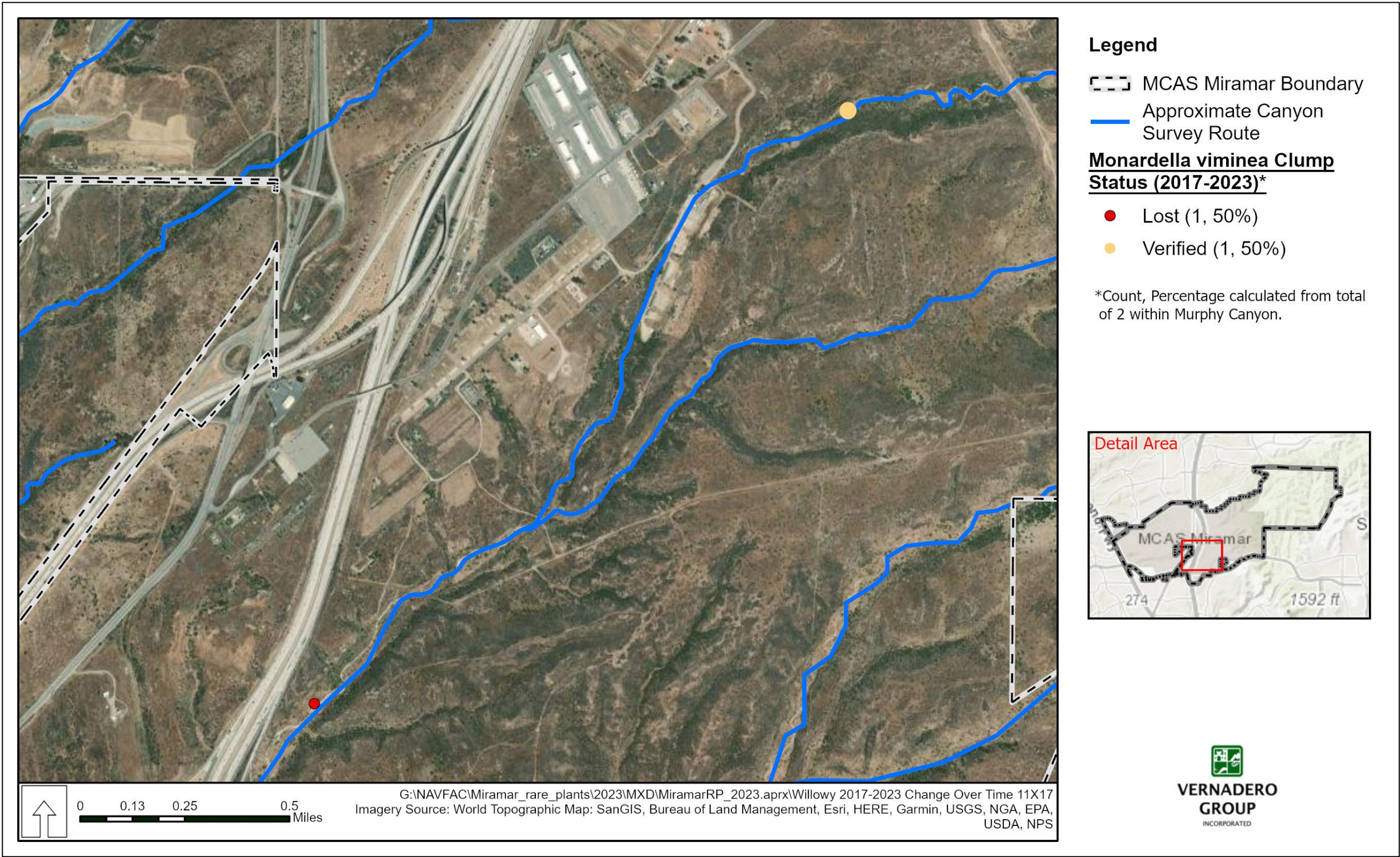


Figure 4-6. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Murphy Canyon

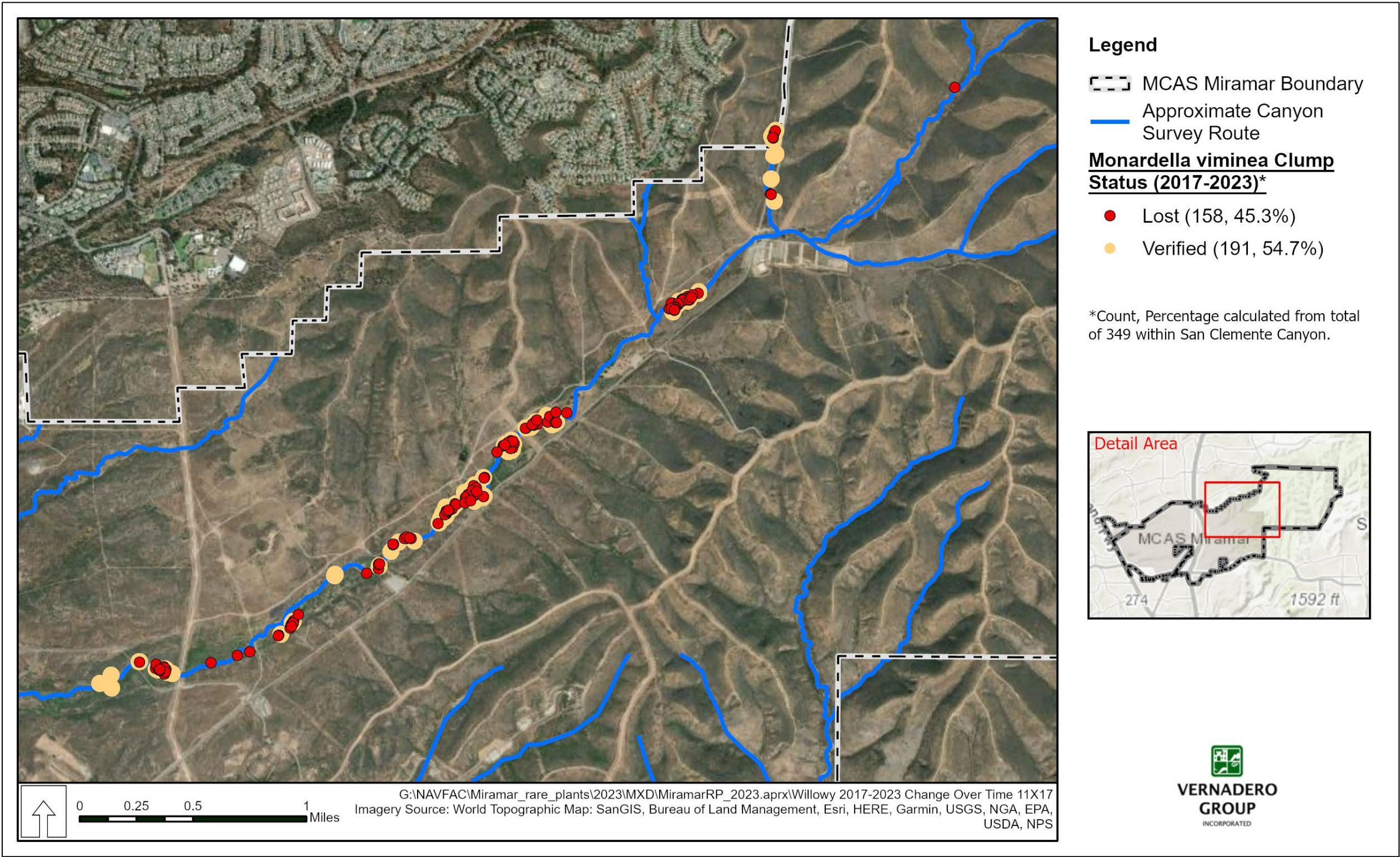


Figure 4-7. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Eastern Portion of San Clemente Canyon

