Status of Ventura marsh milk-vetch at North Campus Open Space

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May 2021

CCBER
CHEADLE CENTER FOR BIODIVERSITY & ECOLOGICAL RESTORATION

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Introduction

Beginning in March 2019, the University of California – Santa Barbara's (UCSB) Cheadle Center for Biodiversity and Ecological Restoration (CCBER) began work on the outplanting and propagating of Ventura marsh milk-vetch (*Astragalus pycnostachyus* var. *lanosissimus*) at North Campus Open Space (NCOS). This project is operating under California Department of Fish and Wildlife (CDFW) Research Permit 2081(a)-17-012-RP. Ventura marsh milk-vetch (VMMV) seedlings were outplanted in a sandy area of NCOS in November 2019 (237), September 2020 (55), and October 2020 (203). As of May 2021, 404 of the 495 planted are thriving and have set seed with abundant seedling germination in winter 2020 and winter 2021. In addition, 75 seedlings that germinated in spring 2020 were still thriving in fall 2020.

Following the successful establishment of the first outplanting area, we collected five cups of seeds from these plants in the fall of 2020 and dispersed them at five sites around NCOS that could potentially support the species (Figure 1). As of March 2021, more than 2000 seedlings are growing adjacent to the primary outplanting site and an additional 151 seedlings are growing from seed that were dispersed in the green areas shown in the map in Figure 2.

Figure 1. Map of Ventura marsh milk-vetch outplanting and seeding locations on NCOS. The small green strip in the upper right is adjacent to Whittier pond. The small patch in the northwest is by a tule seep. The vertical swatch is in the vernal pool swale, and the green dots are in swales on South Parcel. The yellow patch is a swale planted with six seedlings in 2019. The green area in the sandy plover area is south of the primary planted areas shown in pink and purple.

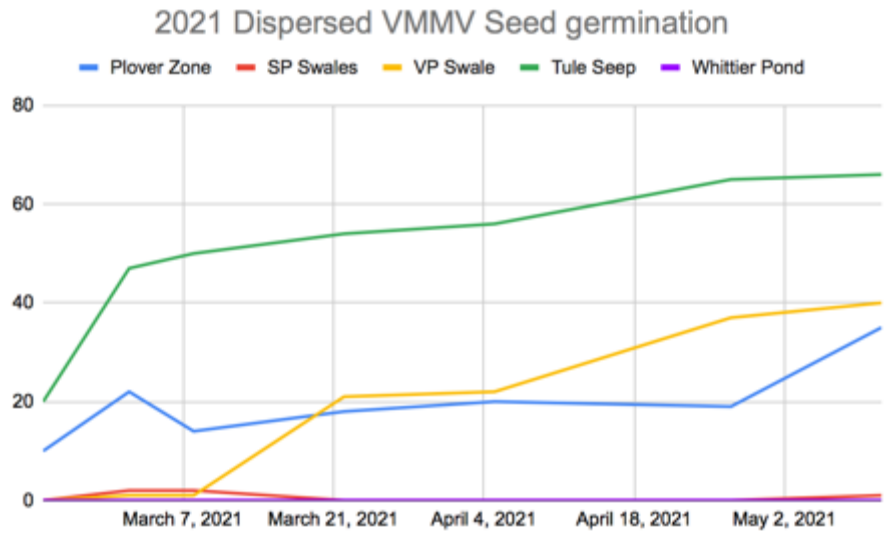

Figure 2. Seed germination and survival at remote sites in spring 2021.

Observations for 2020 and spring 2021

The VMMV seedlings we planted in an array of swales and ridges that were shaped with a tractor at the base of a restored mesa slope on sandy soils with a high water table have not required irrigation since a week after outplanting (Figures 3 and 4). Seventeen percent (40) of the original seedlings that were in swales died primarily by drowning due to high estuary water levels and sediment flow from the sandy soils above the project in January 2020 (Figure 5).

