Ventura Marsh Milk-vetch

(Astragalus pycnostachyus var. *lanosissimus)*

2023 Management and Monitoring Report

North Campus Open Space, Santa Barbara, CA
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Cheadle Center for Biodiversity and Ecological Restoration
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Introduction

UC Santa Barbara's Cheadle Center for Biodiversity and Ecological Restoration (Cheadle Center) began working with the US Fish and Wildlife Service to plan for the introduction of the federally-endangered Ventura marsh milk-vetch (*Astragalus pycnostachyus var. lanosissimus*) at UCSB's North Campus Open Space (NCOS) in 2018. The first individuals were planted in a sandy site with high sub-surface soil moisture on the upper edge of the highwater mark of the newly restored upper arm of Devereux Slough in November 2019. These individuals were grown from seed collected from the original population in Oxnard and obtained from Mary Carroll. In an effort to elevate plants during episodes when the slough is fully ponded and to mimic conditions we believed may be related to success at planted locations in Ventura five east-west trending berms approximately 1.5 meters wide, 0.5 meters tall, and 10 meters long were constructed with a small tractor. These were to test the effect of subtle differences between north and south facing slopes as was observed in Ventura. At the same time, 6 vetch were outplanted in the "EEM" Swale, a willow woodland with sandy soils near an ephemeral stream. In November 2019, 231 (Sandy zone) and 6 other individuals, grown at the Cheadle Center nursery and about 10 months old, were planted, with subsequent planting taking place on adjacent sandy mounds in September 2020 (55) and October 2020 (46) (Figure 1). These are detailed in previous reports.

In December 2020, an estimated five cups of unprocessed seed were collected from the main population of previously planted individuals and dispersed experimentally across different zones of NCOS that were seen as potentially suitable habitat for the expansion of this initial population (Figure 1). The "sandy zone" is a northeast-facing slope and adjacent sandy plain just southeast of the main planted population and consists of recently exposed soils with a similar consistency and make up of fine beach sand. The "Tule Seep" is a perennially wet seep surrounded by willow *(Salix lasiolepis)* and tule *(Shoenoplectus californicus)* and underlain by clay and clay loam soils. Whittier Pond is a small freshwater pond that holds water throughout the entire year. The "Bioswale" site is a string of low-lying swales or subtle vernal pools descending in elevation northwest from the mesa into the saltmarsh transition with dense clay soils. Finally, several square meter plots were seeded in South Parcel on sandy soils, in mixed riparian woodland and coastal sage habitats. Each of these five zones received one cup of collected seed and fruit material. Germinating seedlings were observed and monitored on a monthly basis during the growing season over the past 3 years.

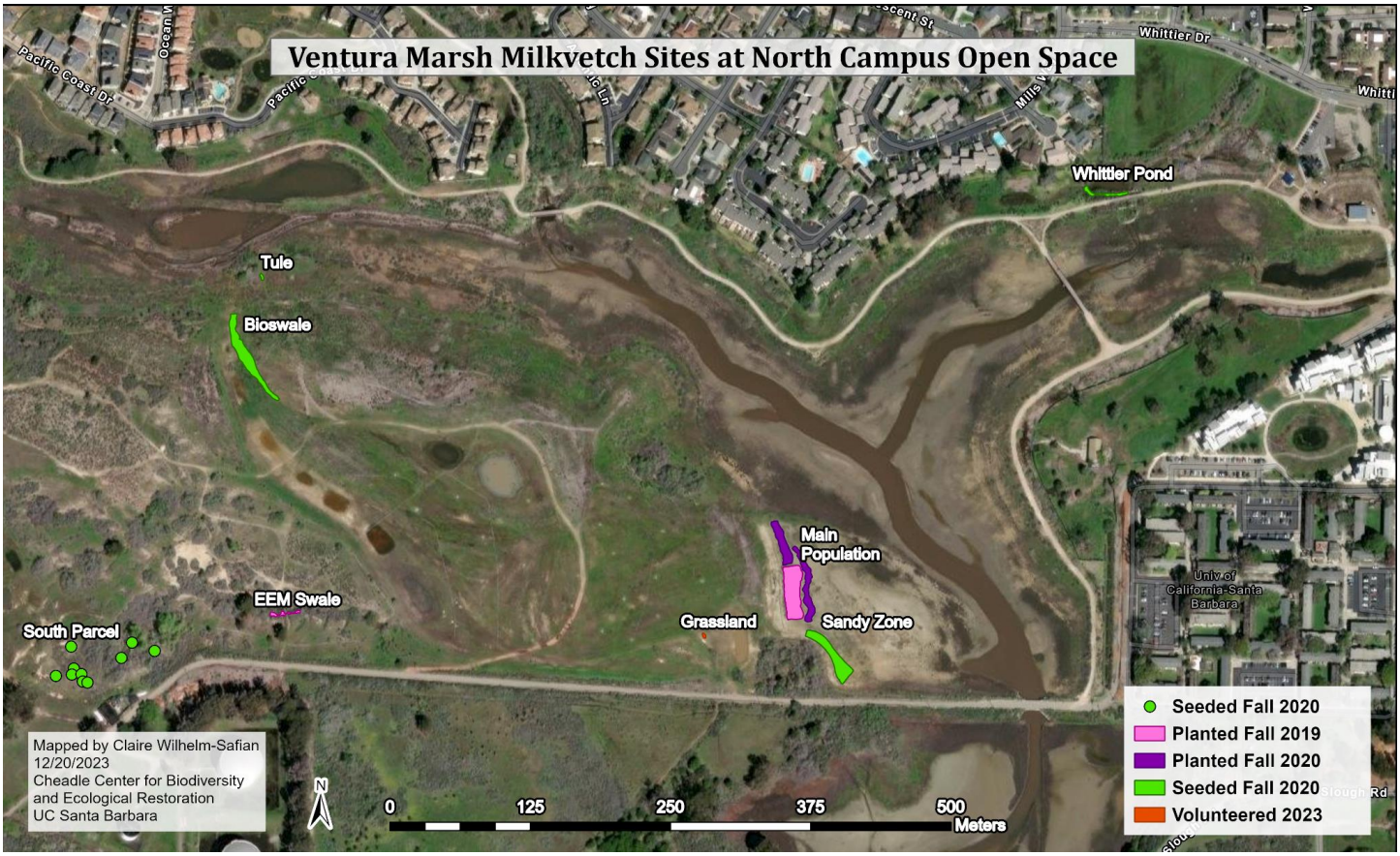

Figure 1: Map of vetch plantings and seed dispersal sites.