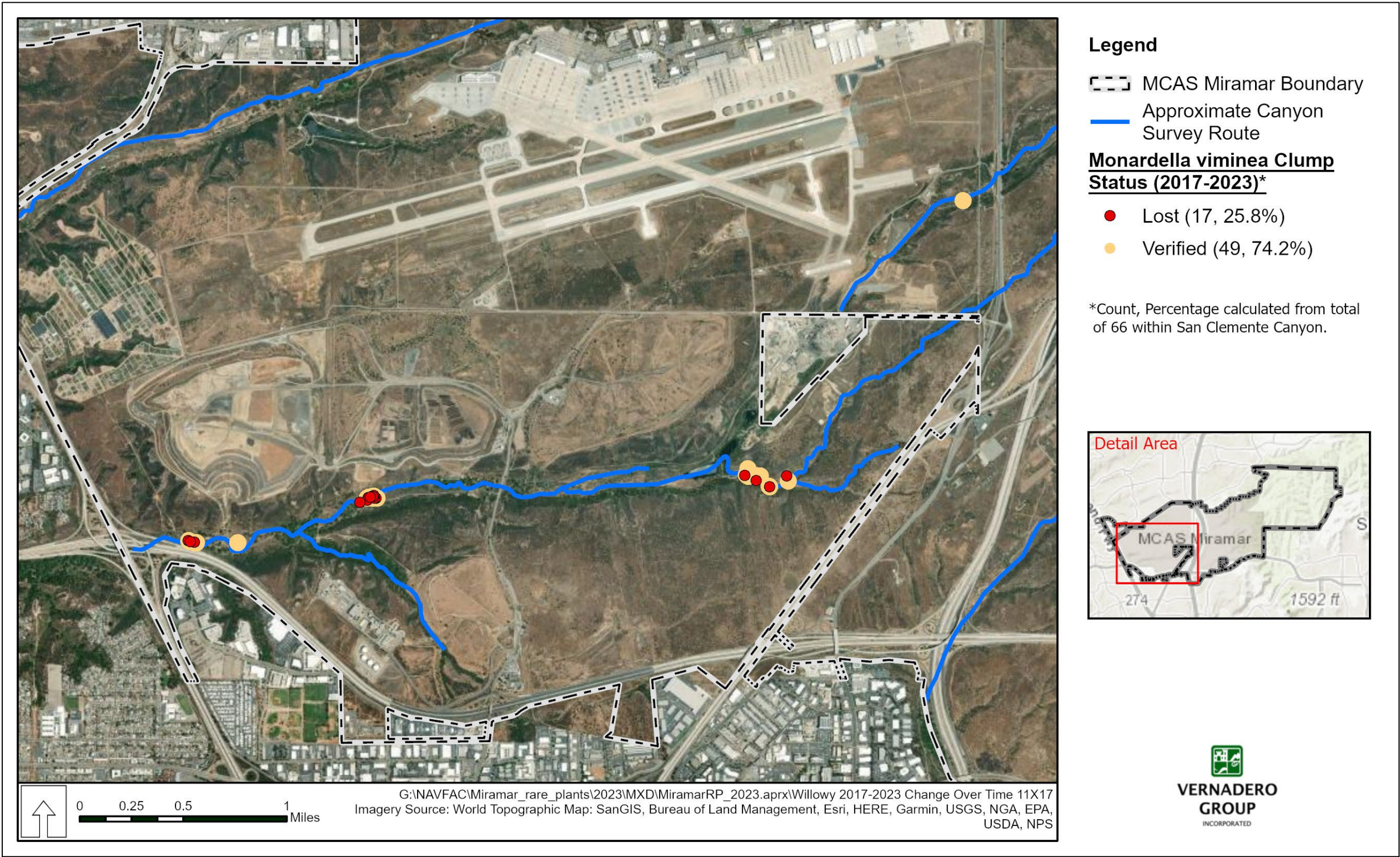


Figure 4-8. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Western Portion of San Clemente Canyon