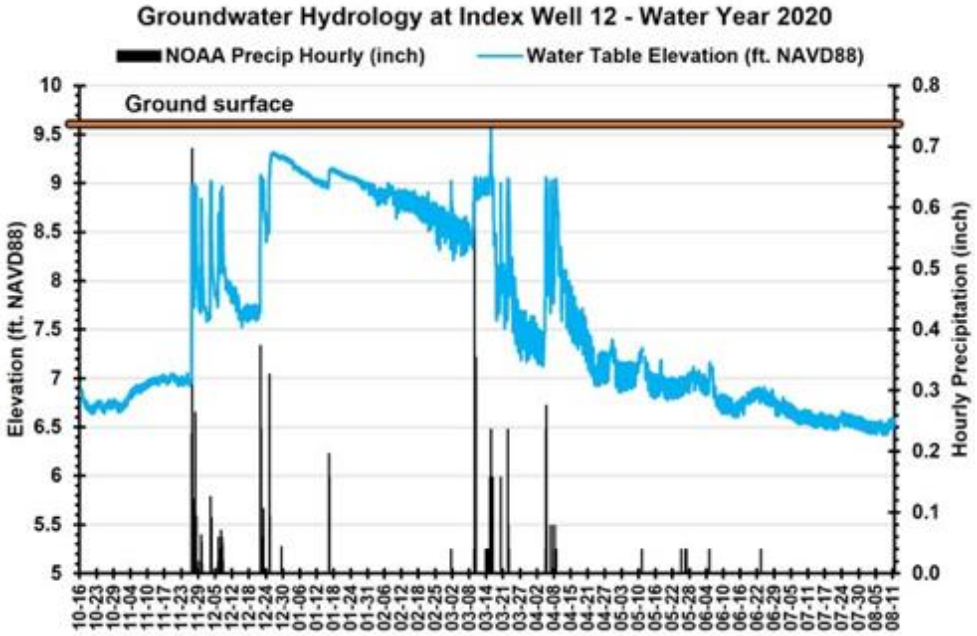

Figure 3. Groundwater level and precipitation events during the 2020 water year. The horizontal orange line indicates the elevation of the ground surface.

Figure 4. Mounds and adjacent swales in February 2020. The elevation difference from top of mound to bottom of swale is approximately two to three feet.

Figure 5. Estuary water levels in Devereux Slough were high from December 2019 to the breach event on March 16, 2020, with some storm events bringing sediment into swales.

The original 237 seedlings represented nine known maternal lines from the North Shore population collected by Mary Carroll in 2019 in a balanced manner so that the maximum biodiversity has been retained in this outplanting (Figure 6).

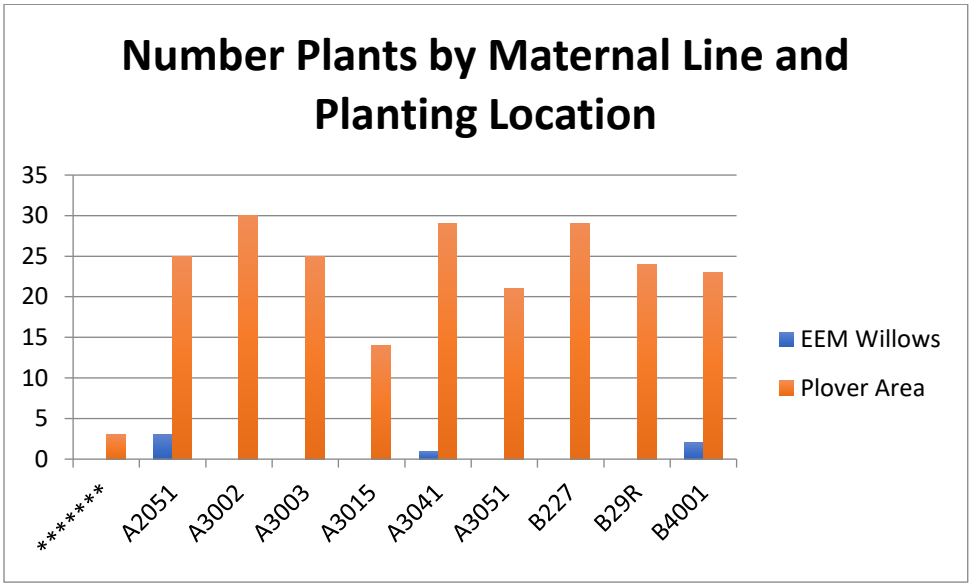

Figure 6. Maternal line relative to outplanting location.

Site Conditions

With a shallow water table and sandy soils, conditions at the site appear to be ideal for Ventura marsh milk-vetch, particularly when plants are located on the ridges and slopes as opposed to in swales where they were not all able to remain out of the zone flooded by high water levels in the estuary. Before seedlings were outplanted, a baseline study of soil moisture by depth and elevation at the proposed plover area outplanting site was assessed based on the collection of soil samples from three elevations (9, 9.5 and 10 feet) and three depths (0-15 cm, 15-30 cm and 30-45 cm). That data indicates that soil moisture is slightly higher at lower elevations and that the surface soil is significantly drier than soil moisture at depth (Figure 7). Similar data were collected from two other proposed planting areas. The area below the vernal pool swale in the western arm had dense clay soils and soil moisture ranged from 7 percent at the surface to 14 percent at depth. The proposed outplanting area in a willow-filled swale on the Environmental Enhancement and Mitigation program (EEM) site on NCOS had soil moisture levels of 20 percent, which is similar to those in the plover area. Salinity conditions in the plover area on NCOS (56 µS/cm) were similar to the McGrath site (72 µS/cm), and less saline than the Mandalay site (433 µS/cm). Soil pH at NCOS (8.9) was slightly more alkaline than at either McGrath (8.6) or Mandalay (8.1) based on a relatively small sample size of 3 to 6 samples per site.

