SACRAMENTO ORCUTT GRASS MONITORING RESULTS AND DISCUSSION FOR PHOENIX FIELD ECOLOGICAL RESERVE, 2014-2024

PREPARED BY THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
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Introduction

This document summarizes the 2014-2024 results from California Department of Fish and Wildlife (CDFW) implementation of the 2018 Phoenix Field Ecological Reserve Sacramento Orcutt Grass Monitoring Plan (Monitoring Plan). The Monitoring Plan includes background ecological information on the state and federally endangered plant Sacramento Orcutt grass (*Orcuttia viscida*), site-specific information on CDFW's Phoenix Field Ecological Reserve (Reserve), and detailed instructions on how to implement monitoring for adaptive management of Sacramento Orcutt grass at the Reserve. Implementation of the Monitoring Plan began in 2014 as a pilot study, and work continued from 2015-2024. This document includes results, interpretation of results, an assessment of the project, and management recommendations. The results and recommendations in this document are a critical step in the adaptive management process that relies on assessment of site conditions and revision of management approaches to improve CDFW's management of this species.

Methods

Monitoring methods are described in detail in the Monitoring Plan and are summarized here. CDFW staff visited the Reserve at least annually between 2014 and 2024 for the purposes of monitoring the Reserve and implementing management responses. There are two frequency monitoring macroplots at the Reserve (Macroplots A and B), and they correspond with the two sections of vernal pools on the Reserve that contain Sacramento Orcutt grass (Pools A and B). Sacramento Orcutt grass germinates in the fall after the onset of precipitation, and after ponding occurs (Griggs 1980), and peak bloom is typically late May through June. Frequency monitoring should take place when Sacramento Orcutt grass is blooming.

We used systematic random sampling to collect nested frequency data within Macroplots A and B on:

- Sacramento Orcutt grass (Figure 1);
- Waxy mannagrass (*Glyceria declinata*), an invasive perennial species (functions as an annual at the Reserve)(Figure 1);
- Spikerush (*Eleocharis macrostachya*), a native rhizomatous perennial; and
- Any non-native plants other than waxy mannagrass.

Frequency can be visualized by imagining an area overlaid with a grid of square cells. The percentage of the cells occupied by the target species is the frequency value. Cell size determines frequency value; larger cell sizes increase the likelihood that an individual will occur within the cell, resulting in a larger overall frequency value. Appropriate cell sizes for frequency monitoring depend on the distribution and density of the target species. To ensure our monitoring

Figure 1. Invasive waxy mannagrass (*Glyceria declinata*, left oval) and endangered Sacramento Orcutt grass (*Orcuttia viscida*, right oval) growing in proximity at Phoenix Field Ecological Reserve

would detect change of different scales in the future, we sampled frequency using three different quadrat sizes via the nested frequency method: 1 m x 1 m (1 m^2), 50 cm x 50 cm (0.25 m^2), and 25 cm x 25 cm (0.0625 m^2). From 2015-2024 we sampled 91 random quadrats within Macroplot A and 96 random quadrats within Macroplot B. The sizes of Macroplots A and B are illustrated in Appendix A.

We also took monitoring photographs from nine different positions, and a total of 43 different perspectives. Five photos were taken from different perspectives at the corners of Macroplots A and B beginning in 2014. These 40 photos were named Aa-At and Ba-Bt. Photopoint C was established in 2016 to monitor the location of a small, isolated population of the rare plant, pincushion navarretia (*Navarretia myersii* subsp. *myersii*). Pincushion navarretia is not federally or state-listed but is tracked by CDFW's California Natural Diversity Database (CNDDB) due to its risk of extinction from rarity, small population sizes, and habitat loss and degradation. Three photos were taken at Photopoint C and labeled Ca-Cc.

SUMMARY OF RESULTS

This document reports on the results of the following monitoring components:

1. Nested frequency monitoring of plants within the two sections of vernal pools on the Reserve that contain Sacramento Orcutt grass, and implementation of management responses, and
2. Photomonitoring of the Reserve.

In addition, precipitation information generated using a PRISM climate model and other observations at the Reserve are reported and discussed. Dates of monitoring visits are in Table 1. Monitoring photos and monitoring data associated with this document are available via the California Natural Resources Agency data portal at the following location: https://data.cnra.ca.gov/dataset/sacramento-orcutt-grass-monitoring-phoenix-field-ecological-reserve.

Table 1. Dates of visits

Year	Day(s)	Purpose of Visit(s)
2014	April 15, June 5, 10	Pilot study and monitoring setup
2015	May 21, September 22	Monitoring
2016	May 5, June 2	Monitoring
2017	April 12, June 7	Monitoring
2018	January 10, March 9, April 3, May 9, June 26	Waxy manna grass removal, monitoring
2019	April 25, June 18, 19	Waxy manna grass removal, monitoring
2020	April 17, June 9	Waxy manna grass removal, monitoring
2021	March 2, June 2	Waxy manna grass removal, monitoring
2022	March 2, May 10	Waxy manna grass removal, monitoring
2023	March 3, 17, May 31	Waxy manna grass removal, monitoring
2024	June 3	Monitoring

NESTED FREQUENCY MONITORING

Sacramento Orcutt grass

Sacramento Orcutt grass was present in monitoring Macroplots A and B every year from 2014 to 2024, with many plants found in the deepest portions of pools. Of the three nested frequency quadrat sizes, the 1 m x 1 m (1 m^2) size was the most useful for monitoring Sacramento Orcutt grass over the monitoring period because its values had the largest range and its average estimated frequency value (41% in Macroplot A, and 40% in Macroplot B) was closest to 50%, allowing the greatest sensitivity for detecting upward and downward change. The highest 1 m^2 frequency of Sacramento Orcutt grass estimated in Macroplot A was 56.0% in 2015, and the lowest was 14.3% in 2021 (Figure 2). The highest 1 m^2 frequency of Sacramento Orcutt grass in Macroplot B was 56.3% in 2015, and the lowest was 24.0% in 2021 (Figure 3). We found a significant positive pairwise correlation between estimated Sacramento Orcutt grass 1 m^2 frequency in Macroplots A & B ($r = 0.82$, $p = 0.004$).

The 3 m x 3 m areas within Macroplots A and B where Sacramento Orcutt grass was most often observed within sampled 1 m^2 frequency quadrats from 2015-2024 are represented in Figures 4 and 5. While Macroplot A contains all Sacramento Orcutt grass within Pool A, we infrequently observed small numbers of Sacramento Orcutt grass individuals just outside of Macroplot B to the southeast.

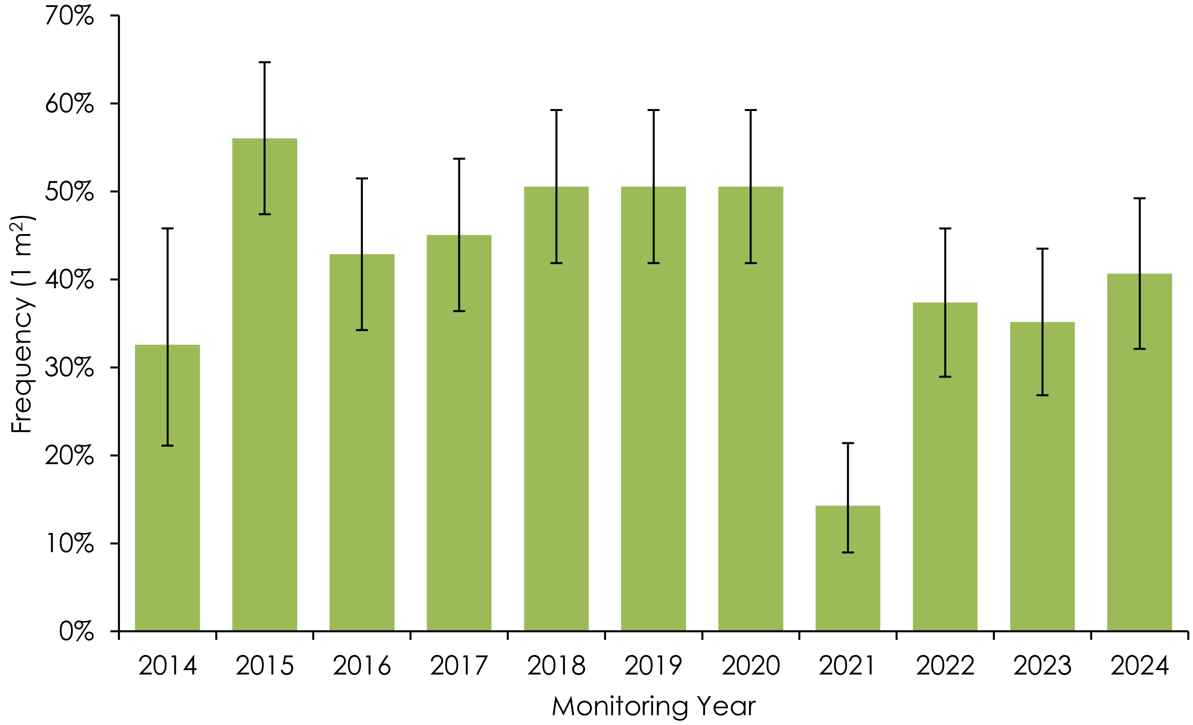

Figure 2. Estimated 1 m^2 frequency of Sacramento Orcutt grass in Phoenix Field Ecological Reserve Macroplot A (90% confidence)

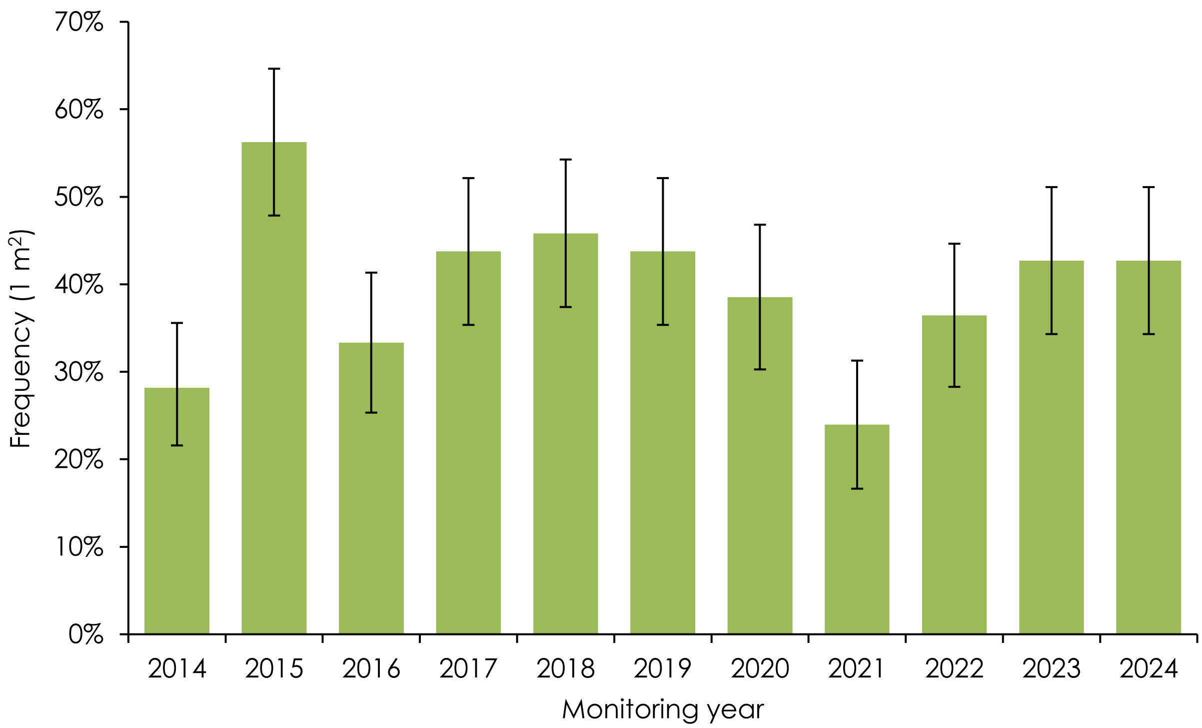

Figure 3. Estimated 1 m^2 frequency of Sacramento Orcutt grass in Phoenix Field Ecological Reserve Macroplot B (90% confidence)