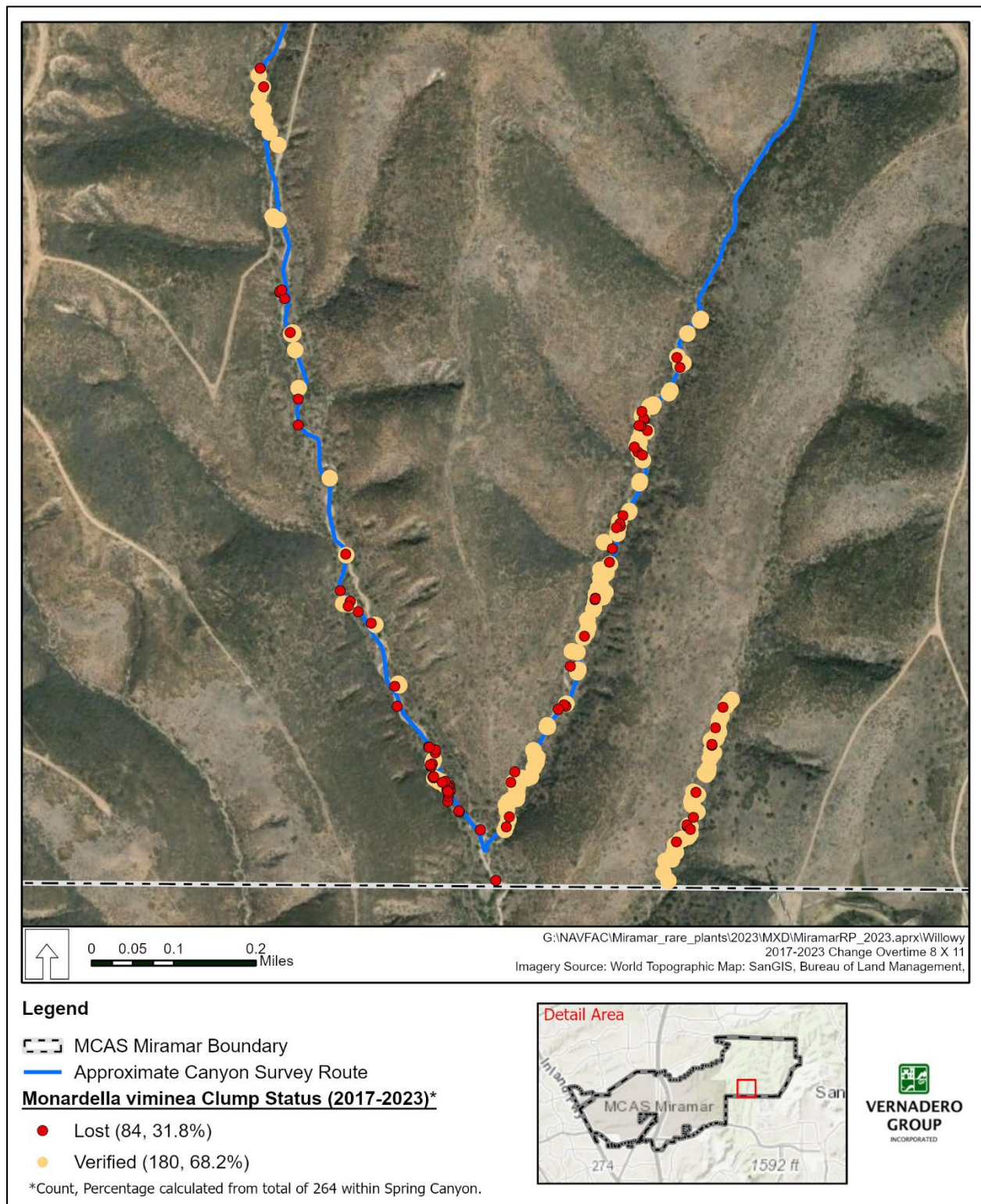


Figure 4-9. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Spring Canyon

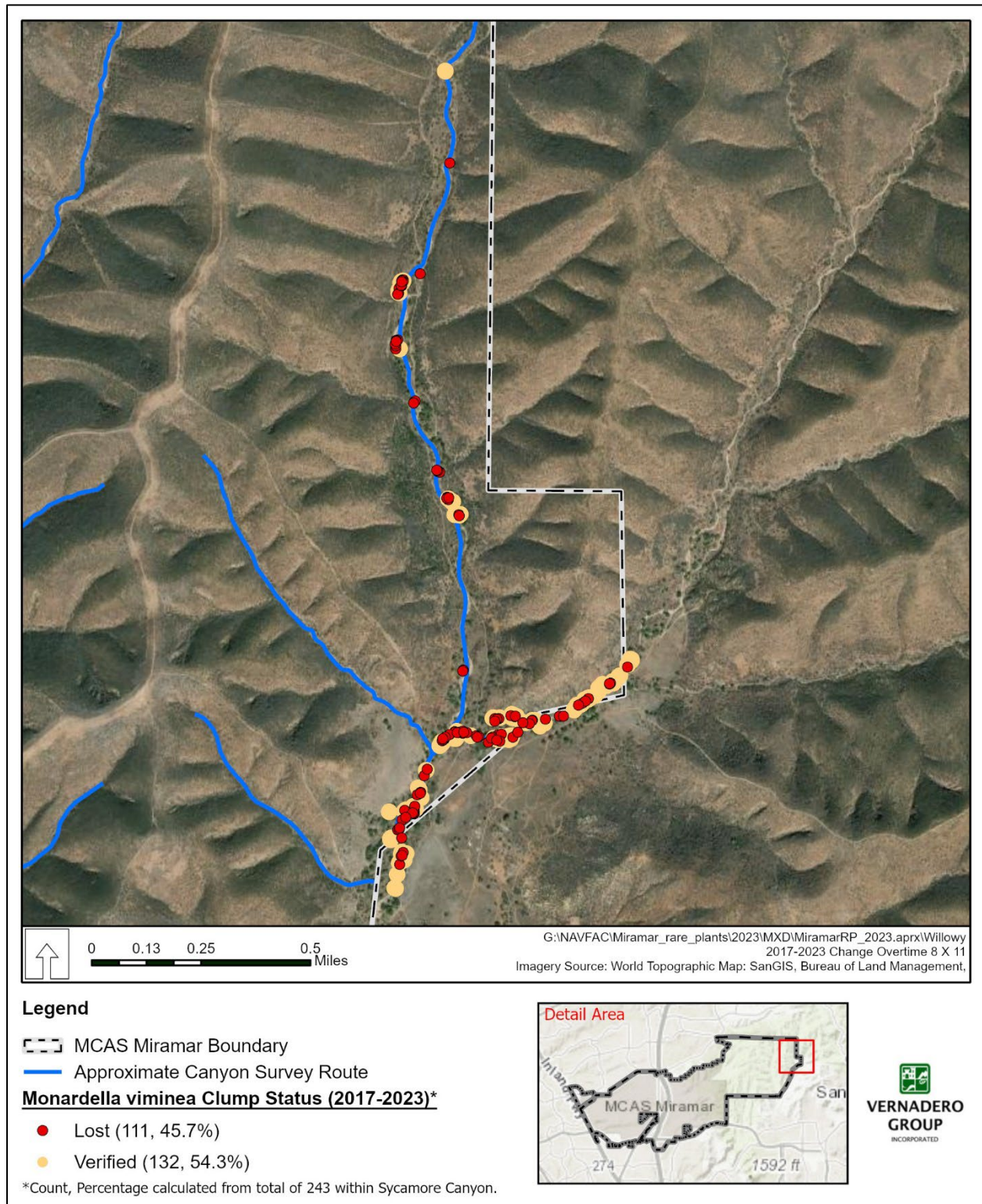


Figure 4-10. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in Sycamore Canyon

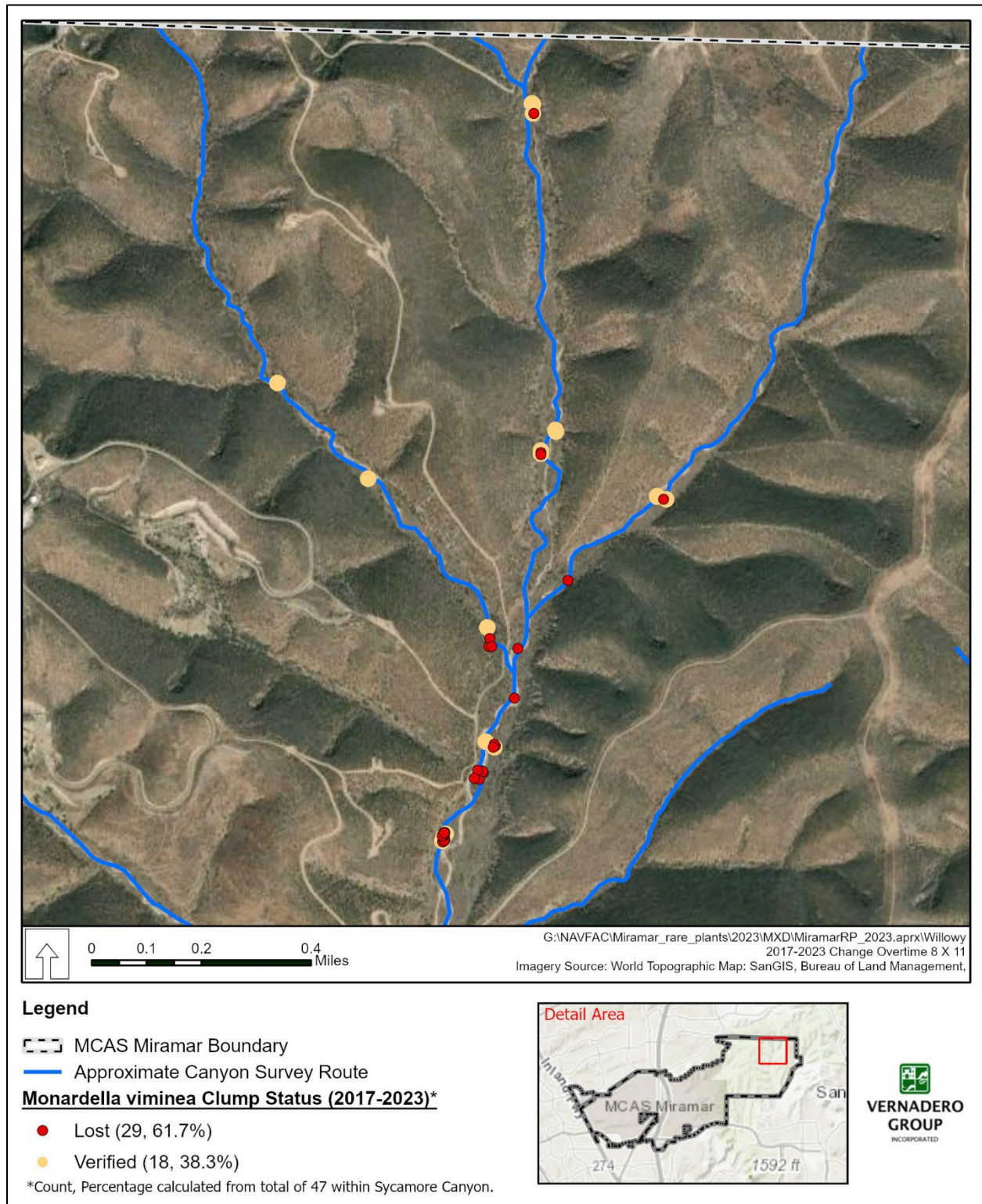


Figure 4-11. Comparison between 2017, 2020, and 2023 Surveys of Willow Monardella Clumps Observed in the Northern Portion of West Sycamore Canyon