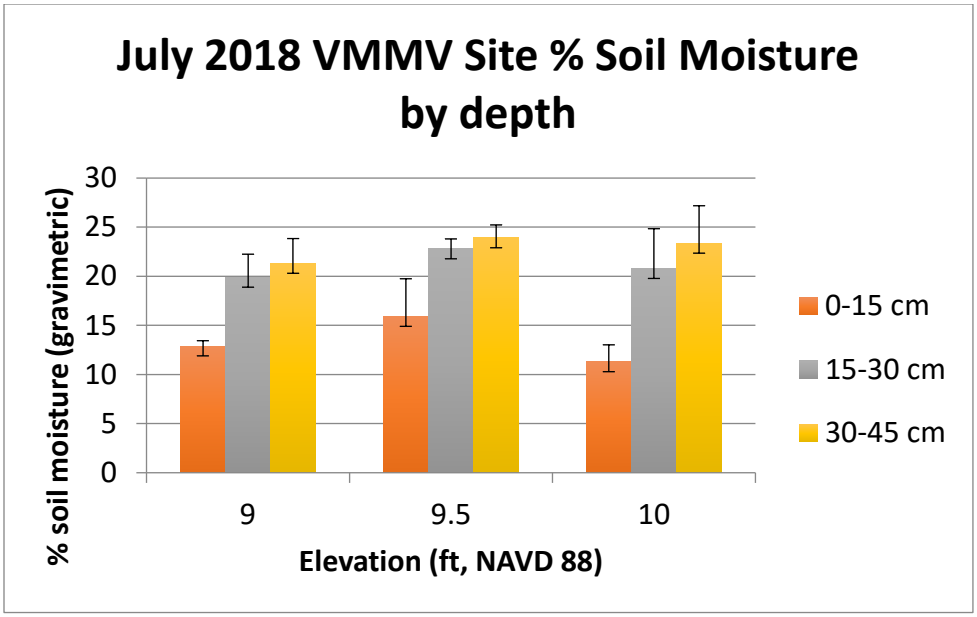

Figure 7. Soil moisture by elevation and depth at NCOS Plover primary planting area using gravimetric methods.

The two VMMV outplanting sites are called the "plover area" (adjacent to the sandy open area created for western snowy plover nesting) and the "EEM Swale" (see maps in Figures 1 and 8) which is in the portion of South Parcel graded in the 1960s to form multiple swales during the golf course construction. The EEM site contains sandy soils and has zones where willow and cottonwood have colonized. These two sites were selected because of the high water table and the sandy soils, which seemed most similar to the Oxnard and Mandalay sites. A water level logger located adjacent to the outplanting site in a piezometer well demonstrates how close the water table is to the surface year-round at this site (Figure 3). The sandy soils create a boundary layer of dried soil on top that reduces water loss from the site by breaking the potential for capillary action to dry soils deeper in the soil profile. In figure 3 the groundwater level is shown relative to the adjacent soil level which is similar to the swale bottom elevation and approximately 40 cm lower than the sandy ridge locations. The chart shows the rain event 11/29/2019 that flooded the swales and filled some with sediment which impacted some seedlings. Water remained high in the estuary through March 16, 2020, when a rain event breached the mouth and the system became tidal. During the dry season water levels are an estimated 2.5 feet below the surface.

There were other outplanting sites that were considered but we were concerned that the soils might get too dry, have too much clay content or be too salty. The soil texture and salinity impacts on germination and plant growth were examined by Ryoko Oono, an Assistant Professor in the Ecology, Environment, and Marine Biology department at UCSB. Ryoko conducted a germination and growth study of seedlings in an array of soil salinities and textures to assess those factors. She found excellent germination and growth in all treatments with no significant differences. These results provide insight about the tolerance of seeds and young plants to different soil conditions, however because the plants were watered and given some

extra nitrogen, these results may not reflect how the plants will perform under ambient lower soil moisture and intermittent flooding conditions. Figure 2 above shows initial data regarding survivorship in the different soil type, moisture and salinity situations as of May 2021 from seeds spread in the fall of 2020.

Blue zone is the existing VMMV outplanting site "plover site" supporting more than 350 seedlings. Green zone is EEM zone with 5 VMMV seedlings remaining from 6 planted in fall 2019.

In fall 2020 Ventura marsh milk-vetch was seeded into 5 other sites plus the Dune Pond edge with approximately 1 cup mixed seeds and chaff per site.
1 = adjacent to moist NE willow woodland; 2 = adjacent to Whittier pond; 3 = upper sandy swale draining upper vernal pools and portions of the mesa grassland; 4= base of vernal pool swale adjacent to tule and salt marsh vegetation; 5= deep sandy swale shaded by willows created and further eroded after 1965 grading of site.

Figure 8. Map of outplanted and seeded Ventura marsh milk-vetch areas on North Campus Open Space.

Monitoring of the rediscovered Ventura marsh milk-vetch population in Oxnard by Arcadis included measurements of soil moisture using Time Domain refractometry measurements of volumetric soil moisture levels. Therefore, we conducted an additional small study to compare gravimetric soil moisture to soil moisture measured with a TDR soil moisture probe that measures volumetric soil moisture using a dielectric current (Spectrum Technology Field Scout TDR 300 probe). We felt that this would help shed light on the differences between these methods so that more accurate comparisons could be made between results. Gravimetric soil moisture was determined by collecting soil, weighing it, drying for 72 hours in a drying oven at 105 degrees Celsius, and re-weighing the sample and then calculating ((wet mass – dry mass)/dry weight *100). The data in Figure 9 illustrate that volumetric soil moisture appears to show percent soil moisture levels approximately 25 percent higher than gravimetric measurements and with values that are more variable.