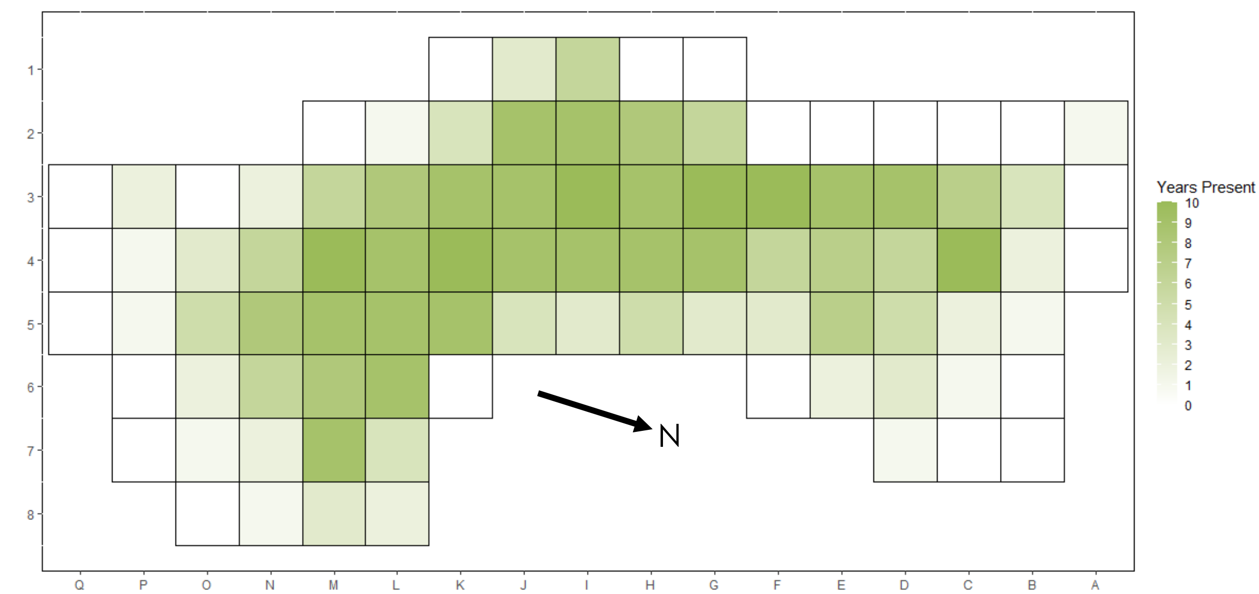

Figure 4. Number of years that Sacramento Orcutt grass (*Orcuttia viscida*) was in a random 1 m² quadrat within a 9 m² (3 m x 3 m) area (grid cells), 2015-2024, Macroplot A. Data collected May or June.

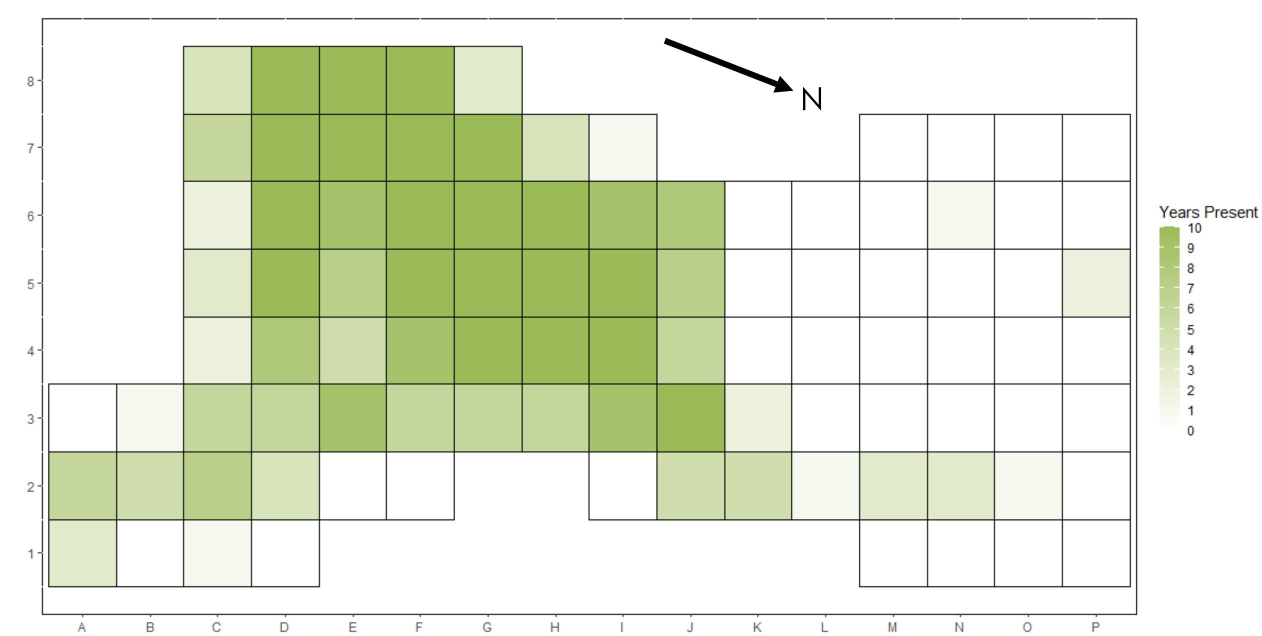

Figure 5. Number of years that Sacramento Orcutt grass (*Orcuttia viscida*) was in a random 1 m² quadrat within a 9 m² (3 m x 3 m) area (grid cells), 2015-2024, Macroplot B. Data collected May or June.

Waxy mannagrass

Invasive waxy mannagrass (*Glyceria declinata*) was not observed at all within Macroplot A from 2014 to 2024, but waxy mannagrass was observed within Macroplot B, particularly in the northeast corner of the macroplot. Of the three nested frequency quadrat sizes, the 1 m x 1 m (1 m^2) quadrat size was the most useful for monitoring waxy mannagrass because even though values for all quadrat sizes were low, a quadrat size of 1 m^2 resulted in highest values and largest range of values so it was the most sensitive for detecting change. The highest estimated frequency of waxy mannagrass in Macroplot B was 18.8% in 2020, and the lowest was 1.0% in 2016 (Figure 6). The 90 percent confidence error bars for waxy mannagrass exceeded a frequency of 10% in 2015, 2017, 2018, 2019, 2020, 2021, and 2023, which is relevant for triggering management responses, as discussed in the Management Recommendations section. Chi-square tests of independence were performed to examine the relationships between waxy mannagrass presence and different monitoring years. Compared with 2015, waxy mannagrass presence in Macroplot B was significantly higher in the years 2018 (χ^2 (1, N = 96) = 0.30, p = 0.08), 2020 (χ^2 (1, N = 96) = 0.26, p = 0.004), and 2021 (χ^2 (1, N = 96) = 0.27, p = 0.019). We found a marginally significant positive pairwise correlation between estimated waxy mannagrass frequency in consecutive years (i.e. between frequency in an a year and frequency in the following year)(r = 0.54, p = 0.1). The 3 m x 3 m areas within Macroplot B where waxy mannagrass was most often observed within sampled 1m^2 frequency quadrats from 2015-2024 are illustrated in Figure 7.

Looking at data from 2014-2024, we found a significant negative pairwise correlation between estimated 1 m^2 frequency of waxy mannagrass and estimated 1m^2 frequency of Sacramento Orcutt grass (r = -0.64, p = 0.05). Locations within Macroplot B where waxy mannagrass and Sacramento Orcutt grass were observed within the same 1 m^2 area during monitoring efforts are identified in Figure 8.

In 2018, we implemented the management response of pulling waxy mannagrass within Macroplot B and other parts of the Reserve and repeated it every year through 2023 (Table 2). Identification of waxy mannagrass during early-season control efforts was challenging because plants were typically not yet flowering, and they typically only had one to a few floating leaves visible. The most common grass species that waxy mannagrass could be confused with at the Reserve are the non-native Italian ryegrass (*Festuca perennis*) and the native annual hairgrass (*Deschampsia danthonioides*). Identification in the field when flowering material was absent was based on (1) waxy mannagrass leaves tending to be slightly more blueish-green in color than other grass species, (2) waxy mannagrass plants tending to have more reddish coloration than other species, particularly the underwater portions of the plants, (3) the width of waxy