Seed Dispersal Site Monthly Monitoring

The five sites selected for seed dispersal were monitored monthly starting in March of 2021. Each individual was counted and assigned a vigor rating from 1 to 4 (1 - Healthy; 2 - Minor Health Defects; 3 - Serious Health Defects; 4 - Dead). An individual was considered an adult once it reached reproductive capability by producing flowers. Only three of the five zones (the Bioswale, the tule seep, and the sandy zone) have produced adult vetch at any point. No vetch has ever germinated at the Whittier Pond site, while only a single seedling germinated at South Parcel, which did not survive longer than a month.

The first two generations of vetch, which germinated in 2021 and 2022 respectively, were counted separately from the seedlings in 2023. The surviving adult population from these years remained relatively steady throughout the year (Figure 2). As Ventura marsh milk-vetch is a short-lived perennial with an average lifespan of three to five years, it is expected that some individuals may not survive the winter dormancy period. The population requires recruitment to remain sustainable.

Most sites experienced very little germination in spring 2023 despite significantly higher than normal rainfall (Figure 3). The Tule Seep is home to 15 large healthy adults, all of which are first generation individuals. There was no germination at this site in either 2022 or 2023,

despite every adult flowering and setting seed. There is very little disturbance at this site, which has compacted clay soils. These factors may account for the lack of recruitment, with seeds remaining dormant in the seedbank until a stochastic disturbance triggers germination. Since this site is fairly densely congested with competing tule, willow, and non-native irises, and the band of habitat supporting this vegetation that could be considered the “edge” between the wetland’s basin and the upland is narrow, a high rate of recruitment is unlikely. The more interesting observation here is that the plants recruited, grew, and survived into adulthood without irrigation, and in soils that are distinctly different from the sandy soils in the main population to the east.

The Bioswale exhibited the most germination in 2023, especially in the lower elevation areas where heavy rains in the winter of 2022-23 caused erosion and deposited fresh sediment from higher elevation vernal pools. One individual was found significantly farther downslope from the original seeding area. New green basal shoots were already observed in December 2023. Additional seed and chaff was spread in the higher elevation vernal pools south of this zone in November of 2023. The monitoring zone will be extended next year to account for possible new germination. The importance of this site is the fact that it represents a success recruitment site with such clay-rich soils and a hydrology that is different from the sandy zone. Observations such as this are suggestive that the taxa could have perennially occurred in some density in the adjacent uplands of associated wetlands that would become ideal habitat only stochastically but could have served as a reservoir after significant disturbance to wetland areas.

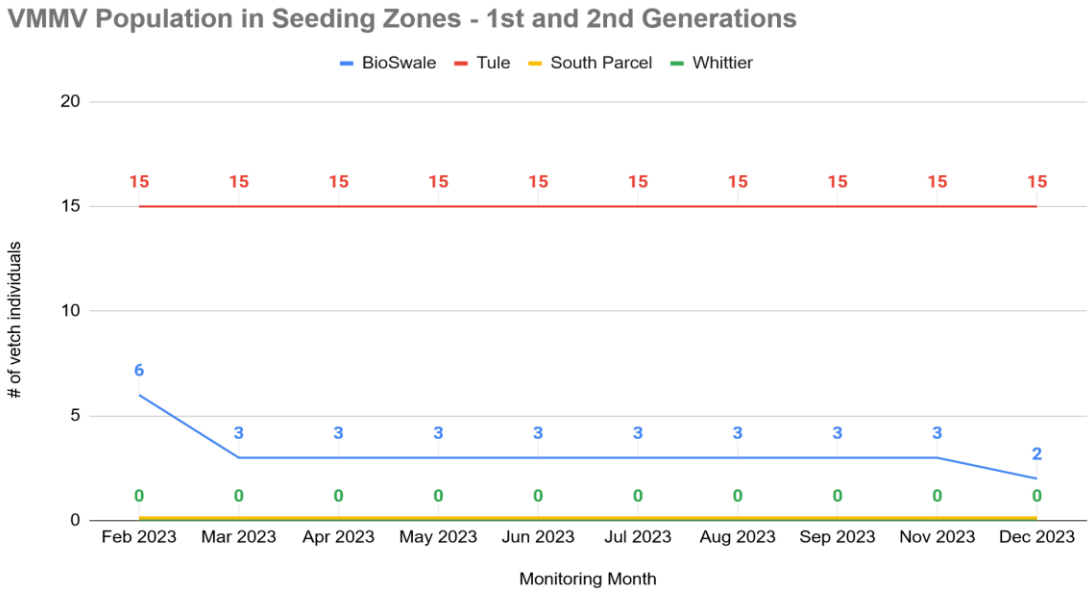

Figure 2: Population of vetch in seed dispersal sites that germinated in 2021 and 2022 and survived into 2023.