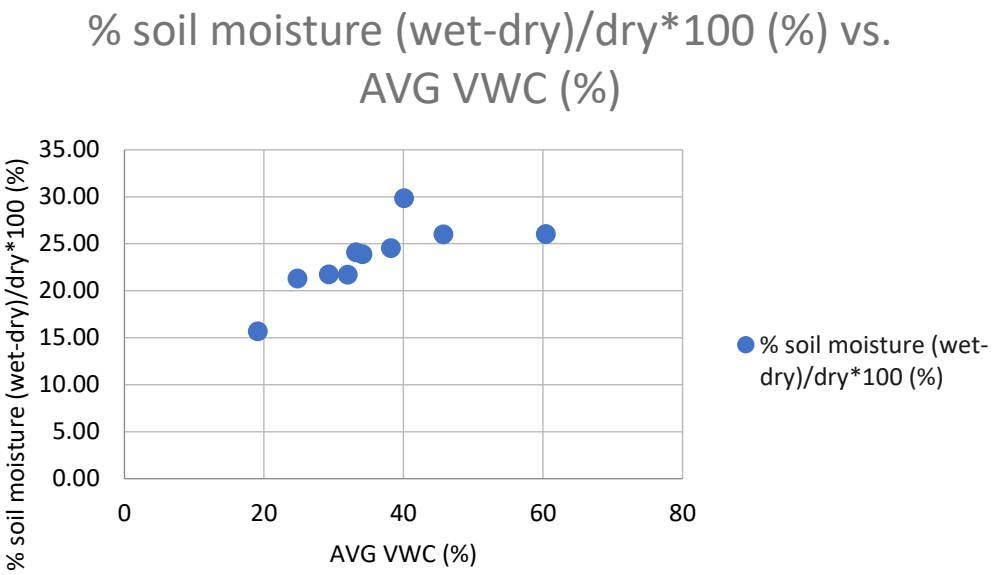

Figure 9. Gravimetric based soil moisture versus TDR probe-based volumetric water content (VWC) measurements.

Seedling performance in fall 2020

Fifty-five percent of the seedlings planted in the swales died (vigor level = 4) and just 41% were high vigor (1), while 89 and 83 percent of the Ridge and Slope seedlings were high vigor with just five percent and nine percent dying (Table 1). This trend can be seen in the average vigor at various points in the monitoring conducted over the 10 months (Figures 10 and 11). Over time, the seedlings on the ridges and slopes increased in vigor while those in the swale never recovered from the initial flooding event in late Fall 2019 and high water in January 2020. Originally there were 43 seedlings planted in the swales, 58 on the ridge and 128 on the slopes of the subtle topography created at the site. An additional six seedlings were planted in a willow-filled swale (EEM site) up slope that had soil moisture levels suitable for Ventura marsh milk-vetch. As of August 2020, only one of those EEM site seedlings had died despite dense willow roots and shading at the site.

Table 1. Percent of seedlings in each vigor category August 2020.

	1	2	3	4
Ridge	89.47	0.00	5.26	5.26
Slope	83.59	3.12	3.91	9.38
Swale	41.86	0.00	2.33	55.81

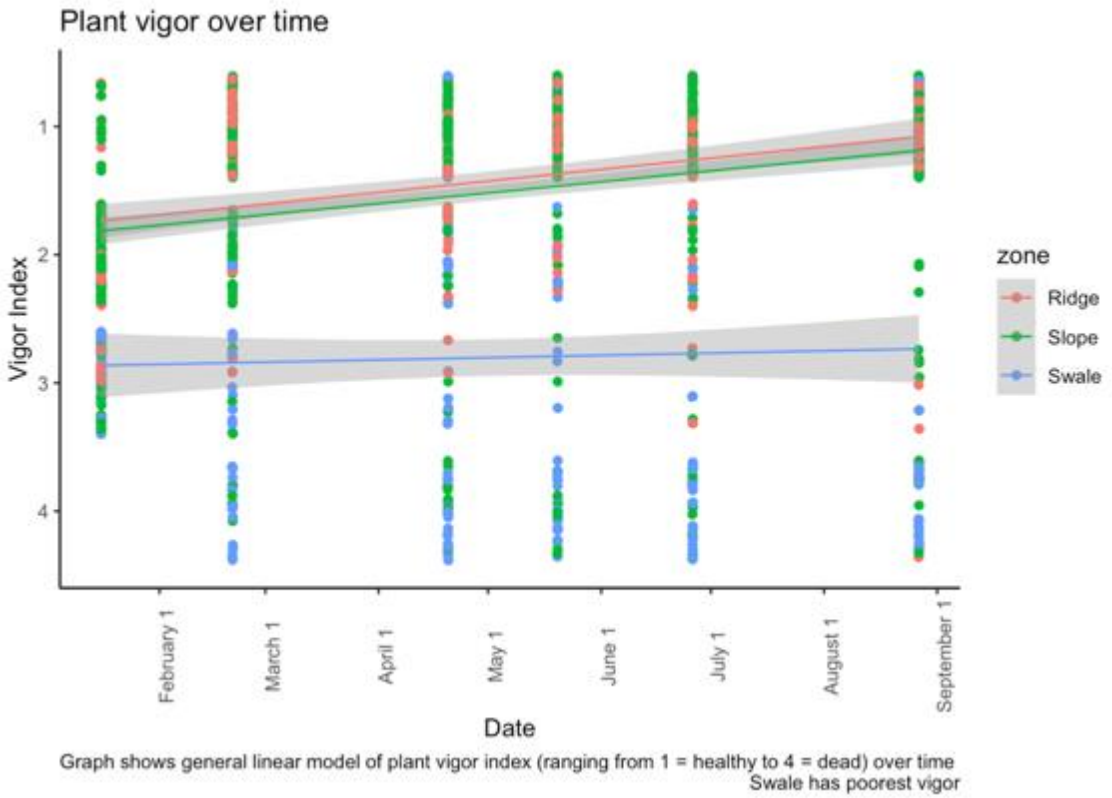

Figure 10. Average vigor over time by planting topography.