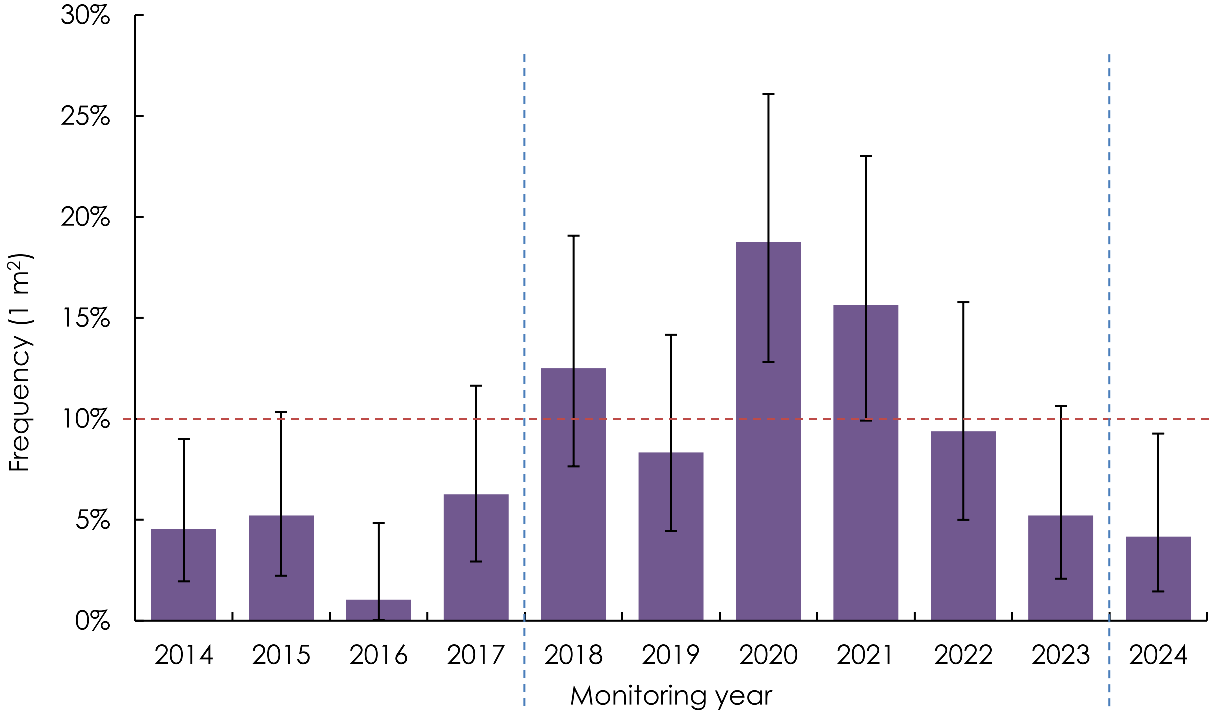

Figure 6. Estimated 1 m^2 frequency of waxy mannagrass (*Glyceria declinata*) in Phoenix Field Ecological Reserve Macroplot B (90% Confidence). The horizontal dashed line represents Management Objective 1 as identified in the Management Plan. Management implications (waxy mannagrass removal) were implemented in the 2018-2023 monitoring years, which are framed between the vertical dashed lines.

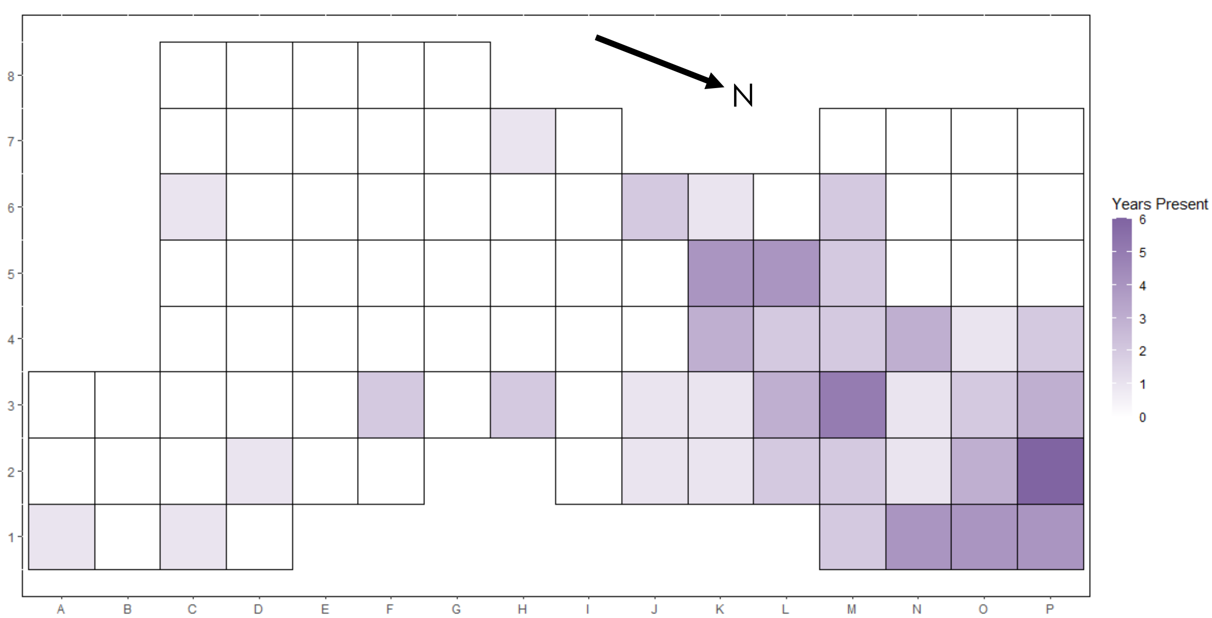

Figure 7. Number of years that waxy mannagrass (*Glyceria declinata*) was in a random 1 m^2 quadrat within a 9 m^2 (3 m x 3 m) area (grid cells), 2015-2024, Macroplot B. Data collected May or June.

mannagrass leaves being intermediate between the thinner annual hairgrass leaves and the wider Italian ryegrass leaves, (4) the waxy mannagrass leaf tips being blunter and more rounded than the more tapered and pointed annual hairgrass and Italian ryegrass leaf tips, (5) the ligule of waxy mannagrass is 4-9 mm and blunt and rounded, similar to its leaf tips, which contrasts with the shorter 1-3 mm ligule of Italian ryegrass and the acute to acuminate (i.e. more pointy) ligule of annual hairgrass, and (6) during its aquatic phase, waxy mannagrass leaves tend to float on the water surface, while leaves of other grass species are sometimes more emergent.

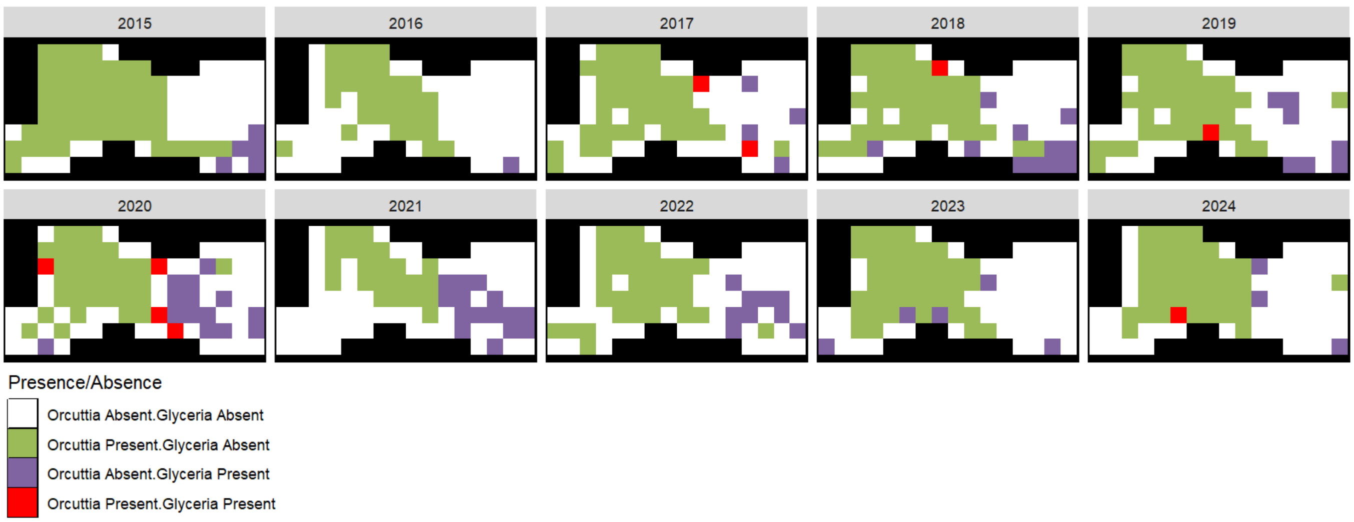

Figure 8. Sacramento Orcutt grass (*Orcuttia viscida*) and Waxy mannagrass (*Glyceria declinata*) presence and absence in a random 1 m² quadrat within a 9 m² (3 m x 3 m) area (grid cells), 2015-2024, Macroplot B. Red squares indicate areas where the two species were present within the same 1 m² quadrat. Data collected in May or June.

Table 2. Waxy mannagrass removal dates, and approximation of effort and biomass removed, 2018-2023.

Year	Day(s)	Approximate removal effort	Approximate biomass removed
2018	April 3	5 person hours	3 garbage bags
2019	April 25	6 person hours	4 garbage bags
2020	April 17	6 person hours	2 garbage bags
2021	March 2	9 person hours	"much less than in previous years"
2022	March 2	9 person hours	<1 garbage bag
2023	March 3 & 17	12 person hours	1 garbage bag

Common spikerush

Native common spikerush (*Eleocharis macrostachya*) was not observed within Macroplot A from 2014 to 2024 but was consistently present in Macroplot B during this period (Figure 9), with a dense concentration in the northern part of the macroplot (Figure 10). Of the three nested frequency quadrat sizes, the 50 cm x 50 cm (0.25 m^2) size was the most useful for monitoring common spikerush because its average estimated frequency value of 51% (range 45% - 57%) demonstrates its sensitivity for detecting both upward and downward change. The estimated frequency of common spikerush in Macroplot B was not significantly different between any of the monitoring years from 2014 to 2024. The 3 m x 3 m areas within Macroplot B where common spikerush was most often observed within a sampled 0.25 m^2 frequency quadrat from 2015-2024 are illustrated in Figure 10.