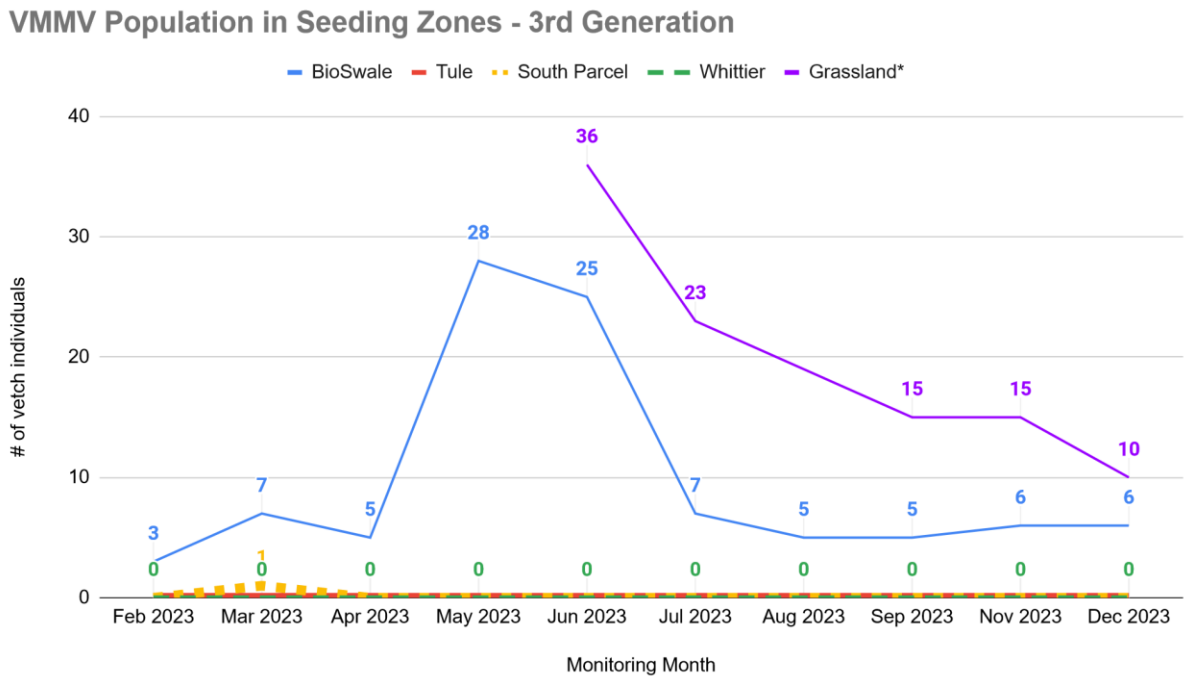

Figure 3: Population of vetch in seed dispersal sites that germinated in 2023, three years after dispersal.

A volunteer population of 36 vetch seedlings was first observed on the edge of the restored *Stipa*-dominated grassland in June, just west and upslope of the original population. No seed was purposefully spread in this area, which is at a higher elevation than the main population and over 200 feet away. The seedlings were flagged and monitored monthly starting in June. None of them flowered or grew taller than one foot in height. The relatively dry and compact clay soils are unlikely to support this population in the long term, but they persisted for the full summer. The method of dispersal is unknown. Since NCOS, broadly speaking, has hundreds of thousands of seeds present and has for several years, it should not be too surprising that they are dispersing around the project site. What is most notable is that upland areas, with heavy clay or clay loam soils and no appreciable subsurface soil moisture, can support Ventura marsh milk-vetch. The Cheadle Center is conducting some experimental seeding trials on sandy soils in Coal Oil Point Reserve (COPR) and studying the groundwater levels and soil conditions. Interestingly we found relatively little germination in sites that appeared suitable but that experienced no flooding. A separate report is available on that study. It is noteworthy that this colonization phenomenon generally does not seem possible in very deep sandy soils without subsurface soil moisture like the ones present at COPR, but is found in denser, upland soils.

For the first two years of monitoring (2021 & 2022), the sandy zone was monitored monthly along with the other four seed dispersal sites. By 2023, the sandy zone had expanded greatly, with thousands of seedlings recruiting, making a monthly full count infeasible. This site was excluded from monthly monitoring and a quadrat survey was conducted in August 2023 during the peak of the bloom period in order to estimate the seedling population. Sixteen square

meter quadrat sites were randomly selected and stratified by seedling density. The sandy zone was mapped using a high accuracy Geode GNS3 receiver to categorize the area of each density class. Four quadrats were surveyed in each density class. The samples of each density class were averaged and multiplied by the percentage of total area. The estimated total seedling population is 17,885 (Table 1). Additionally, an estimated average vigor was assigned to each quadrat. Overall, seedlings were in good health, with an average vigor across the site of 1.38 (where 1 is high, 2 is medium, 3 is poor and 4 is dead) (Figure 4).

None: 0 seedlings/m^2
Low: 1-10 seedlings/m^2
Medium: 11-20 seedlings/m^2
High: 21+ seedlings/m^2

Table 1.

Sandy Zone Seedling Population Estimate				
Density Class	Area (m2)	% of total area	Average Seedlings/m2	Estimated Total
High	147.198591	4.99%	101.67	14,965.19
Medium	140.072283	4.75%	19.33	2,708.06
Low	63.44946	2.15%	3.33	211.50
None	2,600.761436	88.12%	0	0.00
Total	2951.48177	100.00%	124.33	17,884.75

During the seedling survey, we found that the class ranges were too narrow; many quadrats were either low or high, with few in between. In future years, the classes should be expanded to better represent the population's tendency to germinate in dense patches.

Adult vetch were fully counted in this zone and assigned a vigor rating (Figure 4). While there were 19 deaths, mostly of older individuals, the adult population increased to 181 in 2023 from 58 in the previous year. The average vigor among adults was high at 1.845. As of August, 160 were flowering (88.4% of the adult population).

In the past two years, the sandy zone population has experienced increased encroachment by *Melilotus indicus* and, to a lesser extent, *Melilotus albus.* These nitrogen-fixing invasive annual clovers are followed by other non-native species including *Plantago coronopus* and *Polypogon monspeliensis.* The potential change in soil nutrients as well as the increase of competition may pose a challenge to new milk-vetch recruitment. Management of *Melilotus* sp. included extensive hand-weeding efforts prior to fruiting and string-trimming afterwards. String-trimming prevented the clover from dropping seed, but did not remove nitrogen-fixing root nodules from the soil. Further study of soil nutrient conditions may be warranted.