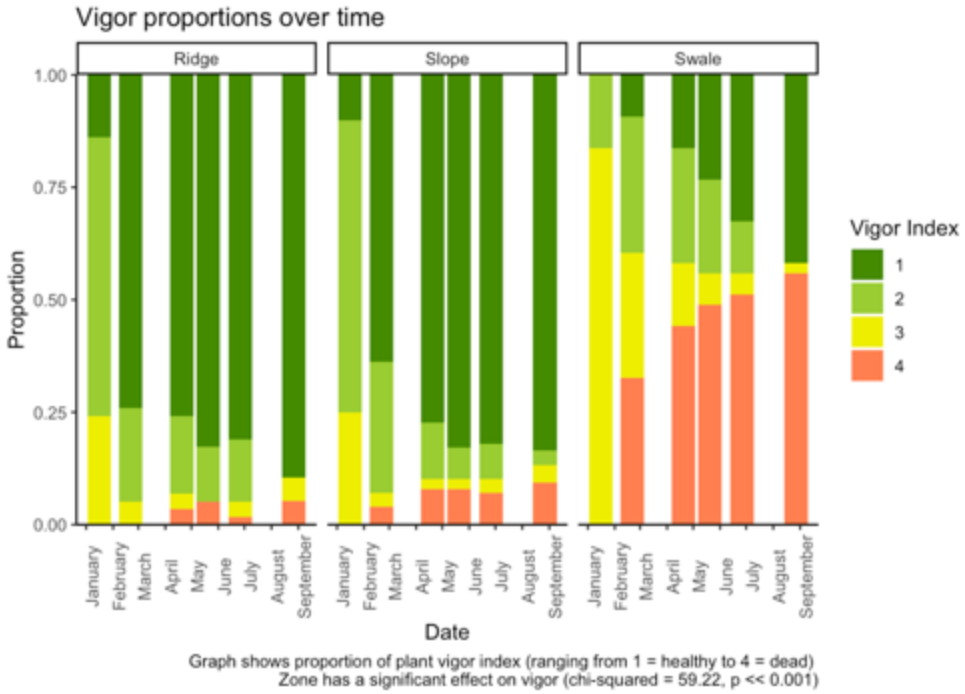

Figure 11. Alternative way of showing the proportion of plants by vigor class over time.

Plant height and estimated number of inflorescences (based on average inflorescence number per stem multiplied by number of stems) were used to further characterize the seedling performance. The average height of plants ranged from 60 to nearly 90 cm and was significantly lower for those seedlings growing in the swale compared to those growing on the ridge and slope locations ($p < 0.01$, Figure 12). Similarly, seed production was significantly higher in the ridge and slope planting locations compared to those growing in the swale ($p < 0.01$, Figure 13).

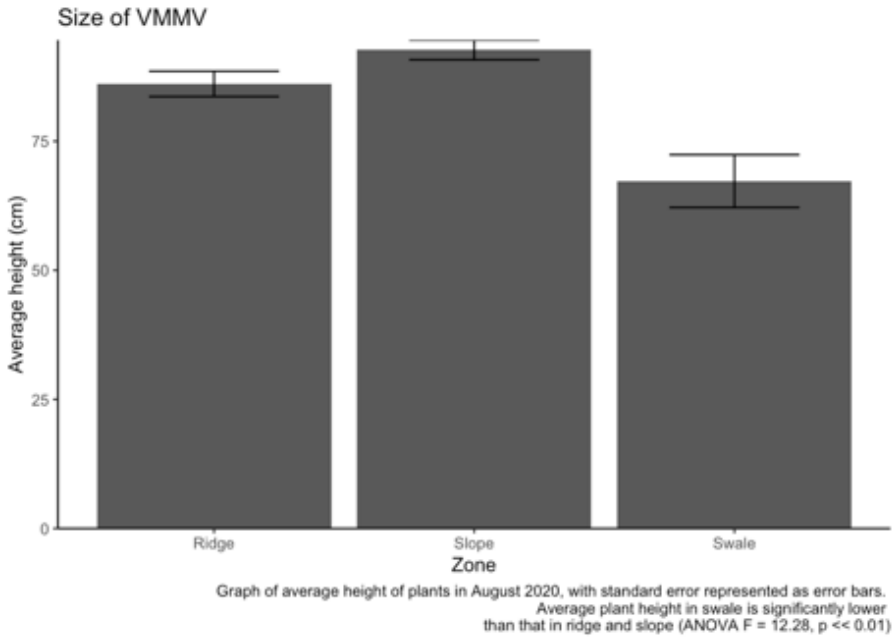

Figure 12. Average height of seedlings in August 2020 by planting zone.