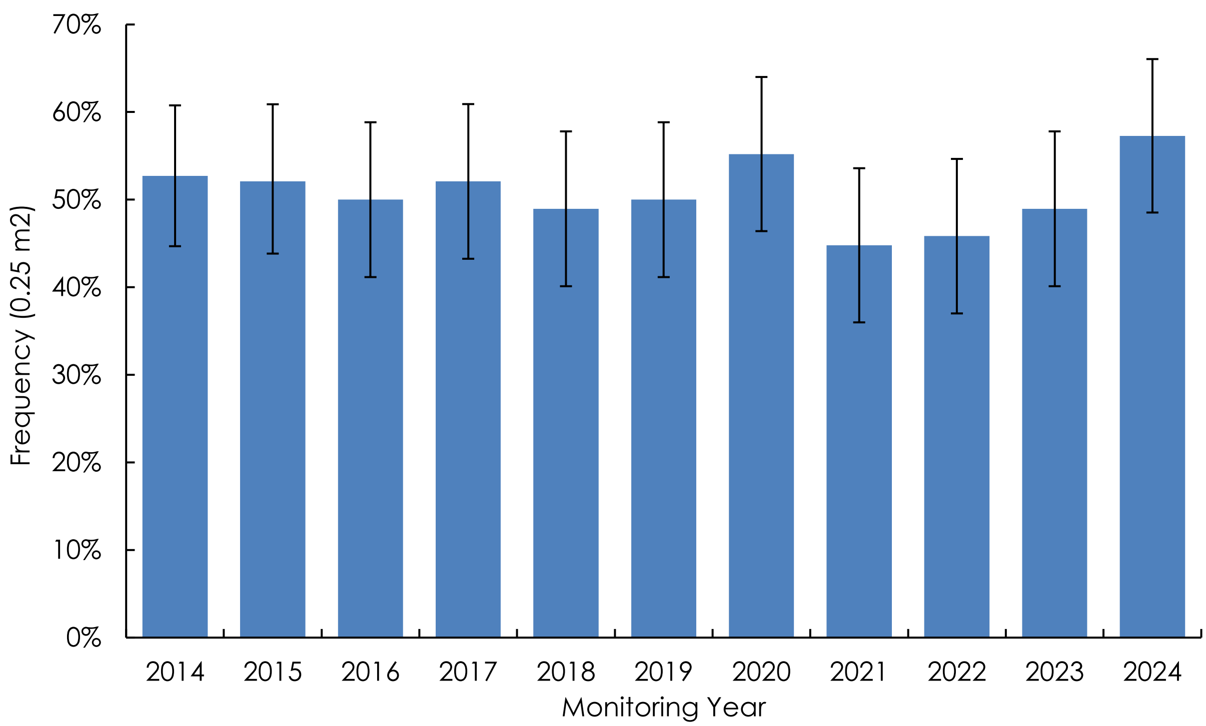

Figure 9. Frequency (0.25 m^2) of common spikerush (*Eleocharis macrostachya*) in Phoenix Field Ecological Reserve Macroplot B, 2014-2024 (90% Confidence)

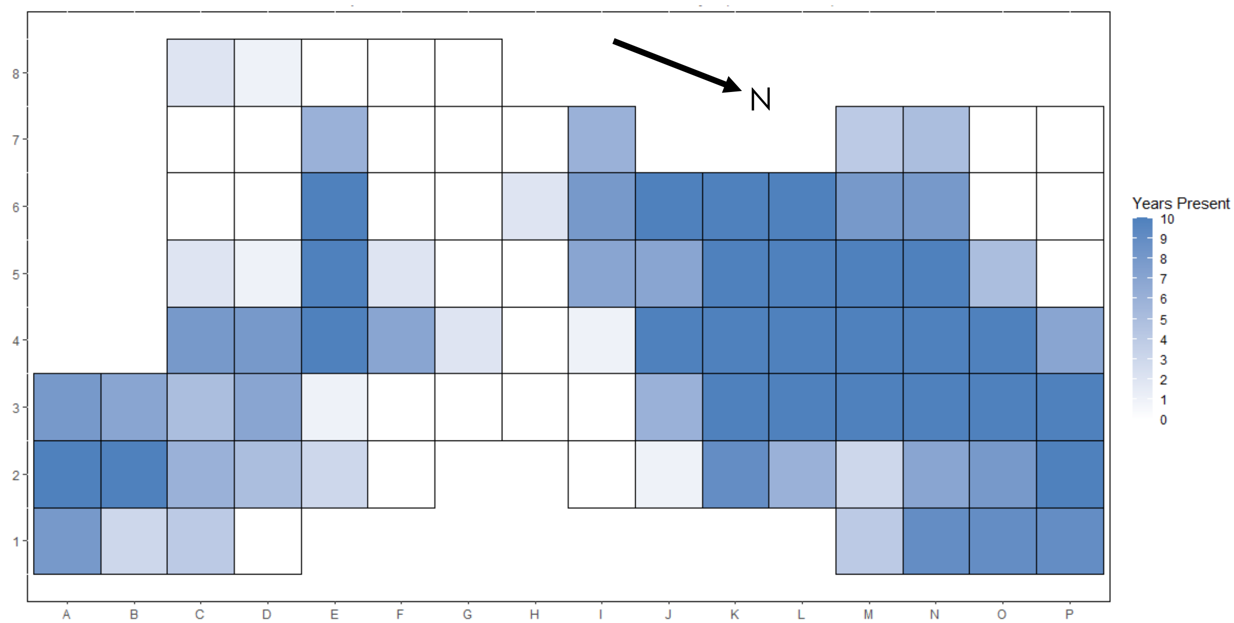

Figure 10. Number of years that common spikerush (*Eleocharis macrostachya*) was in a random 0.25 m^2 quadrat within a 9 m^2 (3 m x 3 m) area (grid cells), 2015-2024, Macroplot B. Data collected May or June.

Other non-native species

Other non-native plants were present within Macroplots A and B every year, particularly in uplands near pool margins. Of the three nested frequency quadrat sizes, the 50 cm x 50 cm (0.25 m^2) size was the most useful for monitoring other non-native plants because its average estimated frequency values of 54% (range 33-76%) and 53% (range 31-79%) in Macroplots A and B were very close to 50% and were therefore sensitive for detecting both upward and downward change. The highest estimated frequency of other non-native plants in Macroplot A was 75.8% in 2021, and the lowest was 33.0% in both 2015 and 2023 (Figure 11). The highest estimated frequency of other non-native plants in Macroplot B was 79.2% in 2024, and the lowest was 31.3% in 2019 (Figure 12). We found a significant positive pairwise correlation between estimated frequency (0.25 m^2) of other non-native plants in Macroplots A and B ($r = 0.62$, $p = 0.05$). Areas within Macroplots A and B where other non-native plants were most often observed within sampled (0.25 m^2) frequency quadrats from 2015-2024 are represented in Figures 13 and 14.

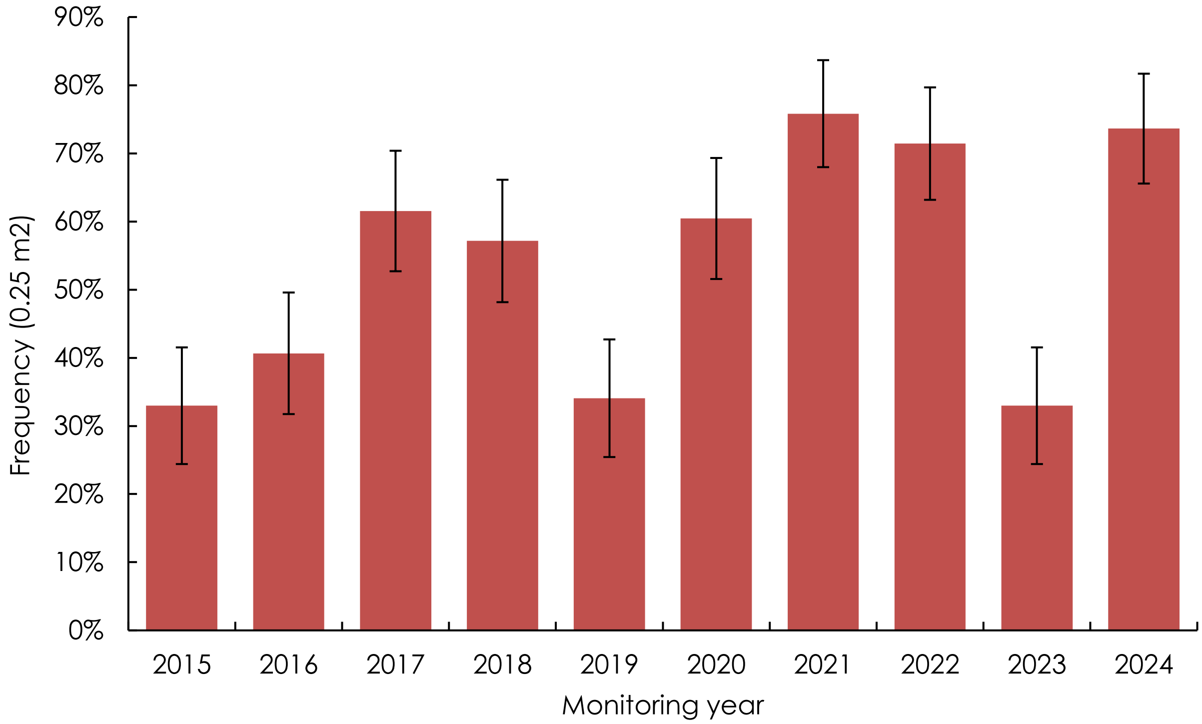

Figure 11. Frequency (0.25 m^2) of non-native plants in Phoenix Field Ecological Reserve Macroplot A

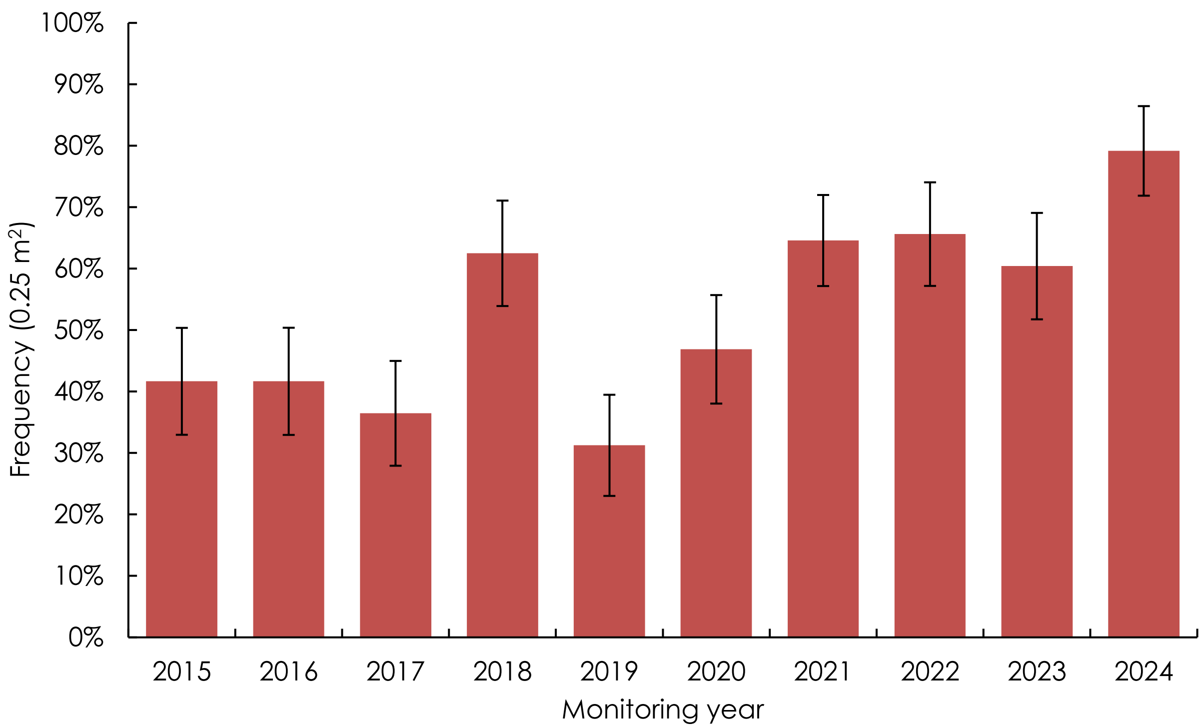

Figure 12. Frequency (0.25 m^2) of other non-native species in Phoenix Field Ecological Reserve Macroplot B (90% Confidence), 2015-2024