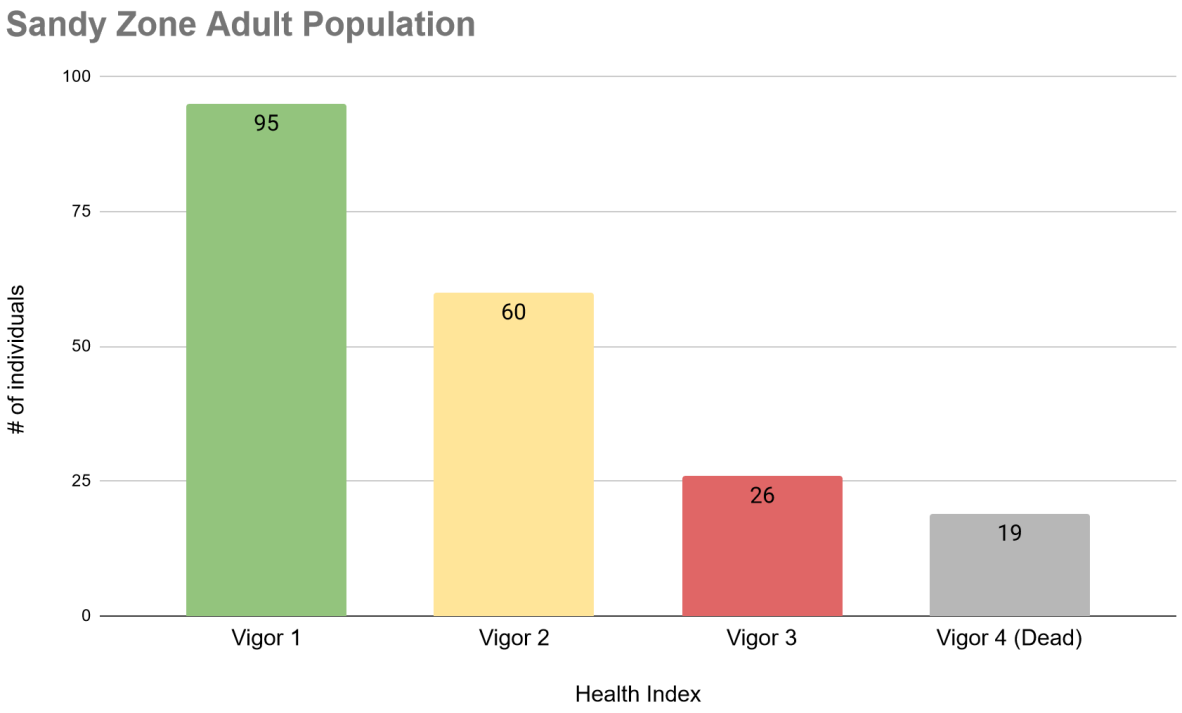

Figure 4: Population of sandy zone adults grouped by vigor.

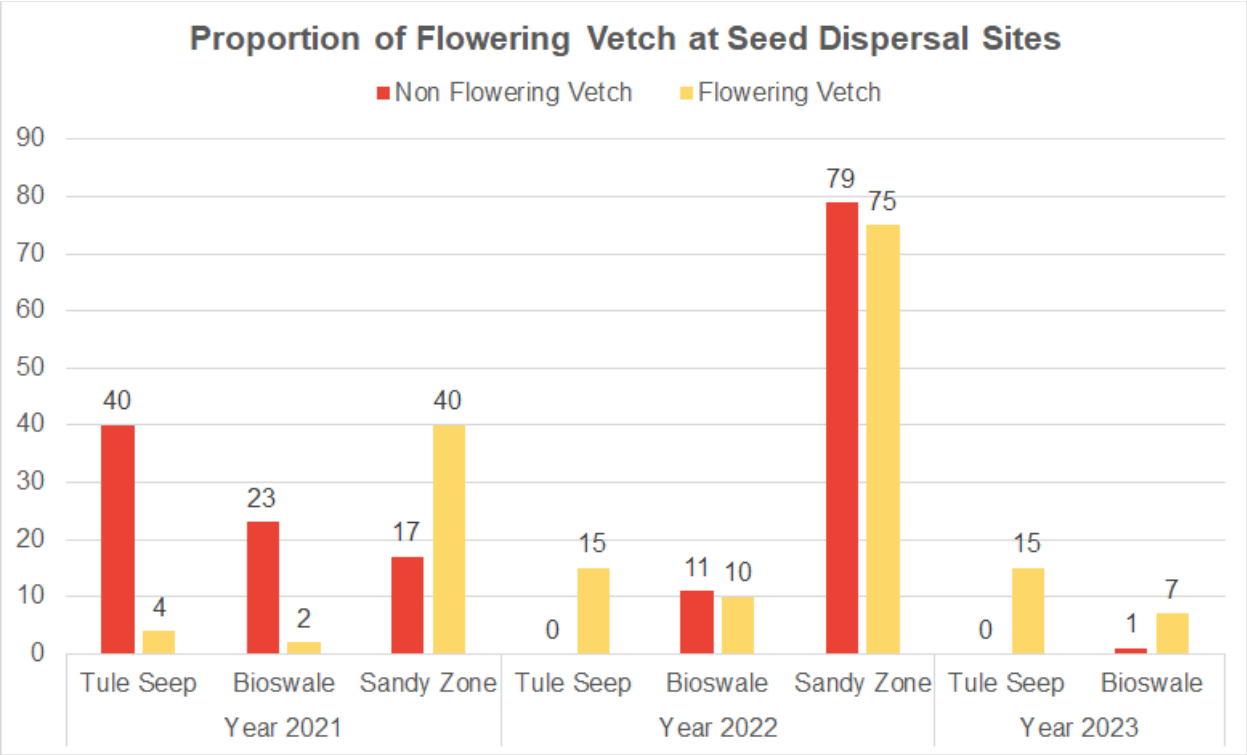

Figure 5: Flowering vs. non-flowering individuals in seed dispersal sites from year to year. sandy zone statistics from 2023 omitted in graph due to high numbers (160 flowering, 17,906 non-flowering).

As the vetch matures, there has been an increase in the proportion of flowering individuals across all sites (Figure 5). Observationally, most flowering plants also produced seed. In 2023, approximately 6 quarts of seed material and chaff was collected from the sandy zone and the main population. Most of the collected seeds were later spread in the vernal pool swale just south of the previously seeded bioswale site (detailed later in this report).

Outplanted Population Monitoring and Management

The main population was originally planted with 231 nursery-grown vetch in November of 2019, with subsequent plantings of 55 individuals in September 2020 and 46 in October 2020. An additional 6 individuals were planted in a willow woodland swale called the EEM Swale, on the Environmental Enhancement and Mitigation Grant parcel of NCOS. These outplanted milk-vetch were arranged in arrays, numbered 1-18. Arrays 1-11 consisted of the November 2019 planting, arrays 12-17 the September 2020 planting, and array 18 the October 2020 planting (Figure 6). Each individual was given a unique ID and a tag was tied to the irrigation line next to it. Due to sufficient rainfall in the winter of 2019-20, the irrigation was never utilized for Arrays 1-11. Arrays 12-17 were irrigated for a few months post-planting until the winter rains began. Array 18 was also hand-irrigated briefly until the rainy season arrived.