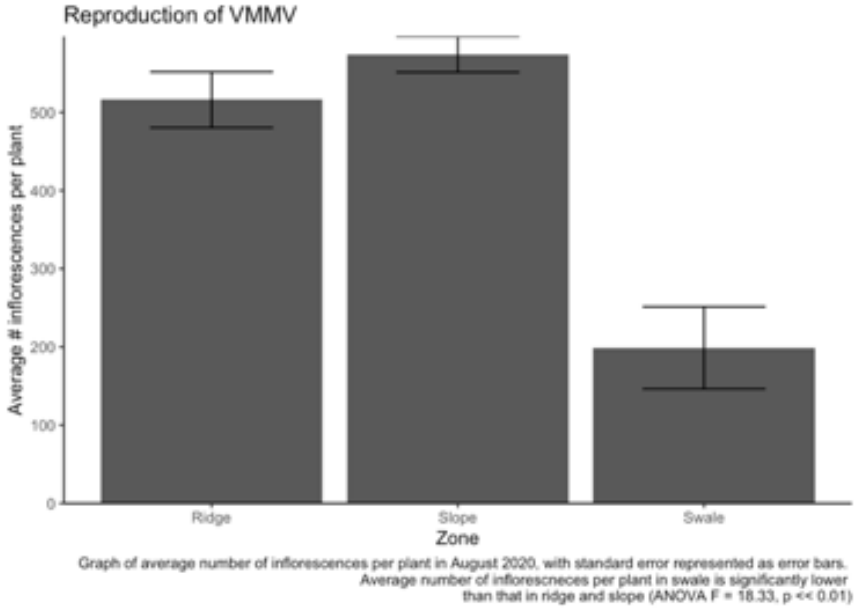

Figure 13. Average number of inflorescences per plant, August 2020.

On-site regeneration

More than 150 seedlings have germinated and 94 continue to thrive on site with no added irrigation. Sixty-four have stem lengths longer than one foot and, of those, 80 percent were reproductive (*e.g*. have flowers and fruits) within 10 months of germination. Interestingly, and not surprisingly, the majority of the new seedlings are growing in the swales where there is more room and where the seeds fall from the large plants (Figures 14a and b).

We also looked at whether maternal line had any impact on seedling germination or survivorship and found no linkage between maternal line and seedling number or vigor (Figures 15 a, b, and c). Because of this seed collection for later dispersal to other potential sites was not sorted by maternal line, but gathered broadly, mixed and then spread to additional sites.