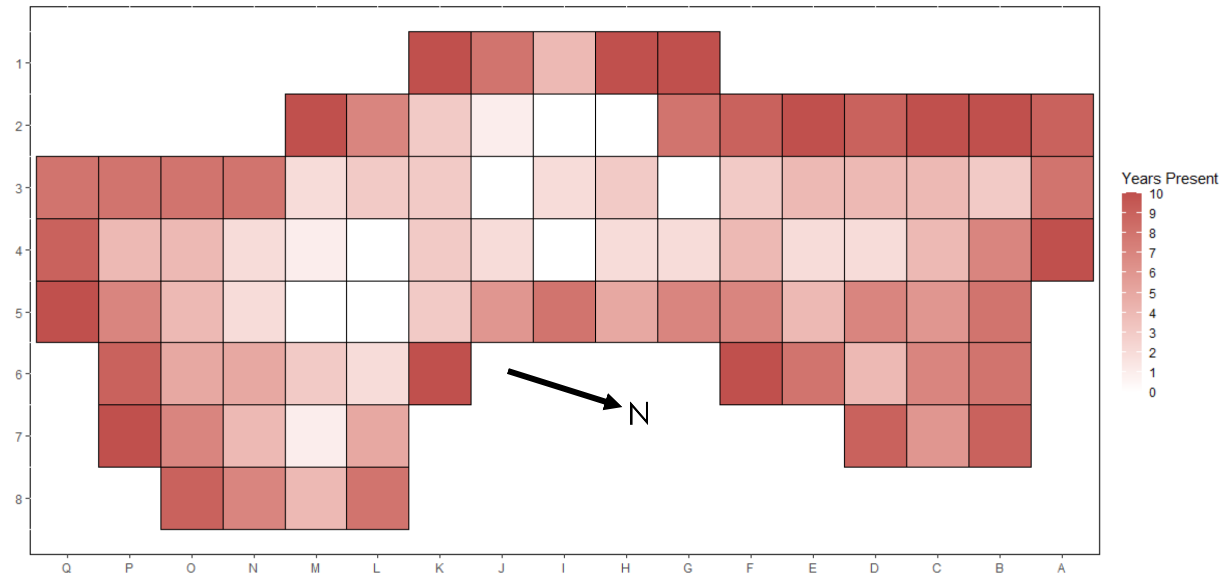

Figure 13. Number of years that any non-native plant (excluding waxy mannagrass) was in a random 1 m² quadrat within a 9 m² (3 m x 3m) area (grid cells), 2015-2024, Macroplot A. Data collected in May or June.

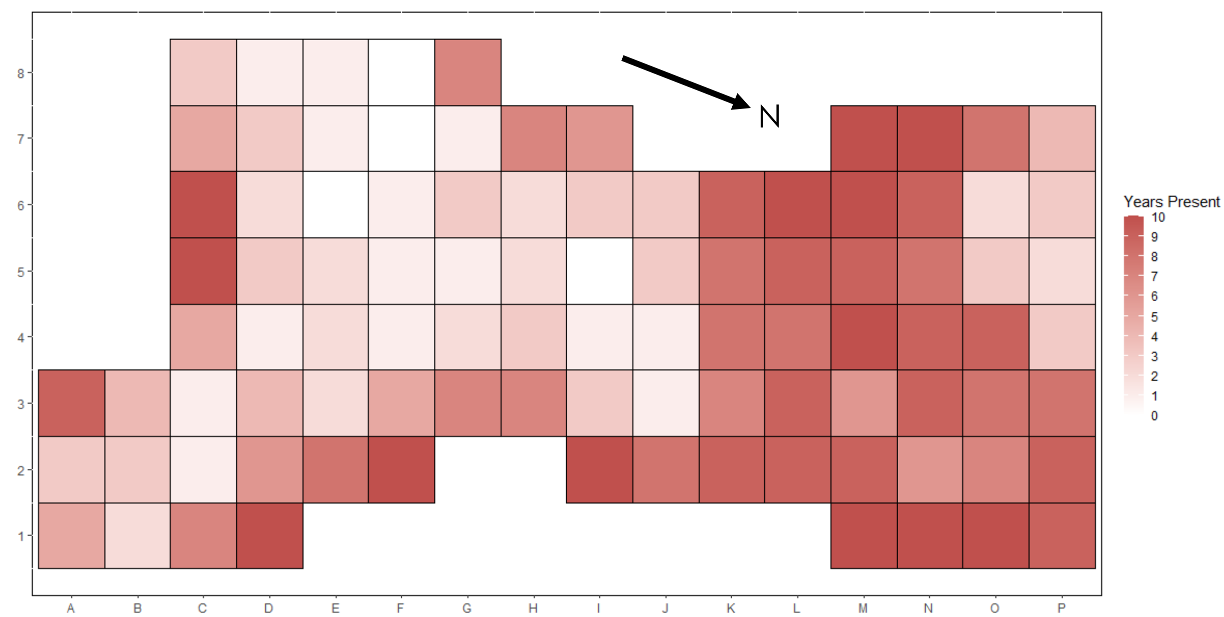

Figure 14. Number of years that any non-native plant (excluding waxy mannagrass) was in a random 1 m² quadrat within a 9 m² (3 m x 3 m) area (grid cells), 2015-2024, Macroplot B. Data collected in May or June.

Annual Photomonitoring

From the 43 monitoring photo perspectives, there are 5-10 years of annual photos to compare conditions at the Reserve. Monitoring photographs from the corners of Macroplots A and B were taken whenever frequency data was collected except in 2021, and photos were taken at Photopoint C in 2016, 2017, 2018, 2019, and 2022. Monitoring photos from positions Ah, Ak, Bf, Br, and Ca are presented in Figures 15 through 19.

Figure 15. Photo Ah, view to the south, showing Vernal Pool A in June 2014 (top), 2019 (middle), and 2024 (bottom).

Figure 16. Photo Ak, view to the northwest, showing Vernal Pool A in June 2014 (top), 2019 (middle), and 2024 (bottom). In spring 2024, the Reserve was mowed and/or weed whipped to reduce vegetation outside of the vernal pools.

Figure 17. Photo Bf, view to the south, showing Vernal Pool B in June 2014 (top), 2019 (middle), and 2024 (bottom). A dense stand of common spikerush is on the right side of the images.

Figure 18. Photo Br, view to the North, showing Vernal Pool B in June 2014 (top), 2019 (middle), and 2024 (bottom).

Figure 19. Photo Ca, view to the southeast, showing the location of pincushion navarretia (*Navarretia myersii* ssp. *myersii*) population in May 2016 (top), April 2019 (middle), and May 2022 (bottom). Pink flags indicate the locations of pincushion navarretia plants in 2016.

PRECIPITATION

We looked at pairwise correlations between precipitation information generated using a climate model (PRISM 2024) and frequency estimates from 2015-2024.

Sacramento Orcutt grass is an obligate vernal pool species, so precipitation that occurs between September and June is most likely to influence its growth and survival. Cumulative September-June precipitation for the 2014-2024 growing seasons is presented in Figure 20. We did not find any correlations between cumulative September-June precipitation and our frequency data, although 2021 had both the lowest frequency of Sacramento Orcutt grass and the lowest September-June precipitation. When breaking down the cumulative precipitation to shorter timeframes, we found a significant positive pairwise correlation between cumulative April and May precipitation and estimated Sacramento Orcutt grass 1 m^2 frequency in Macroplot A ($r = 0.78$, $p = 0.008$), and a marginally significant positive correlation in Macroplot B ($r = 0.55$, $p = 0.10$). We found a significant positive pairwise correlation between cumulative November and December precipitation and estimated Sacramento Orcutt grass 1m^2 frequency in Macroplot B ($r = 0.60$, $p = 0.06$), but did not find a significant correlation in Macroplot A. With only ten years of data our power to detect the effect of monthly precipitation on estimated frequency through multiple regression is limited. However, when we used multiple regression to test the effect of cumulative November and December precipitation and cumulative April and May precipitation on Sacramento Orcutt grass 1m^2 frequency, while accounting for possible positive correlations between these periods in “wet years” and “dry years,” the model was significant for both Macroplot A ($R^2 = 0.71$, $F(2,7) = 8.44$, $p = 0.01$) and Macroplot B ($R^2 = 0.66$, $F(2,7) = 6.76$, $p = 0.02$). Cumulative April and May precipitation was the only period that had a significant positive effect on Sacramento Orcutt grass 1m^2 frequency in Macroplot A ($\beta = 0.060$, $p = 0.007$). For Macroplot B, there was also a significant positive effect of cumulative April and May precipitation on Sacramento Orcutt grass frequency ($\beta = 0.030$, $p = 0.01$) in addition to a small, significant positive effect of cumulative November and December precipitation ($\beta = 0.018$, $p = 0.03$).

We did not find any significant pairwise correlations between estimated waxy mannagrass frequency or common spikerush frequency and cumulative growing season precipitation or precipitation over shorter timeframes (e.g. April and May precipitation or November and December precipitation).

We found a significant negative pairwise correlation between cumulative November and December precipitation and estimated 0.25 m^2 frequency of non-native plants (excluding waxy mannagrass) in Macroplot A ($r = 0.59$, $p = 0.07$), but not in Macroplot B. We found a marginally-significant positive pairwise correlation between cumulative April and May precipitation and estimated 0.25 m^2 frequency of non-native plants (excluding waxy mannagrass) in Macroplot B ($r = 0.57$, $p = 0.09$), but no significant positive correlations between precipitation and non-native plant frequency in Macroplot A.