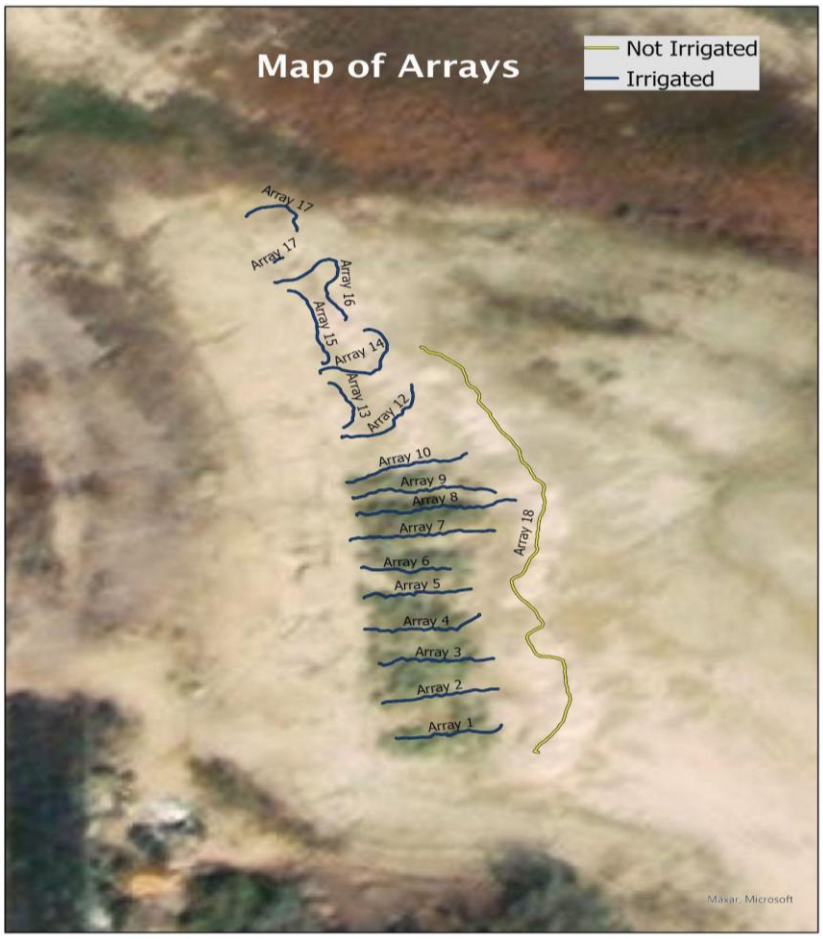

Figure 6: Map of the original outplanting arrays. Not pictured: Array 11 in the EEM Swale.

When going into winter dormancy, the stems of adult vetch die off slowly, and the next year, they grow entirely new stems from their bases. Three winters since the population's establishment, a large buildup of thatch including some dead vetch had accumulated. Furthermore, the population of brush rabbits, California voles, and pocket gophers was now significantly higher than it was at the time of the original planting. It was hypothesized that removal of dead branches would stimulate new growth in adults and provide more space and sunlight to seedlings. It may also remove habitat for rabbits and voles, the latter of which have a propensity to create burrow complexes at the bases of the vetch, and feed on the newly resprouting stems as they begin to emerge in the late winter and early spring. To test the effectiveness of this management strategy, the area of Arrays 3-8 was designated the "de-thatch zone" and Arrays 1 & 2 at the southern end of the population were set aside as a control. In late March 2023, thatch was removed and piled on the adjacent slope so that any seed material would wash back down into the population. In addition, the invasive grass *Polypogon monspeliensis* was encroaching on the site. To help to control this, the de-thatched zone was sprayed with a 1% grass-specific herbicide solution (clethodim formulation). The area comprising Arrays 9, 10, and 12-16 was also sprayed, but not de-thatched. The results of adult and seedling surveys were used to evaluate the efficacy of these management strategies.

In the first two years post-planting, the outplanted individuals were monitored monthly and metrics such as number of stems, number of inflorescences, and height were recorded for each individual. In subsequent years, the amount of recruitment and density of the population made granular monitoring difficult without trampling or otherwise disturbing the vetch. The irrigation lines and metal tags were buried in sediment, making them difficult to locate. Since 2021, the main population has been monitored annually in the summer, during peak bloom period using a sub-sampling method.

The same quadrat survey protocol utilized to estimate the sandy zone seedling population detailed earlier was implemented for the main population in 2023, resulting in an estimation of 14,264 seedlings (Table 2). Largely, seedlings were small and densely clustered, though several individuals did reach reproductive adulthood within their first year and were counted in the adult survey, detailed later. Some percentage of milk-vetch can reach maturity in their first year, especially in good growing conditions. Proportionally, the de-thatched zone had the most recruitment by area, with 61.96% of its area containing seedlings. Comparatively, 43.57% of the spray zone and only 29.24% of the control zone was populated with seedlings (Figures 7 & 8). However, the average vigor in the de-thatched zone and the control was the same (~2.67), while seedlings in the spray zone were healthier (~1.00).

Table 2.

Main Population Seedling Population Estimate					
Density Class	Area (m2)	% of total area	Avg Vigor	Average Seedlings/m2	Estimated Total Seedlings
High	213.10	18.59%	2.33	50.00	10654.96
Medium	172.33	15.04%	2	14.00	2412.59
Low	156.11	13.62%	2	7.67	1196.86
None	604.62	52.75%	4	0.00	0.00
Total	1146.16	100.00%	2.25	71.67	14,264.41