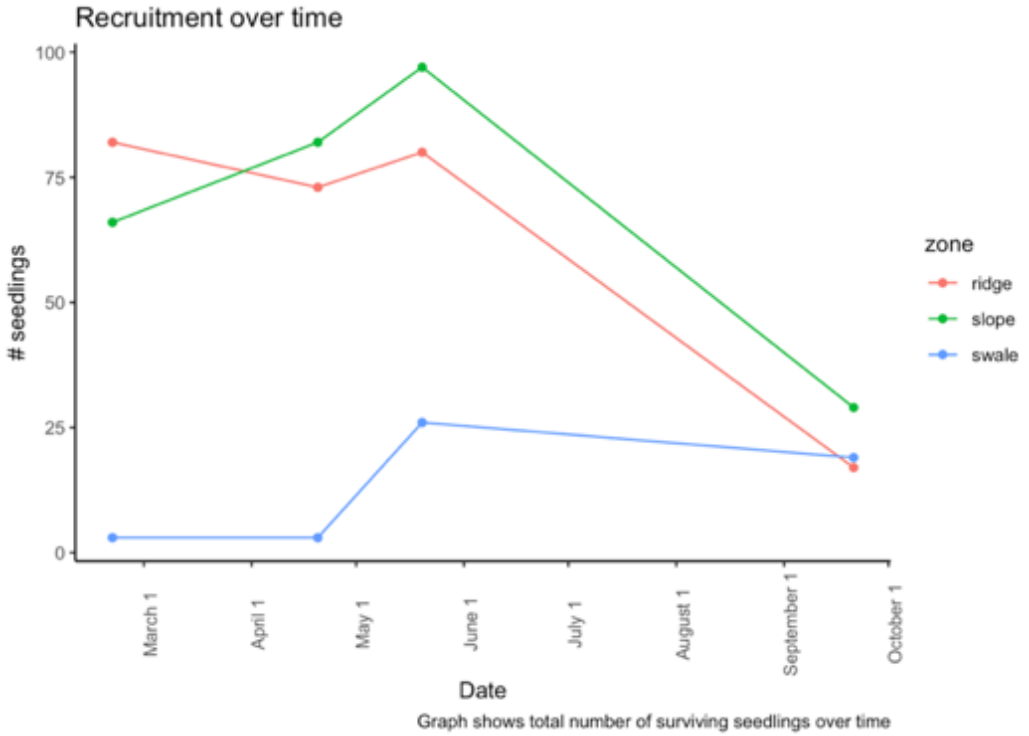

Figure 14a. Seedling recruitment location

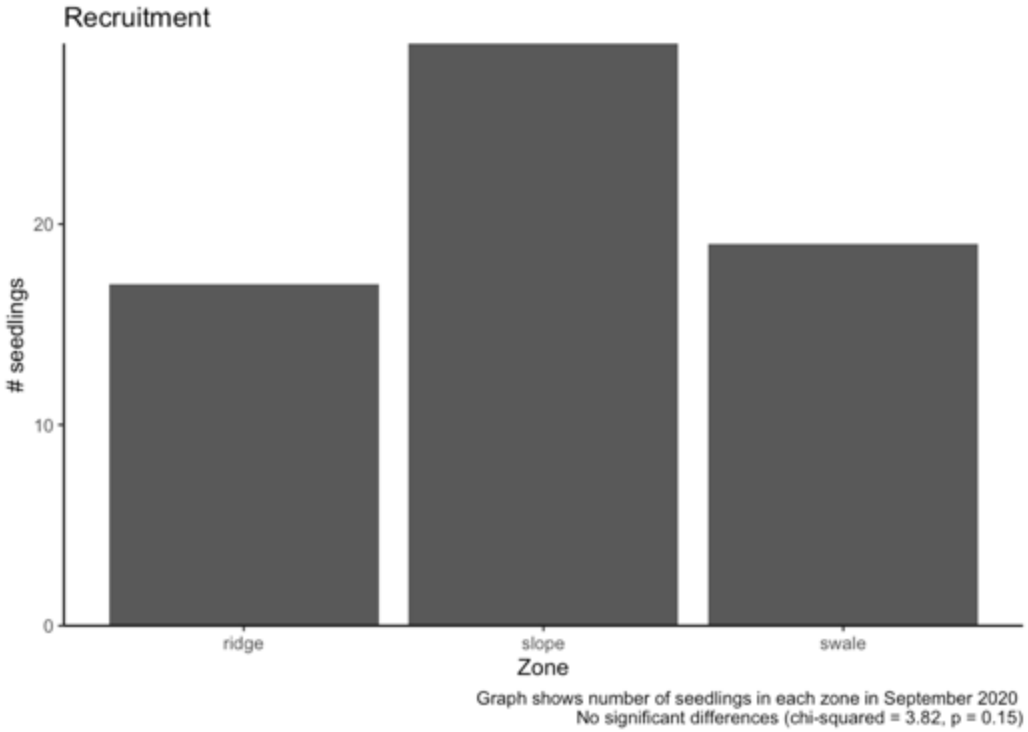

Figure 14b. Seedling establishment as of September 2020.

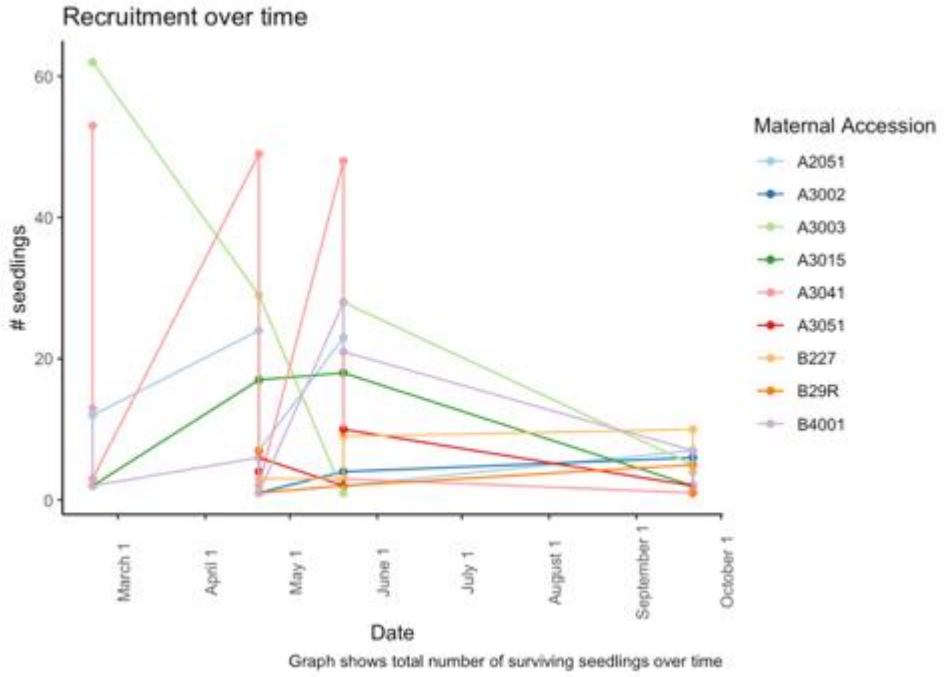

Figure 15a. Recruitment over time by maternal line.