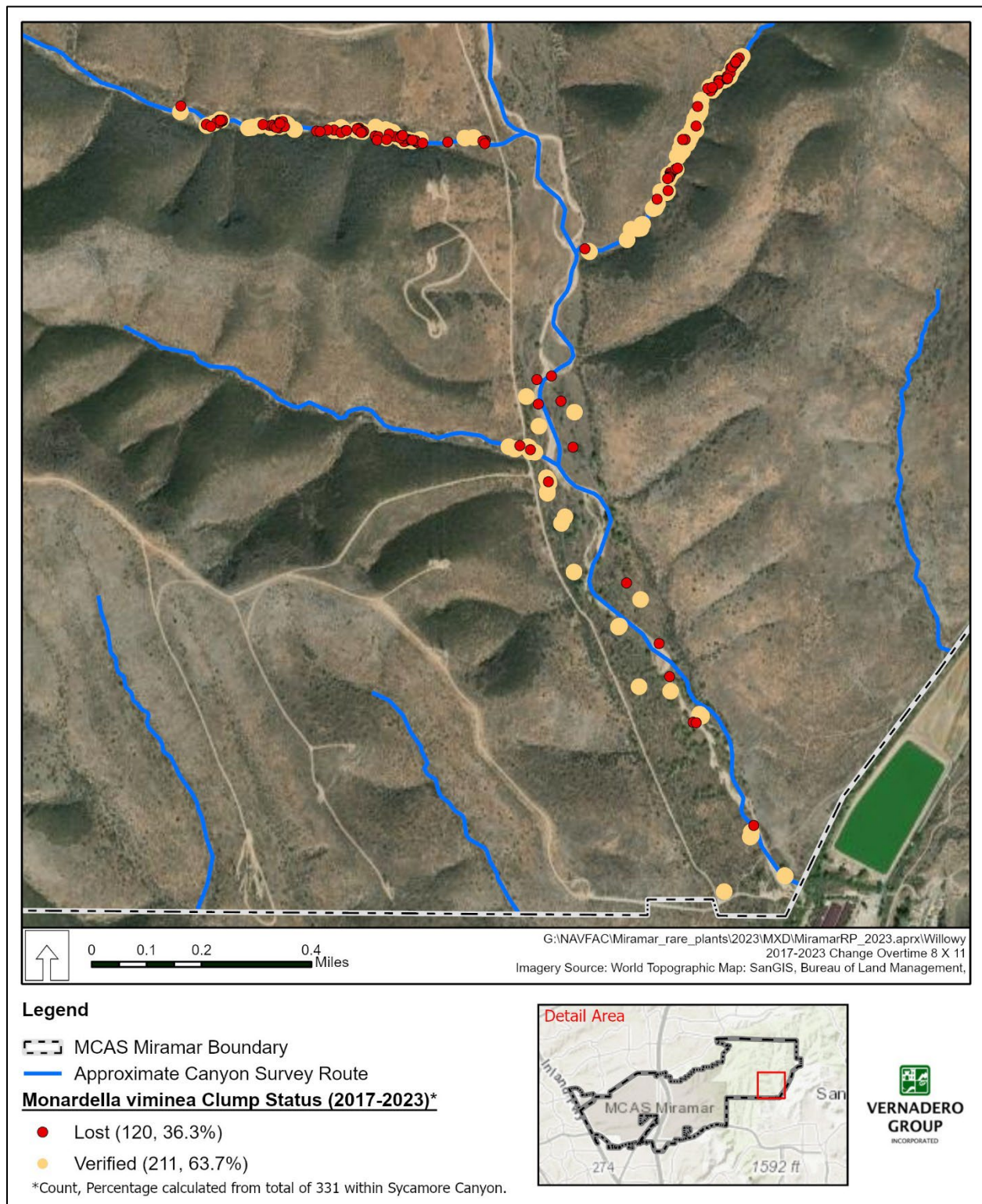


Figure 4-12. Comparison between 2017, 2020, and 2023 Surveys of Willowy Monardella Clumps Observed in the Southern Portion of West Sycamore Canyon

5.0 DISCUSSION

Willowy monardella declined at MCAS Miramar since 2002, with total abundance declining from 3,379 estimated clumps in 2002 to 773 clumps in 2023, a decline of more than 75 percent in 21 years. While rates of population loss slowed between 2020 and 2023, due to modest rates of apparent recruitment occurring in this time interval that offset mortality losses, the overall trends are alarming. A simple count-based population viability analysis (PVA) projected a 100 percent probability of quasi-extinction of the MCAS Miramar willowy monardella population within 45 years. However, inventories completed since 2012 were much more closely defined for inventories that occurred subsequent to 2012 (MCAS Miramar 2013a). We cannot state here that any absolute percentage decline in willowy monardella occurred since 2021, but there were large declines seen since more rigorous studies were implemented.

No willowy monardella clumps were observed in Oak, Quail, or Rose canyons from 2012 to 2023. Of these three canyons, Rose Canyon is the only canyon where willowy monardella has been observed previously, with two clumps found during the 2002 surveys (MCAS Miramar 2013b). The 86 new clumps found in 2023 were distributed among the four canyons where abundance is high (San Clemente, Sycamore, Spring, and West Sycamore), indicating that natural establishment of willowy monardella in suitable habitat where the species is currently not found, or where abundance is low, is unlikely.

The decline of willowy monardella at MCAS Miramar is occurring due to a combination of widespread mortality of established plants and recruitment limitation. Mortality has likely been driven by sustained periods of severe drought, with associated stabilization of the dynamic habitat that willowy monardella is adapted to with encroachment by invasive grasses, native shrubs, as well as severe flooding and erosion events potentially fed by increased runoff from upstream development. Fire directly impacted a portion of habitat in West Sycamore Canyon and San Clemente Canyon before the 2020 monitoring event, temporarily removing invasive plants from monitoring plots, but monitoring data do not show any changes in willowy monardella survival or growth due to the fire. Flooding and erosion have been the largest overt identifiable driver of willowy monardella mortality, implicated in between 4 percent and 16 percent of clump losses from 2017 through 2023. Dense invasive grasses and thatch are associated with 0.5 percent to 8 percent of mortality, with the number of impacted plants increasing over the monitoring period. Herbivory, rodent soil disturbance, high shrub cover, treefall, and vehicle activity may have caused some mortality, with herbivory impacts noted frequently in 2017, but only rarely in 2020 and 2023.

The majority of willowy monardella deaths in any monitoring year are not associated with an observer-recorded detection and are likely due to drought. A series of extreme droughts have been impacting southern California ecosystems over the last several decades (Jacobsen and Pratt 2018; Aguirre et al. 2023), with MCAS Miramar experiencing severe multiyear drought between 2012 and 2016, with 2018, 2021 and 2022 also being drought years. Drought-induced mortality of both common and rare species has been widespread in the southwestern United States (e.g., McAuliffe and Hamerlynck 2010; Paddock III et al. 2013; Jacobsen and Pratt 2018; Miller 2021b; Aguirre et al. 2023). Smaller clumps of willowy monardella were more likely to die

over the monitoring period, likely because they are not deep-rooted enough to access moisture during drought; a similar pattern has been observed with the rare *Penstemon albomarginatus* over the past several decades (Moore and Pavlik 2014; Miller 2021b).

Invasive annual grasses dominate most of the willowy monardella monitoring plots and potential habitat at MCAS Miramar, and they have been implicated as a cause of decline in this species (USFWS 2008; MCAS Miramar 2011, 2013b). Hanson (2012) found that invasive grasses inhibited reproductive output of the rare *Monardella venosa*. Increasing invasive grass and thatch cover between 2020 and 2023 may have been responsible for the reduced growth rates in willowy monardella observed over that time period.

Herbivory has been noted as a possible cause of the decline of the willowy monardella population (USFWS 2008). However, very little herbivory was noted during the 2020 and 2023 censuses and monitoring surveys. Most herbivory occurred on a portion of the plant's stems, but some herbivory caused damage or removal of flower heads. Beetles were noted feeding on willowy monardella flowers at several separate clumps. Browsing by rabbits may have also occurred, as rabbit scat was noted near some plants with recent herbivore damage. In the 2012 census, it was noted that 181 clumps had signs of herbivory: the clumps were usually top foraged with visible vegetative growth and foraged clumps did not show any signs of reproduction (MCAS Miramar 2013b). Alternatively, MCAS Miramar (2011) noted that very little herbivory occurred early in the year, and most herbivory occurred in mid- to late summer rather than in the spring. Further, it was noted that many plants likely recovered from this intense late-season herbivory. The 2017 census found damage to flower heads, with numerous stems and leaves browsed and flower heads left on the ground beneath clumps. But in 2020 and 2023, besides noting beetles feeding on flowers at several willowy monardella clumps, very little herbivory was noted overall. Although herbivory that damages flower heads has the ability to reduce seed production and consequently lead to a decline in plant recruitment, very little flower head herbivory has been noted overall in past surveys. Herbivory intensity frequently increases under drought, switching from a neutral effect in periods of adequate moisture availability to a negative effect during periods of low moisture availability (Tylianakis et al. 2008; McCluney and Sabo 2009; McCluney et al. 2012). If drought occurs after periods of high moisture availability, during which herbivore numbers may increase due to high availability of resources, the effects of herbivory may be particularly severe (McCluney et al. 2012). Herbivory may impact willowy monardella under some conditions, but it has not been a major driver of decline in recent years at MCAS Miramar.

While high mortality rates are driving much of the negative population growth of willowy monardella at MCAS Miramar, poor recruitment is also a significant factor. The adult life stage has strongly dominated the MCAS Miramar population of willowy monardella throughout the monitoring period, with smaller life stages (mature, juvenile, and seedling) comprising a very small proportion of the population. It is likely that some seedlings are not detected during monitoring events since the survey does not happen on a yearly basis, and smaller plants are more difficult to detect, especially if they occur in dense vegetation as is characteristic of much of the current habitat. Smaller plants may exhibit faster growth rates, so the smaller life stages

may be more ephemeral. Nevertheless, the very low proportion of life stages of small plants and near absence of seedlings in every monitoring year may indicate strong recruitment limitation.