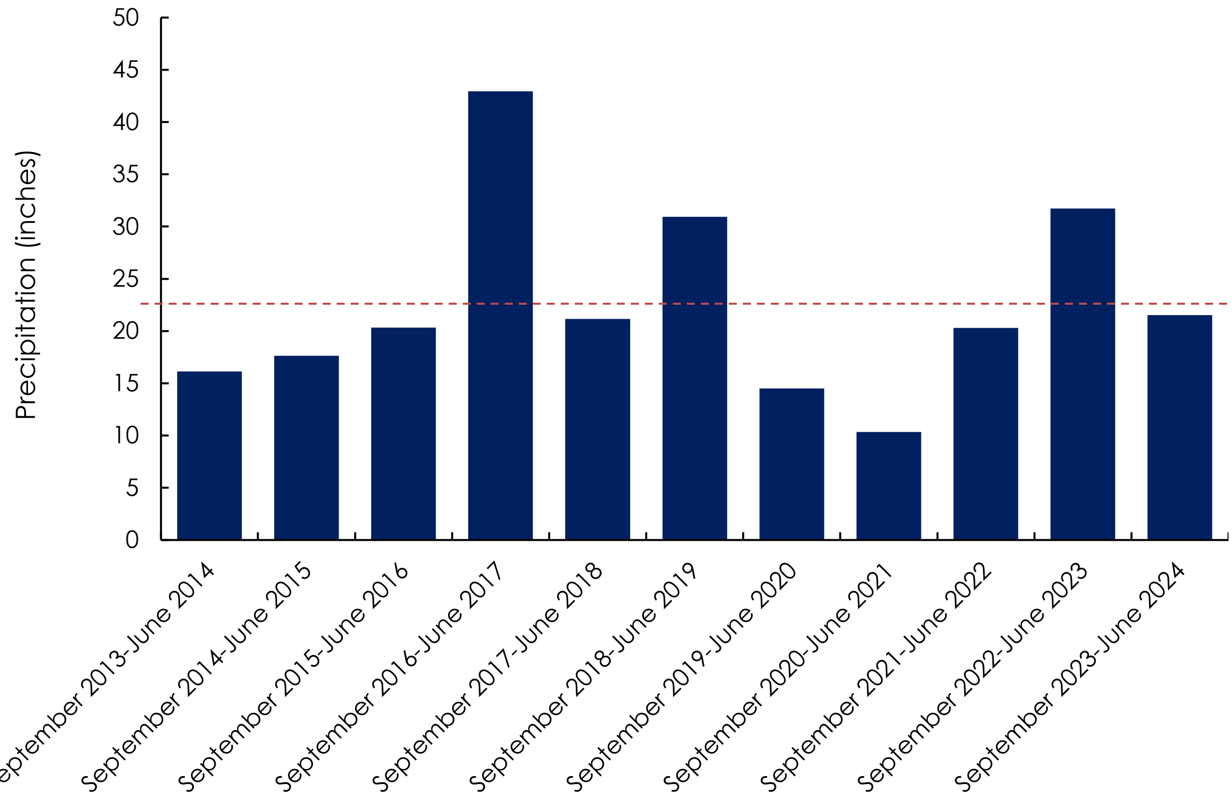

Figure 20. Modeled cumulative September through June precipitation, 2013-2024 (PRISM Climate Group 2024). Horizontal dashed line is average for data shown (22.5 inches).

PINCUSHION NAVARRETIA

On May 5, 2016, we observed approximately 200 to 1000 pincushion navarretia plants. On April 12, 2017, the pools where pincushion navarretia occurs were still inundated, and we could not effectively detect the species. On May 9, 2018 we observed pincushion navarretia but did not estimate abundance, and the population had almost finished blooming. On March 2, 2022, we observed pincushion navarretia as it was beginning to bloom but we did not estimate its abundance.

Interpretation of Results

History and Stability of Sacramento Orcutt Grass Population

Due to the growth and reproduction of a considerable number of Sacramento Orcutt grass plants within Macroplots A and B every year from 2014-2024, the Sacramento Orcutt grass population at the Reserve appears to be relatively stable.

The Sacramento Orcutt grass population in Macroplot A has persisted at a similar frequency through the 2014-2024 monitoring period. However, we observed a drop in frequency in 2021. This drop in frequency corresponded with the lowest cumulative September through June growing season precipitation (10.4 inches) of any monitoring year during the monitoring period (see Figures 2, 3, and 20). Sacramento Orcutt grass abundance was monitored by Griggs (1980) from 1972 to 1979, and no Sacramento Orcutt grass was present at the Reserve in 1976 and 1977 after growing seasons with approximately 9.1 and 8.1 inches of precipitation, respectively. This demonstrates that while Sacramento Orcutt grass can successfully grow despite varying annual precipitation patterns, if the precipitation does not exceed a threshold (perhaps 9-10 inches) the species may not grow, or the abundance may be low.

According to notes on herbarium sheets from 1966, 1973, and 1974 and a survey in 1980, Sacramento Orcutt grass historically occurred in only one vernal pool at the Reserve. Hand-drawn maps through the 1980s illustrate that this occupied pool is Pool A. In 1978 Griggs (1980) translocated "abundant" seed from Pool A to vernal pools that were 200-300 m to the southwest at Phoenix Park (CNDDB element occurrence 15), and this translocated population continues to persist (CNDDB 2024). In 1980, Holland (1986) translocated the seed of 10 Sacramento Orcutt grass plants from Pool A to observe the outcome of dispersal into a new area. Holland "planted them in a narrow row aligned along the fall line (perpendicular to the pool margin) near the northeast corner of the preserve." which is most likely in what we currently call "Pool B". Holland reported that the translocated population persisted in 1986 but had not dispersed farther than 3 meters. In 1982, Susan Cochrane provided a hand-drawn map illustrating that Sacramento Orcutt grass was present in Pool A, absent from the vicinity of Pool B where Holland had dispersed them two years prior, and present in two other areas on the Reserve where the species was not previously documented (Figure 21). Several references from the 1980s and early 1990s provide estimates of abundance, but with insufficient detail to determine the specific locations where plants were observed. In 1996 over 100,000 Sacramento Orcutt grass plants were in Pool A, over 27,000 were in Pool B (identified as "Willow Pool" by Morey (1996)), 60 plants were in the "Road Pool", and 13 plants were in a previously undocumented location called the "Gate Pool" (Figure 22). The

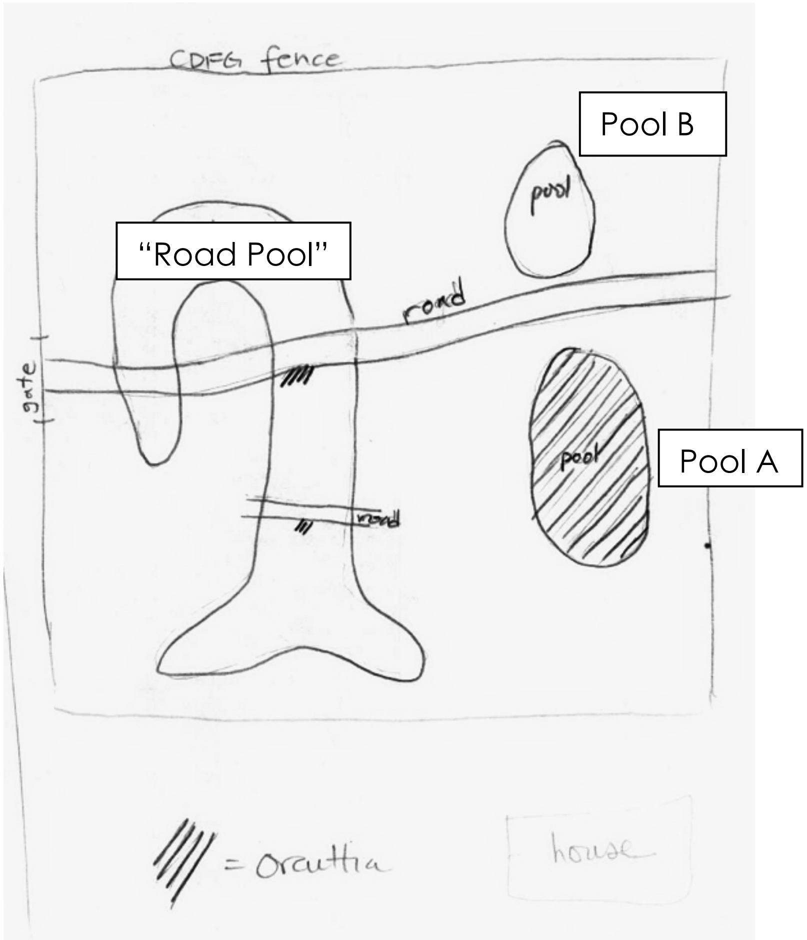

Figure 21. Hand-drawn locations of Sacramento Orcutt grass at Phoenix Field Ecological Reserve in 1982 (Cochrane 1982), with annotations.

Reserve was revisited by the same surveyor in 1997 and plants were only present in Pool A. There are no documented observations of Sacramento Orcutt grass at the Reserve from 1998 to 2009, so there is no population history for that span of time. Sacramento Orcutt grass was observed in Pools A and B in 2010, and again every year from 2013 to 2024, with populations estimated in the tens of thousands. Based on this history of observations, it seems likely that Holland's translocation in 1980 was initially slow to spread, but colonized suitable microhabitat in Pool B, and has now reached a state of apparent equilibrium, with its abundance still fluctuating from year to year in response to weather conditions and ecological interactions.

The apparent colonization of Pool B by Sacramento Orcutt grass after inoculation with a relatively small quantity of seeds from Pool A demonstrates that Sacramento Orcutt grass is a good candidate for translocations to other similar vernal pools. Such translocations may not require much effort after initial inoculation and may therefore be a valuable hedge against extinction of the species.

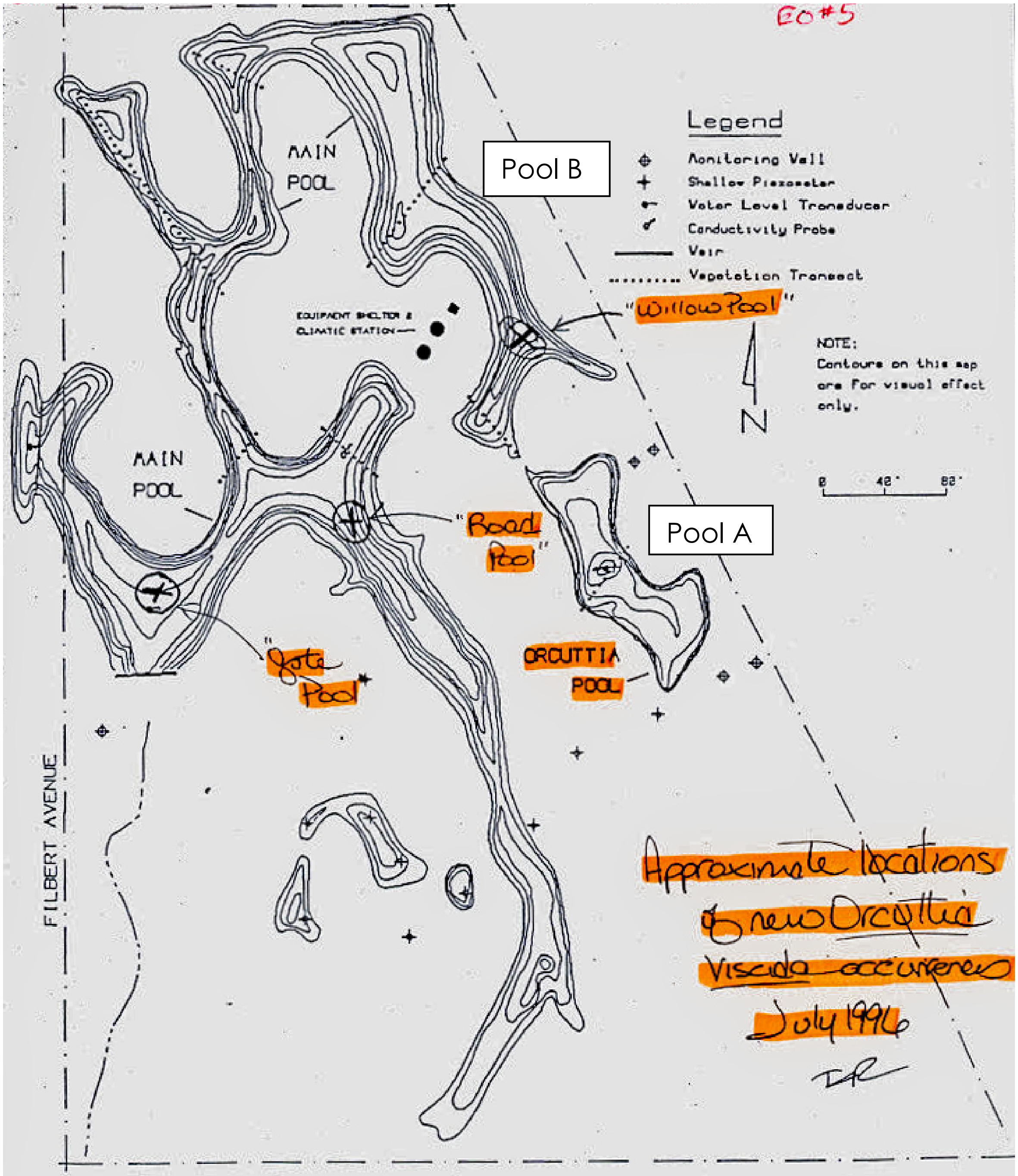

Figure 22. Locations of Sacramento Orcutt grass at Phoenix Field Ecological Reserve in 1996 (Morey 1996), with annotations.