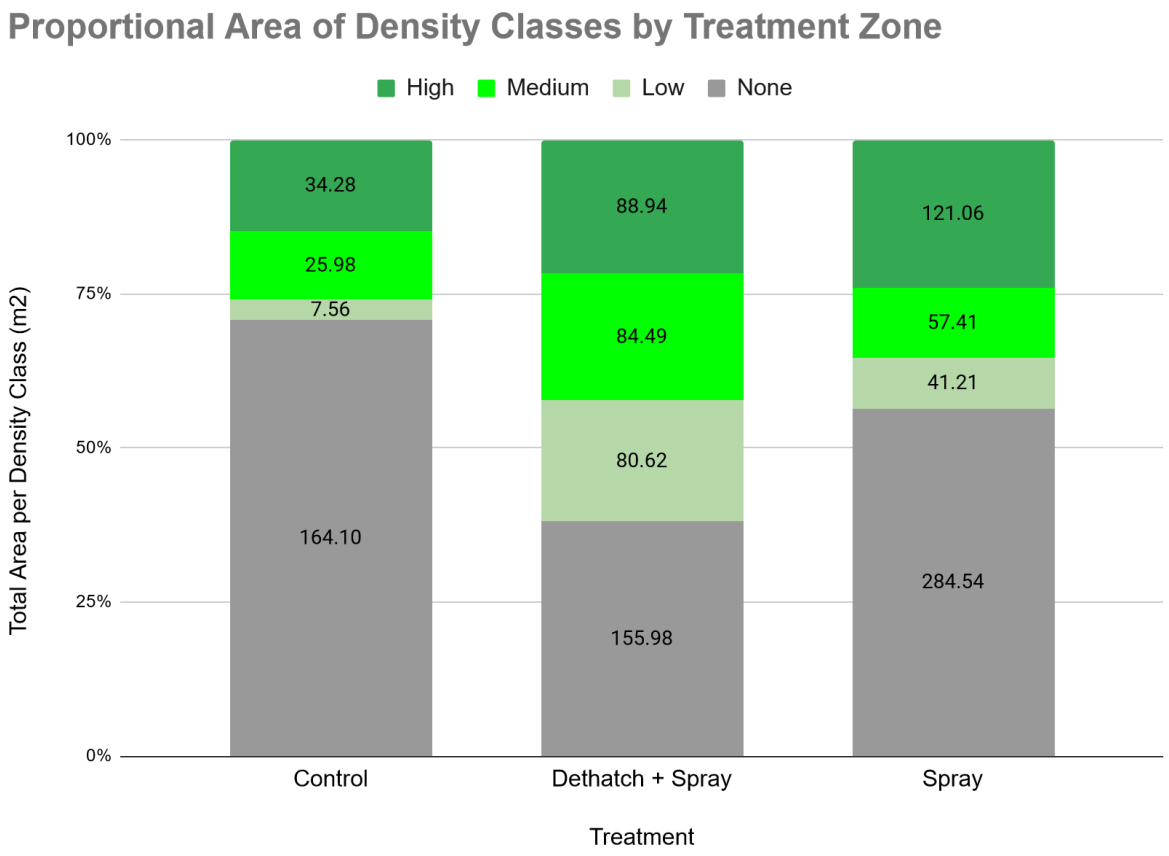

Figure 7: The area (m^2) of density classes in the spray, dethatching, and control treatment zones as a proportion of their total area.

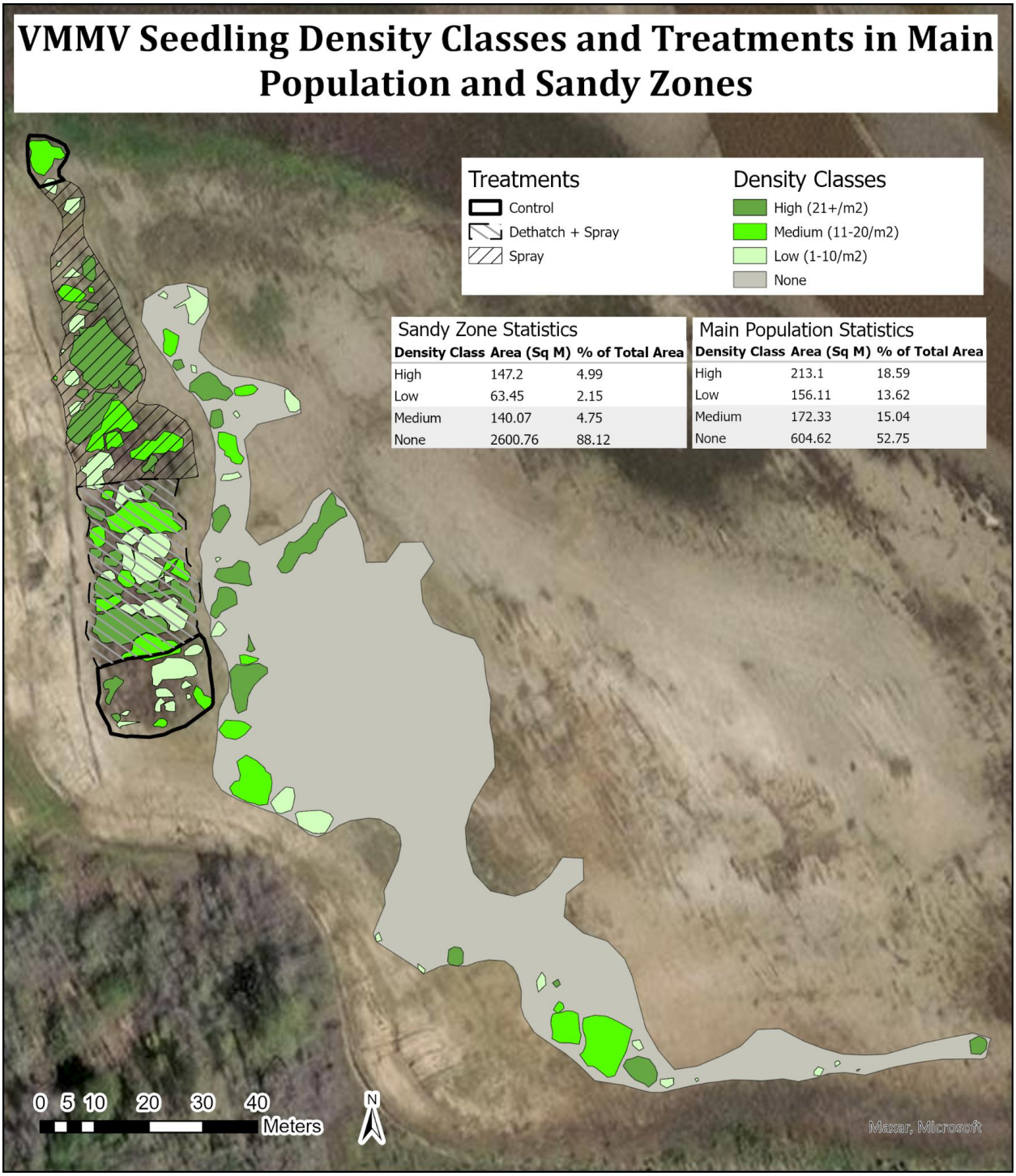

Figure 8. Map of the density of seedlings by zone.

The adult population was estimated via 12 line transects spaced out roughly every 10 meters along the main population (Figure 10). A measuring tape was extended east-west from one edge of the site to the other and the length of the cross-section was recorded. Every adult within one meter on either side of the tape was counted and assigned a vigor. Flowering and non-flowering adults were counted separately and the total number of inflorescences was

estimated. The results of each transect were then normalized by square meter, averaged by the treatment area they belonged to, and multiplied by the area of each treatment zone. The estimated adult population is 814 (Table 3). The de-thatched zone had the highest average of adults/m^2 at 0.86/m^2. However, the health of this zone was the poorest, with an average vigor of 2.66. There were also far fewer inflorescences per flowering plant (5.56) than either the control (12.23) or the spray zone (33.61). Many sterile fruits were observed and there was an infestation of spider mites and mealybugs in this zone that resulted in dying foliage (Figure 9). Initially, it appeared that the dethatching would release the milk-vetch and that increased vigor would be observed. However, after a few months, the vetch displayed dry foliage that appeared to be “burned back”, aborted inflorescences, and overall decreased vigor. With the grasses having been treated, the co-occurring *Erigeron canadensis* became more prominent and dominant. Fears that the low vigor and lack of seed set was due or related to the application of clethodim were somewhat assuaged by the eventual observation of microscopic spider mites on the population. The occasional infestation of insect or other pests could be an expected consequence of the vetch’s successes and dense growth at the site.