Drought-induced inhibition of seed germination and/or seedling mortality after germination, coupled with competition with dense invasive grasses and thatch, may partially explain poor recruitment. Dense exotic grasses and thatch can limit the availability of bare mineral soil, which may be favored for monardella establishment, and compete with monardella for light, nutrients, and moisture in seedlings that do germinate (e.g., Thompson 2005; Jones et al. 2021). Recruitment between 2020 and 2023 was noted in areas that had been recently scoured by flooding, presumably because flooding and erosion remove established vegetation and expose bare mineral soils. This may help enhance recruitment opportunities if sufficient seed is available, and if moisture is available for seedling establishment. Smaller plants are associated with higher bare-soil cover in monitoring plots, possibly because they are newer recruits that have established in more recently disturbed soils. Some scouring and erosion are likely beneficial in maintaining suitable open habitat for willowy monardella; conversely, too much scouring and erosion in stream channels may cause severe damage and mortality to willowy monardella clumps (USFWS 2008; MCAS Miramar 2011).

A declining population abundance exacerbates recruitment limitation, as lower seed production within a smaller population makes it less likely that a seed will land in a safe site for recruitment. While abundance and density of willowy monardella is still relatively high in parts of MCAS Miramar, in areas where few plants remain recruitment limitation is likely to become worse.

The vast majority of willowy monardella have been flowering in all observation years, with potential pollinators frequently observed visiting plants. Flowering limitation is clearly not a limiting factor in recruitment, but it is unknown whether most plants are being effectively pollinated and setting viable seed, and whether this varies across the population. Monardella tends to be outcrossing and visited by a wide range of insect pollinators (Hanson 2012; Akiba et al. 2018). Potential specialist bee pollinators (subspecies of *Calliopsis zonalis*) were observed on two California Coast Range *Monardella* species (Rozen 1958); however, little published literature is available on the pollination ecology of *Monardella* species, with none available for willowy monardella. The rare *Monardella venosa* was found to be capable of self-pollination, but it had a higher seed set with outcrossing, and have highly variable rates of reproductive output in different site (Hanson 2012), a phenomenon also observed in several rare *Penstemon* species in the western United States (e.g., Lewinsohn and Tepedino 2007).

Effective pollination rates may decrease as plant abundance and density decline (e.g., Oostermeijer et al. 2000; Wilcock and Neiland 2002; Wall et al. 2003; González-Varo et al. 2013), restricting gene flow and leading to inbreeding depression and decreased fitness over time (e.g., Akiba et al. 2018). Understanding the reproductive ecology of rare species is important for their conservation management. Although no studies on the seed production relative to precipitation rates have been done on willowy monardella, in many plants drought stress can lead to the production of fewer seeds as well as smaller, less viable seeds (Yaklich 1984; Fougereaux et al. 1997; Kosinski 2007).

MCAS Miramar recommends maintaining a small willowy monardella seed collection to protect against stochastic events such as those that occurred from 2011 through 2017. Given the extent of the decline of willowy monardella on MCAS Miramar, seed collection and reintroduction with habitat enhancement are recommended to protect the population from devastation due to drought, flood, fire, or their combination.

6.0 MANAGEMENT IMPLICATIONS

In the 2017 through 2023 surveys, Vernadero collected the length, width, and height for all willowy monardella clumps, not just those that occurred in monitoring plots as required by the Field Monitoring Protocol (MCAS Miramar 2013a). Vernadero recommend that these data continue to be collected for all clumps in the future to better track the growth patterns of the remaining willowy monardella, especially because low numbers in many of the monitoring plots means that sample sizes are not large enough to detect trends. The level of effort to collect these data is not great, but the collection of these data would be highly valuable in the long term, allowing the health of all clumps that can be relocated in future surveys to be tracked through their growth rates. We recommend that categories of disturbances impacting each individual (using the categories presented in Table 4-1) are incorporated into the protocol and collected systematically for every individual. It would be helpful to record the percentage of dieback and percentage of herbivory impacting each plant according to categorical scales (e.g., 0%, 1-10%, 11-25%, 26-50%, 51-75%, 76-100%) to better quantitatively include these in statistical models and to follow the impacts of herbivory and dieback on recruitment, growth, and survival. Herbivory observations should include whether the herbivory is mammalian or insectile, and which part of the plant is being impacted. Data on reproductive output per plant and seed viability would greatly enhance understanding of population dynamics. These data could be collected as part of a demographic PVA, which is described in Section 7.1, then vital rates extrapolated to the census data (included past data) to better project future outcomes of willowy monardella across MCAS Miramar.

6.1 Scour and Bank Erosion

Because scour and bank erosion during high stream-flow events following large storms are burying or displacing willowy monardella clumps and seeds, management of stream-channel hydrology could protect existing willowy monardella clumps and suitable habitat needed for seedling recruitment. The results from the 2017 and 2023 census and monitoring noted substantial channel erosion and loss of willowy monardella clumps, which supports the Station's recommendation. However, the 2023 results show scour and erosion impacting plants, but with little related mortality and potential increased recruitment in scoured areas. One concern is that a dynamic hydrological environment is part of the natural ecology of willowy monardella (USFWS 2008), and too much stabilization, which promotes increases in competing vegetation, is likely detrimental. The largest clump losses, however, appear to be among the larger canyons, and that may indicate that offbase development could be affecting populations through increased stream velocities that outstrip historic norms.

6.2 Herbivory

Building and installing herbivory exclusion devices around seedlings to prevent browsing was recommended by MCAS Miramar (2011). The 2020 and 2023 survey and monitoring recorded only low levels of herbivory, although whether herbivory is impacting new recruits before they are detected is unknown. An adaptive management approach would be informative to measure whether natural recruitment increases. Plant fitness and recruitment with protection from

herbivory compared to controls with no protection, using large exclosures that exclude deer and rabbits and are large enough to capture new recruitment. Seeding trials would also be informative to increase the likelihood of detecting results; natural seeding and experimental seeding would need to be conducted separately.

Other work excluding herbivores for sensitive perennial plants in California has proven useful. Caging individuals and seedlings of *Penstemon albomarginatus* increased average plant size, survival of all age classes, improved reproductive output, and provided safe areas for recruitment (Moore and Pavlik 2014; Miller 2021a). Herbivore exclusion could be trialed as part of the demographic PVA approach described in Section 7.2. MCAS Miramar should consider opportunities to reduce herbivory of willowy monardella clumps.

Incorporating a consistent, quantified method regarding how herbivory is monitored will improve understanding of herbivory impacts on population trends. Invertebrate herbivory may be as impactful as vertebrate herbivory; for example, leafcutter ants completely decimated the threatened *Penstemon albomarginatus* populations in Arizona, eliminating any successful reproduction of this species in 2021 (Miller 2021b); beetle herbivory of willowy monardella flower heads was observed at MCAS Miramar in 2017, but impacts on reproductive output are unclear. While insect herbivory is likely part of the natural ecology of willowy monardella, imbalances due to extreme drought and precipitation cycles could have had strong effects in some years; consistent, individual-based monitoring will enable these effects to be detected.

6.3 Pollination Ecology

An understanding of the pollination ecology of rare plants is essential for conservation management, especially if reproductive fitness declines without effective outcrossing from pollinators. Lower pollinator abundance during drought years could limit seed set and declines in population density and abundance can lead to declines in pollinator visitation. Climate-change-induced impacts on plant-pollinator relationships such as large-scale pollinator declines, phenology mismatches, and interactions with invasive species have been observed in other studies and are predicted to increase (e.g., Wall et al. 2003; Gonzalez-Varo et al. 2013). Research focused on pollination ecology of willowy monardella, including field observations of pollinator identities, visitation behavior, and timing that collectively examine a range of population densities, as well as field and/or greenhouse experiments that examine how outcrossing affects reproductive fitness could greatly help with overall conservation management. The use of video recording systems to document pollinator visitation is increasingly being used as an ecological tool (e.g., Barlow and O'Neill 2020; Barlow and Pavlik 2020; Pegoraro et al. 2020), and the nearby California Botanic Garden could conduct pollination experiments.