WAXY MANNAGRASS CONTROL

A primary concern of this monitoring project has been the presence and expansion of waxy mannagrass in pools supporting Sacramento Orcutt grass and its possible negative effects on the species. Invasion of vernal pools by waxy mannagrass has been shown to significantly alter the function of pools (Gerlach

2012), and dense populations of waxy mannagrass are reported to eliminate or significantly reduce populations of all native plant species (DiTomaso et al. 2013). As demonstrated by Gerlach (2012), waxy mannagrass control is difficult, so it is critical to either prevent introduction of waxy mannagrass or eradicate it when population density is low. The presence of waxy mannagrass at the Reserve has been a concern since the mid-2000s (Gerlach et al 2009). There was a dense population of waxy mannagrass in Pool A in early 2007 (Figure 23) but after control efforts began in 2007, waxy mannagrass was reported to be absent from Pool A in both 2010 and 2011 (Gerlach pers. comm. 2007, Gerlach 2012). Our monitoring confirms that Pool A has continued to be free of waxy mannagrass from 2014 to 2024.

Figure 23. Waxy mannagrass (*Glyceria declinata*) in Pool A in spring 2007 prior to hand weeding. Photo from Gerlach (2012).

Gerlach (2012) made mention of "a few plants at the northeast corner of the site which I have not been weeding," which is likely the population of waxy mannagrass we have been working to control in Pool B. Our efforts to control waxy mannagrass from Pool B between 2018 and 2023 appear to have halted its expansion (see Figures 6 and 8) but we have not yet eradicated it from the pool, so it will continue to be a threat to Sacramento Orcutt grass and the other native species in Pool B. A notable difference between pools A and B is the presence of common spikerush in Pool B (see Figure 10) and its absence from Pool A. In addition, Pool B is closer to residential landscaping in the northeastern corner of the Reserve, and Pool A is farther from and more hydrologically isolated from landscaping runoff. From a management standpoint, the common spikerush in Pool B made it difficult to detect and remove waxy mannagrass from that pool, which likely decreased the effectiveness of our control effort. Runoff from residential landscaping may also create conditions that are more favorable for waxy mannagrass in the northeastern corner of Pool B, where we most frequently detected that species (see Figure 7).

Although we did not eradicate waxy mannagrass from Pool B, we were nevertheless able to reduce waxy mannagrass frequency enough to meet Management Objective #1 in 2024 (see Management Recommendations section, below), with no additional control efforts in 2024. While the waxy mannagrass population at the Reserve does not appear to be expanding rapidly at this time, the waxy mannagrass population could expand rapidly in the future if unchecked. Continued monitoring of waxy mannagrass and reinitiating management actions if the threshold is crossed again will be necessary to safeguard against the expansion of waxy mannagrass within the Reserve.

COMPETITION

We found a correlation between Sacramento Orcutt grass frequency in Macroplots A and B for the 2014-2024 monitoring period, which suggests that the populations in both pools respond similarly to environmental conditions such as weather. Unlike in Pool A, Sacramento Orcutt grass co-occurs with both waxy mannagrass and common spikerush in Pool B, and the dynamics of these species could therefore affect Sacramento Orcutt grass frequency. Indeed, we found a negative correlation between waxy mannagrass and Sacramento Orcutt grass frequency in Pool B, although the two species were rarely seen in proximity during our monitoring visits (but see Figures 1 and 8). On the one hand, the negative correlation could be explained by differing responses of the species to weather patterns. On the other hand, there could be strong competition between Sacramento Orcutt grass and waxy mannagrass during earlier life stages such as during germination and springtime aquatic growth that result in the appearance of almost no overlap in distribution of the species later in the season in May and June. Waxy mannagrass seed germinates after early rains and before vernal pool inundation and then plants develop an aquatic form after inundation (Gerlach 2012). Seeds of *Orcuttia* species germinate in January and February after inundation (Griggs 1980, Griggs and Jain 1983, Keeley 1998). Established waxy mannagrass plants could therefore exclude Sacramento Orcutt grass from germinating and establishing in the areas it occupies, even if the waxy mannagrass is later removed or killed by land managers, wildlife, or other impacts. We actively removed waxy mannagrass from 2018 to 2023 in Macroplot B, so our frequency data from 2018 to 2023 is not representative of natural waxy mannagrass recruitment alone, but instead represents locations where waxy mannagrass evaded our detection and persisted to maturity despite our efforts. Even if low densities of waxy mannagrass have little effect on Sacramento Orcutt grass, higher densities would almost certainly have an effect. Ensuring that waxy mannagrass populations are controlled or eradicated at the Reserve continues to be a very important objective, particularly in the pools supporting Sacramento Orcutt grass, but also to stop any spread into other pools that could support Sacramento Orcutt grass in the future.

We were initially concerned that a dense stand of common spikerush in Pool B would impact the Sacramento Orcutt grass population if it expanded, but our data shows no significant change in common spikerush frequency, and we therefore do not believe that expansion of common spikerush in Pool B is a major concern.

Frequency of other non-native plants (excluding waxy mannagrass) fluctuated but had an overall increasing trend over the monitoring period. We did not collect data on the specific non-native plant species we detected in our quadrats, which makes it difficult to interpret the frequency results of other non-native plants. Nevertheless, based on our general observations, the upland areas at and above the vernal pool margins were dominated by a suite of non-native species typical to the area, including grasses such as barbed goat grass (*Aegilops triuncialis*), Pacific bent grass (*Agrostis avenacea*), silver hair grass (*Aira caryophyllea*), large quaking grass (*Briza maxima*), small quaking grass (*Briza minor*), ripgut grass (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), and Bermuda grass (*Cynodon dactylon*). There were also forbs including storksbill (*Erodium* spp.), dwarf rush (*Juncus capitatus*), hairy hawkbit (*Leontodon saxatilis* ssp. *longirostris*), and winter vetch (*Vicia villosa*). At the transition between upland areas and vernal pools we frequently detected rye grass (*Festuca perennis*). The non-native species that we most frequently encountered within vernal pools was rabbitsfoot grass (*Polypogon monspeliensis*). We therefore suspect that rye grass and/or rabbitsfoot grass may have been the primary contributors to the increasing frequency of other non-native plants within Macroplots A and B. Because rabbitsfoot grass is more likely to compete with Sacramento Orcutt grass than rye grass, rabbitsfoot grass is a good candidate to monitor individually within the macroplots.

OTHER OBSERVATIONS

From 2014 to 2024, there did not appear to be any major perturbations that could be detected by the monitoring photographs taken during frequency estimation (in May or June); however, there were minor fluctuations in the amount of dry standing biomass in and around vernal pools. Monitoring photographs also show the growth of native oak trees on the Reserve and increasing biomass of exotic trees and other vegetation around the Reserve's perimeter. We did not take measurements of residual dry matter on the Reserve, but the monitoring photographs show that it remained relatively high throughout the monitoring period. Prior to our monitoring visit in 2024, weed whips or other equipment were used to knock down some vegetation around the reserve perimeter (see 2024 foreground in Figure 16).

We observed significant impacts from harmful algal blooms in the southern part of the Reserve as a result of runoff from a yard where one or more horses are kept (38.654146, -121.214660). Portions of vernal pools that are hydrologically connected to and nearby the horse-yard have low abundance of native vernal pool species and high abundance of exotic species such as dock (*Rumex* sp.) when compared with vernal pools that are farther away. A new home was also constructed adjacent to the northwestern corner of the Reserve in 2023 (see Figure 16) which is now contributing additional urban runoff to vernal pools in the northwestern corner of the Reserve.

ASSESSMENT OF THE MONITORING PROJECT

The monitoring project has been a success in that we now have an 11-year dataset of baseline frequency and photomonitoring data that can easily be collected again in the future to make historical comparisons. We identified areas of Sacramento Orcutt grass habitat at highest risk from waxy mannagrass spread and implemented waxy mannagrass control efforts that kept waxy mannagrass at a low and manageable frequency. The monitoring and management we implemented is also extremely time efficient. We can implement it with only four person-workdays of field effort per year (two people to implement the mannagrass control in March and two people to collect data in May or June).

Macroplot corners were utilized as the positions for photomonitoring, which was convenient and allowed assessment of the overall condition of the Reserve across years, but photos were taken too far away from dense populations of Sacramento Orcutt grass to make effective qualitative assessments of population conditions. The photomonitoring would have been more effective if the photopoints had been selected by prioritizing the best fields of view, both close and far, across the Reserve.

The frequency monitoring protocol could be improved by specifically collecting frequency data on rabbitsfoot grass to determine whether the species is increasing within the pools. Collection of common spikerush frequency data does not need to continue annually; however, it may be valuable to collect common spikerush frequency data every five years for comparison with the baseline data.

The monitoring project could be improved with annual monitoring of the pincushion navarretia population. Pincushion navarretia is the rarest plant at the Reserve, but our monitoring and management visits were not conducted at the appropriate time of year to effectively monitor this species. Monitoring visits for pincushion navarretia would need to occur in late April or early May.

Our waxy mannagrass control visits in early March were a little too early, which made identification of the species difficult. Our waxy mannagrass control visits in April were a little too late because some plants had already gone to seed. Mid-March may be the ideal time to implement waxy mannagrass control at the Reserve, but the ideal date will change slightly each year based on pool inundation and plant phenology.