Table 3.

Main Population Adult Population Estimate					
Treatment	Area (m2)	% of total area	Avg Vigor	Average Adults/m2	Estimated Total Adults
Control	231.92	20.23%	2.27	0.41	95.2
Dethatch + Spray	410.03	35.77%	2.66	0.86	354.6
Spray	504.22	43.99%	1.29	0.72	364.1
Total	1146.16	100.00%			814.0

Figure 9. Mealybugs feeding on a milk-vetch, with resulting dead foliage.

Figure 10. Map of the line intersect surveys used to estimate the main adult population.

The outplanted EEM Swale population has remained relatively small; it is still monitored monthly along with the seed dispersal sites. While nine individuals from previous generations died in 2023, there was also some recruitment, with 5 seedlings surviving to the end of the year (Figure 11). The average vigor of the population was high throughout the year (1.56), though by the end of the year it was medium (2.20) (Figure 12). The mixed sand and clay soils at this site may be limiting the recruitment of new milk-vetch compared to the boom of the outplanted main population.

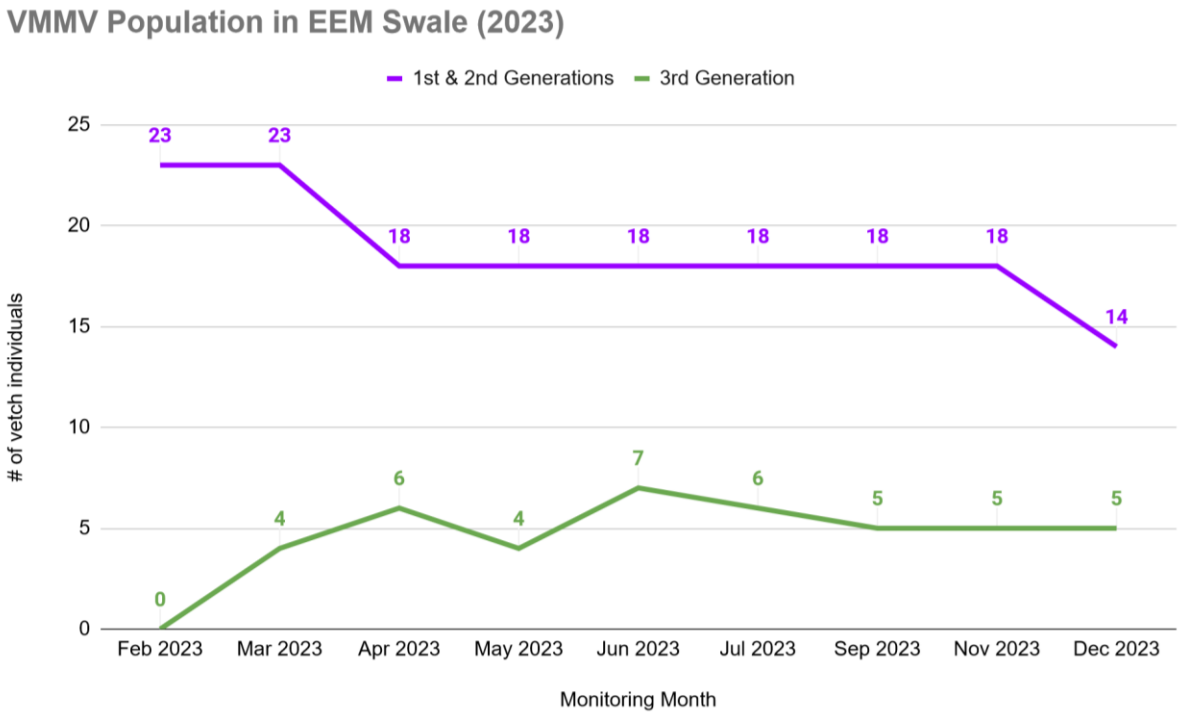

Figure 11. Population of vetch in the EEM swale, including previous generations and new recruits from 2023.

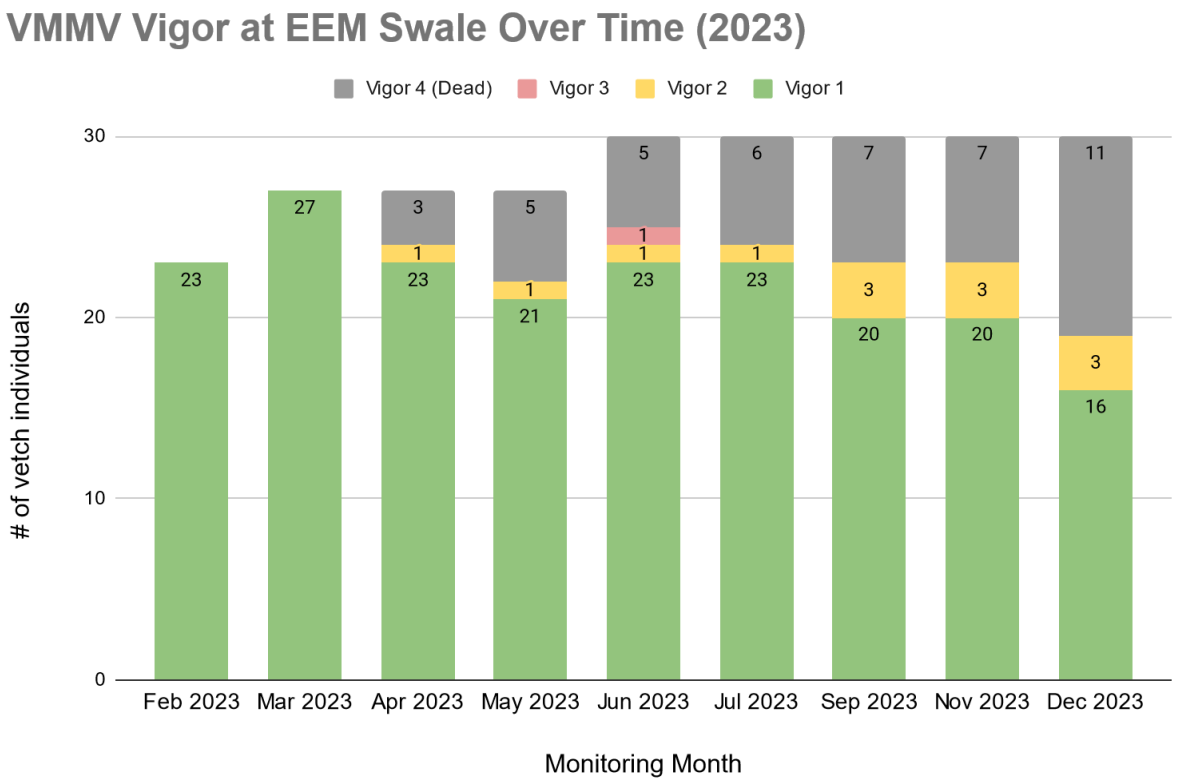

Figure 12. Vigor of vetch in the EEM swale.