6.4 Nonnative Grasses

While regression models did not identify a statistically significant effect of grass cover on willowy monardella size, the data do show a trend for smaller plants to be associated with higher cover of nonnative grasses. Observations of high grass cover impacting willowy monardella clumps

increased from 2020 to 2023, and monitoring plot photographs show increasing nonnative grass and herb cover (Appendix A), coinciding with generally negative growth rates in willowy monardella over that time frame despite higher precipitation availability. High grass and thatch cover are very likely limiting reproductive output and recruitment. Weed management for all willowy monardella clumps at MCAS Miramar would likely be beneficial. The effects of weed management on population dynamics could be trialed using the demographic PVA approach described in Section 7.1. Indeed, the pairing of secondary canyons with willowy monardella is perfect for controlling for herbicide trials with and without herbicide in adjacent canyons. This is also a very inexpensive method of finding a valuable tool for boosting willowy monardella recruitment if found effective.

6.5 Habitat and Growth

The 2017 and 2023 monitoring data indicated that smaller clumps of willowy monardella are associated with higher levels of bare ground. This could be a correlative relationship, reflecting the fact that plants are more likely to recruit in bare soils, and plants on more bare soils are younger and smaller, or could be causative, reflecting harsher growing conditions in these exposed habitats. The 2023 data suggest a positive relationship between willowy monardella clump size and herbaceous (both native and nonnative) plant cover. Sites with herbaceous cover may represent a successional stage where larger willowy monardella clumps are found, or herbs could help ameliorate environmental stress without suppressing plant vigor. Analysis that examines the effects of habitat characteristics on plant growth rather than on static plant size may be more informative in terms of causal relationships; however, the monitoring plot sample size is too small to reliably detect trends. Since all plants are being tracked with the census anyway, collecting plot data throughout all willowy monardella populations, or for a random subset of plants throughout its distribution at MCASM would be more informative in detecting meaningful relationships than restricting these samples to only study plots.

Optimum habitat for willowy monardella could be refined using a multivariate approach (e.g., ordination or principal components analysis) to analyze existing monitoring plot data to look for relationships between willowy monardella abundance and biotic (dominant species covers) and abiotic (channel depth, soils, location in drainage, drainage type, distance from creek bed) variables. Or new plots could be established in stratified randomly selected locations that capture the range of variability in willowy monardella abundance across MCAS Miramar, with plot-level data including the biotic community (e.g., covers of all species present) and abiotic variables (variables above, ground cover composition), and analyzed with a multivariate approach. These plots could be used for the PVA described in Section 7.2.

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7.0 MONITORING RECOMMENDATIONS

7.1 Population Viability Analysis

Simple count-based PVA predicts that willowy monardella will effectively become extinct at MCAS Miramar within 45 years if the patterns in mortality and recruitment observed over the past 21 years continue. However, simple count-based analysis cannot provide information on life stages that are most important for population growth, and a census conducted every three to five years will miss critical events that are impacting the population, obscuring correlations between factors that are causing declines. A demographic PVA provides vital rate information for each critical stage of the life cycle with sensitivity and elasticity analysis showing how these contribute to overall population growth rates and extinction probabilities (e.g., Caswell 2000; Morris and Doak 2003).

Given the extent of the decline in willowy monardella, with both mortality and lack of recruitment contributing to negative population growth, establishing an annual demographic monitoring of willowy monardella to fill in gaps in knowledge about reproduction and recruitment, and pinpoint the drivers of the ongoing population decline. The PVA could be combined with an adaptive management approach examining the effects of invasive plant control and herbivore exclusion on population dynamics, to allow for informed and effective management of this species.

Demographic population viability analysis involves collecting individually tracked data on vital rates, i.e., birth, growth, fecundity and survival rates, for all relevant life stages of the organism in question (Caswell 2000; Morris and Doak 2003). These data are used to construct projection matrices for each pair of observation years, which integrate the proportion of individuals in each life stage and the stage-specific vital rates to determine population growth and viability (Morris and Doak 2003). Each projection matrix can be used to generate deterministic growth rates that are based on the actual values measured, with a set of matrices used to model stochastic growth rates, that reflect the inherent variation present in ecological systems (Morris and Doak 2003). Probabilities of extinction are modelled using stochastic growth rates.

The first step in performing a demographic PVA for willowy monardella would be to collect demographic monitoring data on marked individuals across a representative range of environmental and population variation in annual (or regular) census intervals. The population vital rate estimates used to build matrix projection models must be representative of the range of variation found across the population, with sampling locations unbiased, and sample sizes large enough to account for the range of variation found within population parameters. Ideally, the sample is large enough to capture sufficient individuals in each size class that will be used to construct projection models (Caswell 2000; Morris and Doak 2003); however, given natural variability and population responses to climatic conditions, in some years certain stage classes, such as seedlings, may not be present. A stratified random approach could be used to select sampling locations across the geographic range of willowy monardella that captures both habitat variation and variation in population densities to understand if and how population vital rates vary. Populations below a threshold size (e.g., 100 individuals) could be fully enumerated, while for larger populations a clustered sampling approach, such as plots or transects, could be used

to select individuals for monitoring. Simulations of population growth rates using a range of sample sizes for a long-lived understory herb *Heliconia acuminata* (Heliconiaceae) showed that a sample size of 50 plants per population was sufficient for unbiased estimates, and that improvements with larger sample sizes were small (Fiske et al. 2008). Similarly, simulations with an annual plant with high variation in transition rates (*Collinsia verna*), showed that a 50-plant sample size was sufficient for accurate results (Doak et al. 2005).

Demographic monitoring should follow the data collection protocols on plant size already employed by past monitoring, but should identify plants as individuals, so that identification of new recruits, and the fate of each individual (which is key for demographic PVA) can be followed. Data on per-plant reproductive output, for example, total number of inflorescences, number of buds, flowers, and fruits on a sample of randomly chosen inflorescences, and a later season assessment of the number of seeds produced per inflorescence would be necessary. Since herbivory may impact willow monardella, the percent of the plant impacted by herbivory (0%, 1-25%, 26-50%, 51-75%, 76-100%) should be recorded. The percent of the plant impacted by dieback (0%, 1-25%, 26-50%, 51-75%, 76-100%) should be recorded as a measure of drought stress, and cover of habitat variables following MCAS Miramar (2013a) around the plant should be quantified.

The demographic data would be analyzed to identify appropriate size and stage classes to build the matrix projection model. Different size classes are appropriate when there are size dependent differences in vital rates such as reproductive output, growth, and survival. For example, life stages that do not reproduce, such as seedlings, should be separated, and adults, which have markedly different size-based seed production, should be separated. For willow monardella, data indicate that smaller plants are less likely to survive, and there is an inverse relationship between plant size and rate of growth, but data on reproductive output are not available. Stage classes would likely include seed, seedling, juvenile (with lower survival rates and likely lower reproductive output), and adult classes of different sizes. Survival is estimated as the probability of being alive after a sampling event. Fecundity can be estimated as the mean seed to seedling transition of total population seed output in year 1 to total seedlings observed in year 2 (Morris and Doak 2003) and would involve collecting data on per-plant seed production, seed viability, and seedling establishment rates. Logistic regression of survival versus size, reproductive versus size, linear or polynomial regression of seed production versus size would be used to refine appropriate life stages to model.

Accurately quantifying the transition from seed to seedling that incorporates seed longevity and recruitment from the seed bank is among the most difficult to measure in demographic PVA (Doak et al. 2002; Moore and Pavlik 2014). Because of the difficulty and time required to accurately measure soil seed bank longevity and germination, and how these are influenced by environmental conditions, assumptions on seed banking and seed germination are frequently made to facilitate the use of PVA, and if other vital rates are well quantified, simulations of population growth and extinction using different rates of seed germination can examine the outcome of possible scenarios (Doak et al. 2002). That is, in the absence of data, different rates of seedling recruitment can be modelled to explore how these impact population growth; the

seed stage would be left out of the projection matrix. However, it would be valuable to collect data on age-dependent germination and survival rates of willowy monardella seeds since no data on seed longevity or viability are available.

Seed longevity can be determined by burying seed in mesh bags within representative habitats and examining germination and survival at successive time intervals (e.g., 6 months, 12 months, 18 months, 24 months). Alternatively, a known amount of collected seed could be sown into a plot and seedling emergence monitored over a period of time. *In situ* estimates of seed behavior are preferable to greenhouse studies because it is much more realistic (Doak et al. 2002), but since basic data on viability, germinability, and longevity of willowy monardella seed are not available, *ex situ* examination of these parameters is also recommended. *Ex situ* techniques would involve collecting seeds from monitored individuals and conducting viability (e.g., tetrazolium chloride and/or germinability tests (e.g., on moist filter paper in a controlled setting).