Management Recommendations

The management objective and management implication identified in the Monitoring Plan are included below, with a discussion of whether the management implication should be triggered based on the monitoring results.

Management Objective #1

Maintain a 1 m^2 waxy mannagrass frequency of 10 percent or less in Macroplots A and B at Reserve in every year. (This is a target/threshold type of management objective.)

Management Implication—If any portion of the 90 percent confidence interval for waxy mannagrass frequency at the 1 m^2 scale exceeds 10 percent in Macroplot A or Macroplot B, CDFW shall organize and initiate a waxy mannagrass hand pulling effort in the following spring, before waxy mannagrass seeds have set.

Recommendation—The 90 percent confidence interval for waxy mannagrass exceeded ten percent in Macroplot B in 2015 and every year from 2017-2023. The management implication was triggered and implemented from 2018-2023. Because the 90 percent confidence interval for waxy mannagrass did not exceed ten percent in Macroplot B in 2024, the management implication is no longer triggered, and we ceased waxy mannagrass control activities in 2024.

Other Recommendations

- CDFW should strive to eradicate waxy mannagrass from the Reserve. So, even in years when the management threshold is not reached, CDFW should continue efforts to remove waxy mannagrass from Pool B and the entire Reserve while the population sizes remain low.

- Continue annual frequency monitoring at the Reserve as described in the Monitoring Plan, at least until waxy mannagrass is eradicated from Pool B, at which point monitoring interval could be reduced to every two years.
- Collect rabbitsfoot grass frequency data during future monitoring site visits using the same nested frequency protocol described in the Monitoring Plan.
- Reduce the common spikerush frequency monitoring to every five years.
- Monitor the pincushion navarretia population at the Reserve annually in late April or early May for several years to establish baseline population data and ensure that the population is resilient. Due to its small population size, a complete census of the pincushion navarretia population may be possible. Establishing a monitoring plot would aid data collection.
- Establish photomonitoring points that can capture a closer view of patches of Sacramento Orcutt grass to provide a visual for changes in population density and the interspersed vegetation over time.
- Implement and monitor additional translocations of Sacramento Orcutt grass to unoccupied pools at the Reserve.
- Conduct annual water quality testing at several pools one to three times per season to establish a baseline for the pools in the Reserve and provide a measure of nutrient loading from the surrounding developed area.

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Letter from John Gerlach to Sara Holm regarding permission to weed Glyceria declinata at Phoenix Field Ecological Reserve, April 13, 2007.

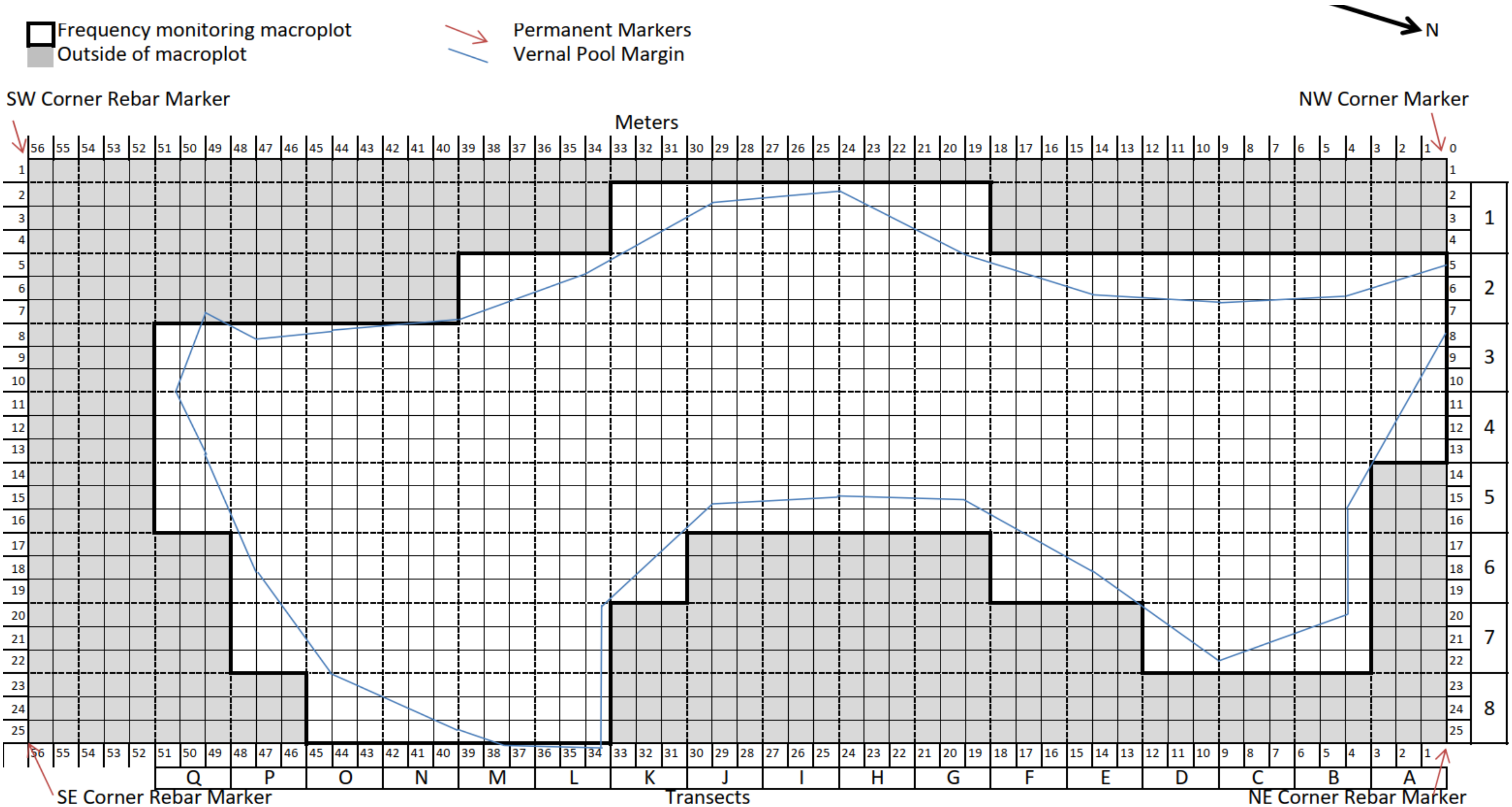
Reviewers

This document was prepared by Jeb McKay Bjerke, a senior environmental scientist (specialist) in the CDFW's Native Plant Program. The following individuals reviewed this document:

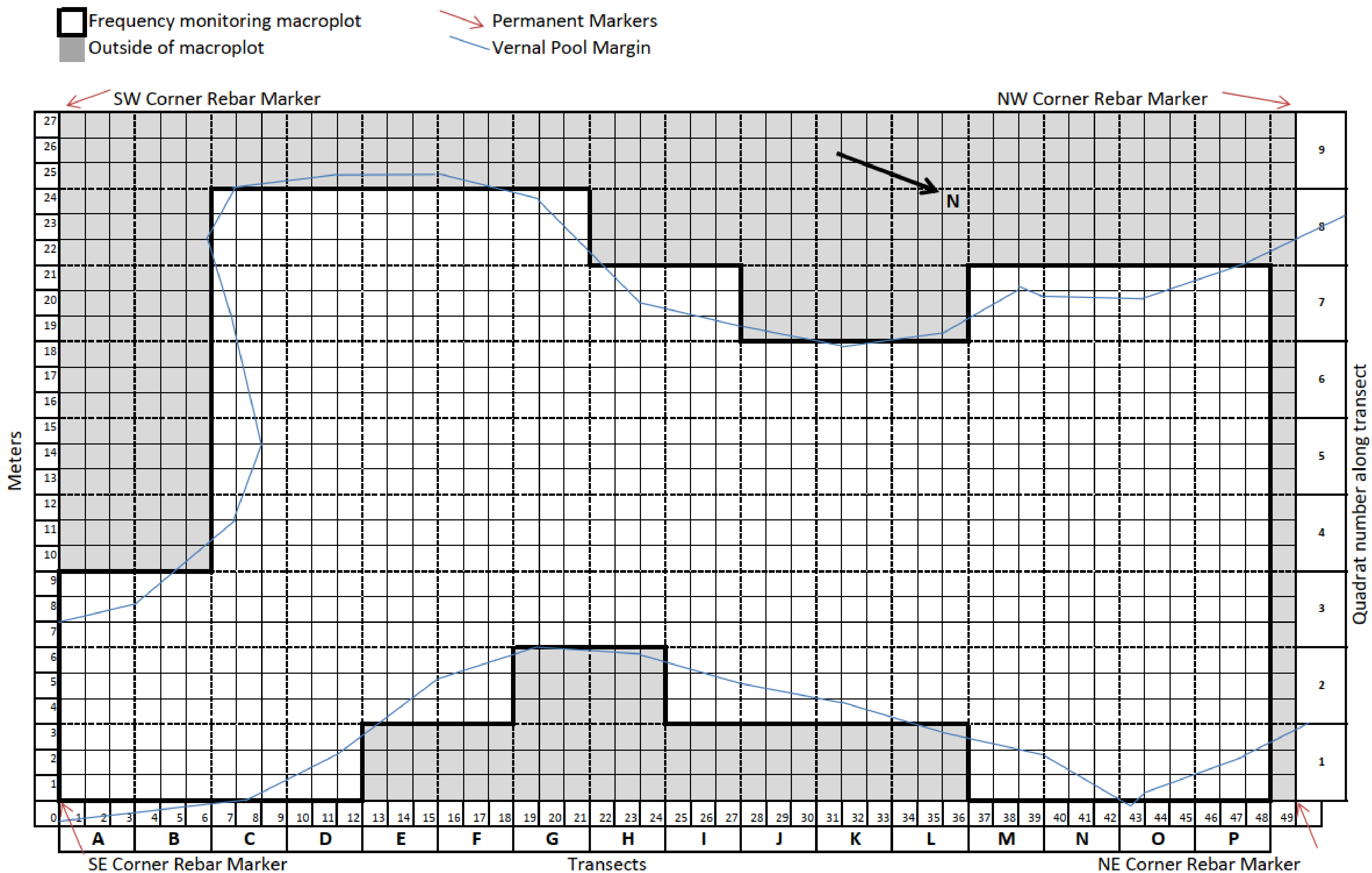
- Cherilyn Burton, CDFW Native Plant Program
- Raffica La Rosa, CDFW Native Plant Program
- Rachel Powell, CDFW California Natural Diversity Database
- Dustin Wallis, CDFW North Central Region

Appendix A: Frequency monitoring macroplots at Phoenix Field Ecological Reserve

Macroplot A



Macroplot B


Frequency monitoring macroplot
Outside of macroplot
Permanent Markers
Vernal Pool Margin
SW Corner Rebar Marker
NW Corner Rebar Marker
N
Meters
Quadrat number along transect
SE Corner Rebar Marker
Transects
NE Corner Rebar Marker
A B C D E F G H I J K L M N O P