Photo Monitoring

Standard photo monitoring points were established around the main population in October 2021 in order to capture visual changes of the population over time. Photos are usually taken once a year during the peak bloom. In 2023, additional photos were taken before and after removing thatch, in March and May respectively. A selection of these photos are included in this report. The full photo monitoring dataset is available upon request.

Figures 13, 14, and 17 capture the main population during peak bloom period. The recruitment of native annuals such as *Erigeron canadensis* in 2023 is particularly noticeable in Figure 17. Figure 15 shows the amount of thatch that had built up from previous year's growth. Figure 16 shows the new growth sprouting from the bases of the milk-vetch after the thatch had been removed.

Figure 13. Photo monitoring point 1A capturing the main population from SW corner (August 2021).

Figure 14. Point 1A capturing the main population from SW corner (July 2022).

Figure 15. Point 1A capturing the main population from SW corner, pre-thatch removal (March 2023).

Figure 16. Point 1A capturing the main population from SW corner, post-thatch removal (May 2023).

Figure 17. Point 1A capturing the main population from SW corner during peak bloom period (August 2023).

Seeding of the Vernal Pool Swale

On November 17, 2023 approximately 6 quarts of vetch fruiting material (estimated 59,548 seeds) was sown before the rainy season in the swale of vernal pools #3-7 at the NCOS site. The seed was collected in the summer of 2023 from the main population and sandy zone. This seed spreading is a continuation of experimental expansion of the vetch into locations around NCOS. The selection of this site was informed by observations of vetch surviving in surprisingly dry uplands elsewhere on site, and at the previously seeded bioswale site. This new vernal pool swale lies directly south of the previously seeded swale that feeds towards the tule site, and may be viewed as an extension of that seeding site. Unlike NCOS vernal pools #1 and 2 which hold water for longer, at pools # 3-7 water tends to percolate into deeper substrates more quickly. It is assumed some of this water could be available and conducive to supporting vetch throughout the dry summers. The ephemeral nature of ponding water in these pools is also an indication that vetches may recruit and survive in the basins of some of the pools themselves, or their lower elevations, where their survival would otherwise be precluded by extended flooding. This vernal pool swale is fairly large (1.7 ac) and represents an exciting potential expansion of the vetch at NCOS (see inset map below).

Inset map of Vernal pool swale Nov. 2023 seeding of VMMV

Flooding at Sandy Zone

Most of the low-lying area in the sandy zone as well as the eastern edge of the main outplanted population flooded after a rain event on December 21, 2023. Devereux Slough remained full near the high-water line for 30 days, as the berm at the mouth of the slough did not breach until January 21, 2024. Past flooding events have been closer to two weeks long. The milk-vetch was senescent at the time. Prolonged submergence may have killed many adults and seedlings from the 2023 growing season. Monthly monitoring will recommence in February of 2024, so it remains to be seen how flooding may have impacted the established populations and whether the disturbance will trigger a large wave of germination.

Figure 18: A photo of an adult milk-vetch in the sandy zone, mostly submerged in water. Photo by Jeremiah Bender.

Threats and Future Management Plans

One potential management challenge at the site is the incremental accrual of both nitrogen and associated vegetation in the most desirable places for the vetch. The most unique and important feature of the site is its hydrology and beneficially high water table, and this cannot be duplicated, expanded, or moved. If indeed this plant was the colonizer of vast swaths of fresh sediment as produced by millenia-old processes such as hundred year storms, and our location is an attempt to mimic that, we may find that our site, while maintaining the desired hydrologic features, is not providing fresh alluvium or otherwise deposited material that is low in nitrogen and without the seedbanks of annual plants. The main sandy zone where the population is largest has steadily accumulated more native and non-native vegetation since 2018. Native taxa include many perennial rhizomatous species such as *Ambrosia psilostachya, Distichlis spicata, Jaumea carnosa.* These may be problematic as they become more entrenched and established, leaving fewer niches for new vetch germination and recruitment and possibly competing with adult plants as well. Previous observations and recommendations indicated that these taxa are ideally not present in high densities for vetch survival (Carroll, pers comm). In addition, woody vegetation, primarily arroyo willow (*Salix lasiolepis)* has continually colonized the site and is removed by the hundreds each year. The southernmost arrays in the

dethatching zone and the southern edge of the main population (control area) have the largest and most mature willows.

More concerning are the expansions of non-native annual weeds such as rabbit's-foot grass (*P. monspeliensis)* and sweet clover (*Melilotus sp.)* which are occurring in the entire footprint of the sandy site. Although vegetation encroachment is not limited to these taxa, they present a potential issue that could change the nature of the entire site, moving it away from N-poor, open sandy soils and towards a thickly-vegetated site with fewer and fewer opportunities for endangered plants to occur. These two taxa likely work in concert, with the annual *Melilotus sp.* fixing nitrogen and the annual *Polypogon sp.* subsequently taking advantage of the increased nutrient availability. *Polypogon sp.* has been known to be extremely invasive in other wetlands, monopolizing niches and spaces physically, reducing or eliminating native taxa, and also being allelopathic after the fact with its dead thatch. The N-fixation issue is magnified by the fact that the vetches themselves are fixing N and may be contributing to the transition into other vegetation types. Some of the most robust and largest *Polypogon* observed have been directly underneath mature vetch plants. Ideally, some of these soils could be periodically relocated and swapped with clean, N-poor and seed-free soils, but how this would be achieved remains unclear. Regardless, the site has changed annually since its creation and its trajectory is dynamic. We propose to significantly disturb the 'control site' in the summer of 2024 in order to see if vegetation removal and upending the soil are sufficient to stimulate new germination by milk-vetch and re-set the soil biology of the site. We hope to collaborate with Professor Carla D'Antonio who has extensive experience studying soil nitrogen processes.