Each pair of monitoring years provides stage specific, deterministic transition rates from which population growth can be calculated. Multiple transitions, ideally that capture a range of environmental conditions, including drought and wet years, are necessary to model stochastic population growth and extinction probabilities. Data capturing a range of conditions can be used to simulate different scenarios, for example, the probability of extinction under increased drought could be modelled by choosing transitions collected only during drought years, or data collected in areas where invasive grasses have been removed could be used to model extinction probabilities with this stressor removed. Elasticity and sensitivity analysis examine how changes in matrix components impact population growth rates and can be a powerful management application of PVA. For example, identifying the life stages and transitions most critical to population growth can help to target management that improves that component.

Multiple software packages exist for construction and analysis of demographic population viability analysis. The package popbio in R (Stubben and Milligan 2007) is a powerful, relatively user-friendly software designed for demographic PVA, and numerous R scripts based on MATLAB code developed by Morris and Doak (2003) are available.

7.2 Comparison with Off-base Populations

Together with the PVA discussed above, it would be wise to determine if the decline in population size is restricted to MCAS Miramar or is occurring across pops among nearby off-base willowy monardella populations. This may be a plant that is in total decline rangewide and what may be happening on MCAS Miramar may be paralleling the disappearance of other willowy monardella populations off-base. Region-wide willowy monardella monitoring may be required so that comparisons can be made. All management agencies and parties responsible for willowy monardella populations off-base should perform the same monitoring as described in this report, as well as PVA monitoring occurring among off-base populations.

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Appendix A. Monitoring Plot Photographs

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MONITORING PLOT A



Figure A-1. Monitoring Plot A Photograph Taken on 15 July 2023



Figure A-2. Monitoring Plot A Photograph Taken on 8 July 2020



Figure A-3. Monitoring Plot A Photograph Taken on 3 July 2017



Figure A-4. Monitoring Plot A Photograph Taken on 15 July 2015



Figure A-5. Monitoring Plot A Photograph Taken on 3 July 2012

MONITORING PLOT C



Figure A-6. Monitoring Plot C Photograph Taken on 21 July 2023



Figure A-7. Monitoring Plot C Photograph Taken on 14 July 2020



Figure A-8. Monitoring Plot C Photograph Taken on 12 July 2017



Figure A-9. Monitoring Plot C Photograph Taken on 16 July 2015



Figure A-10. Monitoring Plot C Photograph Taken on 10 July 2012

MONITORING PLOT G



Figure A-11. Monitoring Plot G Photograph Taken on 21 July 2023



Figure A-12. Monitoring Plot G Photograph Taken on 14 July 2020



Figure A-13. Monitoring Plot G Photograph Taken on 12 July 2017



Figure A-14. Monitoring Plot G Photograph Taken on 16 July 2015



Figure A-15. Monitoring Plot G Photograph Taken on 5 July 2012

MONITORING PLOT H



Figure A-16. Monitoring Plot H Photograph Taken on 21 July 2023



Figure A-17. Monitoring Plot H Photograph Taken on 9 July 2020



Figure A-18. Monitoring Plot H Photograph Taken on 12 July 2017



Figure A-19. Monitoring Plot H Photograph Taken on 15 July 2015



Figure A-20. Monitoring Plot H Photograph Taken on 5 July 2012

MONITORING PLOT I



Figure A-21. Monitoring Plot I Photograph Taken on 8 July 2023



Figure A-22. Monitoring Plot I Photograph Taken on 7 July 2020



Figure A-23. Monitoring Plot I Photograph Taken on 4 July 2017



Figure A-24. Monitoring Plot I Photograph Taken on 17 July 2015



Figure A-25. Monitoring Plot I Photograph Taken on 5 July 2012

MONITORING PLOT J



Figure A-26. Monitoring Plot J Photograph Taken on 8 July 2023



Figure A-27. Monitoring Plot J Photograph Taken on 7 July 2020



Figure A-28. Monitoring Plot J Photograph Taken on 4 July 2017



Figure A-29. Monitoring Plot J Photograph Taken on 17 July 2015



Figure A-30. Monitoring Plot J Photograph Taken on 3 July 2012

MONITORING PLOT L



Figure A-31. Monitoring Plot L Photograph Taken on 21 July 2023



Figure A-32. Monitoring Plot L Photograph Taken on 14 July 2020



Figure A-33. Monitoring Plot L Photograph Taken on 12 July 2017



Figure A-34. Monitoring Plot L Photograph Taken on 16 July 2015



Figure A-35. Monitoring Plot L Photograph Taken on 5 July 2012

Monitoring Plot N



Figure A-36. Monitoring Plot N Photograph Taken on 15 July 2023



Figure A-37. Monitoring Plot N Photograph Taken on 1 July 2020



Figure A-38. Monitoring Plot N Photograph Taken on 2 July 2017



Figure A-39. Monitoring Plot N Photograph Taken on 15 July 2015



Figure A-40. Monitoring Plot N Photograph Taken on 6 July 2012

MONITORING PLOT O



Figure A-41. Monitoring Plot O Photograph Taken on 15 July 2023



Figure A-42. Monitoring Plot O Photograph Taken on 1 July 2020



Figure A-43. Monitoring Plot O Photograph Taken on 2 July 2017



Figure A-44. Monitoring Plot O Photograph Taken on 15 July 2015



Figure A-45. Monitoring Plot O Photograph Taken on 3 July 2012

MONITORING PLOT P



Figure A-46. Monitoring Plot P Photograph Taken on 5 July 2023



Figure A-47. Monitoring Plot P Photograph Taken on 6 July 2020



Figure A-48. Monitoring Plot P Photograph Taken on 30 June 2017



Figure A-49. Monitoring Plot P Photograph Taken on 14 July 2015



Figure A-50. Monitoring Plot P Photograph Taken on 15 July 2012

MONITORING PLOT Q



Figure A-51. Monitoring Plot Q Photograph Taken on 6 July 2023



Figure A-52. Monitoring Plot Q Photograph Taken on 6 July 2020



Figure A-53. Monitoring Plot Q Photograph Taken on 1 July 2017



Figure A-54. Monitoring Plot Q Photograph Taken on 14 July 2015



Figure A-55. Monitoring Plot Q Photograph Taken on 12 July 2012

MONITORING PLOT R



Figure A-56. Monitoring Plot R Photograph Taken on 23 July 2023



Figure A-57. Monitoring Plot R Photograph Taken on 10 July 2020



Figure A-58. Monitoring Plot R Photograph Taken on 5 July 2017



Figure A-59. Monitoring Plot R Photograph Taken on 17 July 2015

MONITORING PLOT S



Figure A-60. Monitoring Plot S Photograph Taken on 23 July 2023



Figure A-61. P Monitoring Plot S Photograph Taken on 2 July 2020

No photograph of Monitoring Plot S was taken in 2017.



Figure A-62. Monitoring Plot S Photograph Taken on 17 July 2015

MONITORING PLOT T



Figure A-63. Monitoring Plot T Photograph Taken on 22 July 2023



Figure A-64. Monitoring Plot T Photograph Taken on 2 July 2020



Figure A-65. Monitoring Plot T Photograph Taken on 30 July 2017



Figure A-66. Monitoring Plot T Photograph Taken on 17 July 2015

MONITORING PLOT U



Figure A-67. Monitoring Plot U Photograph Taken on 19 July 2023



Figure A-68. Monitoring Plot U Photograph Taken on 23 July 2020



Figure A-69. Monitoring Plot U Photograph Taken on 18 July 2017



Figure A-70. Monitoring Plot Photograph Taken on 20 July 2015

MONITORING PLOT V



Figure A-71. Monitoring Plot V Photograph Taken on 13 July 2023



Figure A-72. Monitoring Plot V Photograph Taken on 13 July 2023



Figure A-73. Monitoring Plot V Photograph Taken on 15 July 2017



Figure A-74. Monitoring Plot Photograph Taken on 20 July 2015

MONITORING PLOT W



Figure A-75. Monitoring Plot W Photograph Taken on 13 July 2023



Figure A-76. Monitoring Plot W Photograph Taken on 13 July 2020



Figure A-77. Monitoring Plot W Photograph Taken on 14 July 2017



Figure A-78. Monitoring Plot W Photograph Taken on 21 July 2015

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Appendix B. Monitoring Plot Data Sheets

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Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	A
Date	July 15, 2023
Surveyors	NB,other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	30
Photo Point ID	D196FFE9
Photo Filename	07.jpg
Photo Aspect	SW

Demographic Data			
Life Stage		Phenology	
Number of Clumps	3	Number of Vegetative Individuals	0
Number of Adults	3	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	3
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	

Disturbance Observations	
	Flooding, high cover annual grass in some areas, road runs through plot

General Observations	
Butterflies, hummingbirds, bumble bees, small bees	

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	C
Date	July 21, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	56
Photo Point ID	EA4DCBD1
Photo Filename	12.jpg
Photo Aspect	S

Demographic Data			
Life Stage		Phenology	
Number of Clumps	2	Number of Vegetative Individuals	0
Number of Adults	2	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	2
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
Heavy thatch on benches

General Observations
Bees

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	G
Date	July 21, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	120
Photo Point ID	023DB878
Photo Filename	14.jpg
Photo Aspect	E

Demographic Data			
Life Stage		Phenology	
Number of Clumps	2	Number of Vegetative Individuals	0
Number of Adults	1	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	0
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	1

Disturbance Observations
Flooding, erosion of main channel. High thatch cover throughout half of plot.

General Observations
Bees, swallowtail

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	H
Date	July 21, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	61
Photo Point ID	FFA3516A
Photo Filename	13.jpg
Photo Aspect	W

Demographic Data			
Life Stage		Phenology	
Number of Clumps	6	Number of Vegetative Individuals	0
Number of Adults	4	Number of Budding Individuals	0
Number of Mature Individuals	1	Number of Flowering Individuals	3
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	2

Disturbance Observations
Road/trail runs through plot. Recent fire ca. 50m south of plot. High cover of thatch over half of plot.

General Observations
Bees, butterflies

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	I
Date	July 8, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	52
Photo Point ID	2B7B6B01
Photo Filename	03.jpg
Photo Aspect	NE

Demographic Data			
Life Stage		Phenology	
Number of Clumps	20	Number of Vegetative Individuals	0
Number of Adults	19	Number of Budding Individuals	0
Number of Mature Individuals	1	Number of Flowering Individuals	18
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	2

Disturbance Observations
None

General Observations
Bumble bees, moths, and various butterflies visiting Monardella

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	J
Date	July 8, 2023
Surveyors	NG,other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	33
Photo Point ID	661972A2
Photo Filename	04.jpg
Photo Aspect	S

Demographic Data			
Life Stage		Phenology	
Number of Clumps	8	Number of Vegetative Individuals	0
Number of Adults	8	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	8
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations	

General Observations
Honey bee pollination

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	L
Date	July 21, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	35
Photo Point ID	F2C4E063
Photo Filename	15.jpg
Photo Aspect	SE

Demographic Data			
Life Stage		Phenology	
Number of Clumps	1	Number of Vegetative Individuals	0
Number of Adults	1	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	1
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
Flooding and bank erosion, high thatch cover on benches

General Observations
Bees, butterflies, bumble bees

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	N
Date	July 15, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	60
Photo Point ID	DA00BD83
Photo Filename	10.jpg
Photo Aspect	E

Demographic Data			
Life Stage		Phenology	
Number of Clumps	5	Number of Vegetative Individuals	0
Number of Adults	3	Number of Budding Individuals	0
Number of Mature Individuals	1	Number of Flowering Individuals	3
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	1

Disturbance Observations
Flooding, high erosion of banks, high thatch and annual grass cover on alluvial terraces

General Observations
Bumblebees, deer fawn, deer bedding, butterflies, honey bees, small bees

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	O
Date	July 15, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	65
Photo Point ID	E70151D1
Photo Filename	09.jpg
Photo Aspect	SE

Demographic Data			
Life Stage		Phenology	
Number of Clumps	1	Number of Vegetative Individuals	0
Number of Adults	0	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	1
Number of Juvenile Individuals	1	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
High amount of flooding, bank erosion, high cover of thatch and exotic grasses

General Observations
Bumblebees, butterflies,

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	P
Date	July 6, 2023
Surveyors	NG,other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	
Photo Point ID	19D19919
Photo Filename	02.jpg
Photo Aspect	W

Demographic Data			
Life Stage		Phenology	
Number of Clumps	8	Number of Vegetative Individuals	0
Number of Adults	6	Number of Budding Individuals	0
Number of Mature Individuals	2	Number of Flowering Individuals	7
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	1

Disturbance Observations
High cover of Nonnative grasses

General Observations

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	Q
Date	July 5, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	60
Photo Point ID	1AD2E35B
Photo Filename	01.jpg
Photo Aspect	SW

Demographic Data			
Life Stage		Phenology	
Number of Clumps	14	Number of Vegetative Individuals	0
Number of Adults	13	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	7
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	6

Disturbance Observations
N/A

General Observations	
N/A	

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	R
Date	July 23, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	60
Photo Point ID	2DE6DD16
Photo Filename	18.jpg
Photo Aspect	SE

Demographic Data			
Life Stage		Phenology	
Number of Clumps	5	Number of Vegetative Individuals	0
Number of Adults	5	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	5
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
high flood disturbance and bank erosion. High annual grass and thatch cover on terraces.

General Observations
Bumble bees, swallow tails, other butterfly spp., small bees/wasps, honey bees

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	S
Date	July 23, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	52
Photo Point ID	339CDA6A
Photo Filename	17.jpg
Photo Aspect	SW

Demographic Data			
Life Stage		Phenology	
Number of Clumps	14	Number of Vegetative Individuals	0
Number of Adults	12	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	12
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	2

Disturbance Observations
A lot of channel undercutting/downcutting and erosion. Small trail through plot. Dense thatch over portions of plot.a

General Observations
Swallowtails, bumble bees, honey bees, butterflies

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	T
Date	July 22, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	27
Photo Point ID	84A83745
Photo Filename	16.jpg
Photo Aspect	S

Demographic Data			
Life Stage		Phenology	
Number of Clumps	8	Number of Vegetative Individuals	0
Number of Adults	7	Number of Budding Individuals	0
Number of Mature Individuals	1	Number of Flowering Individuals	8
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
Flooding, high cover of thatch in some areas

General Observations
Swallowtail, bumble bees, honey bees, butterflies, hummingbird

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	U
Date	July 19, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	20
Photo Point ID	DF37DE43
Photo Filename	11.jpg
Photo Aspect	S

Demographic Data			
Life Stage		Phenology	
Number of Clumps	9	Number of Vegetative Individuals	0
Number of Adults	9	Number of Budding Individuals	0
Number of Mature Individuals	0	Number of Flowering Individuals	9
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	0

Disturbance Observations
High amount of thatch over large portion of plot

General Observations
Bees, butterflies

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	V
Date	July 13, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	33
Photo Point ID	B03DDD10
Photo Filename	06.jpg
Photo Aspect	SE

Demographic Data			
Life Stage		Phenology	
Number of Clumps	22	Number of Vegetative Individuals	1
Number of Adults	20	Number of Budding Individuals	0
Number of Mature Individuals	2	Number of Flowering Individuals	18
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	3

Disturbance Observations
High cover of exotics, extensive ground disturbance by rodents

General Observations
Butterflies, bees

[illegible]

[illegible]

Long-Term Willowy Monardella Monitoring Data Sheet

General Information	
Plot	W
Date	July 13, 2023
Surveyors	other
Drainage Mapped	Yes
Depth of Drainage (centimeters)	
Photo Point ID	C0D7C638
Photo Filename	05.jpg
Photo Aspect	N

Demographic Data			
Life Stage		Phenology	
Number of Clumps	8	Number of Vegetative Individuals	1
Number of Adults	7	Number of Budding Individuals	1
Number of Mature Individuals	1	Number of Flowering Individuals	5
Number of Juvenile Individuals	0	Number of Seeding Individuals	0
Number of Seedlings	0	Number of Fruiting Individuals	0
		Number of Dead/Dormant	1

Disturbance Observations
High floods moved through washes. Much of plot covered in dense <i>Brachypodium</i> , <i>Bromus diandrus</i> , and <i>Avena</i> thatch

General Observations
Monarchs visiting milkweeds, tarantula wasps, bees and several species of butterflies present

[illegible]

[illegible]