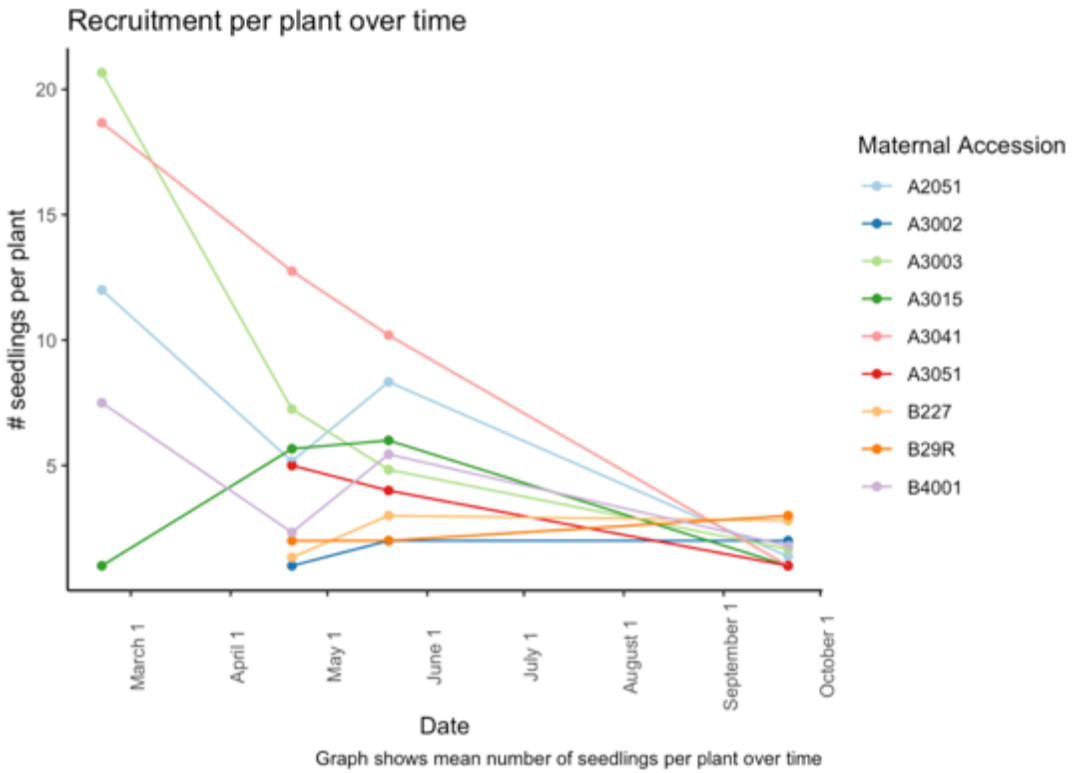

Figure 15b. Number of seedlings per plant surviving over time by maternal line.

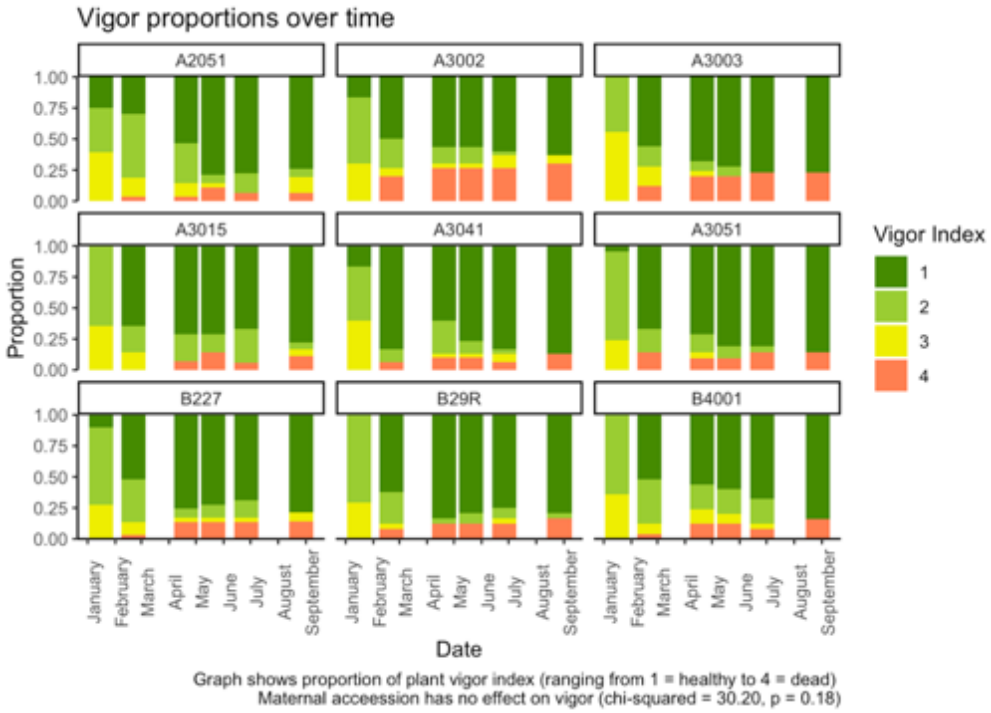

Figure 15c. Vigor of seedlings by maternal line.

Notes on other experimental factors

There was some concern that the sandy soils would be too depauperate in nutrients or water-holding capacity to support the plants. However, performance in terms of plant height, survivorship, and number of inflorescences showed no significant differences between the amended and un-amended seedlings. Twenty-three seedlings were planted with varying amounts of loamy soil extracted from the Campus Lagoon "Island", and 11 seedlings were planted with additions of compost to the planting hole. Growth, survivorship and number of inflorescences per plant were comparable in all three treatments.

There was also an initial concern that the exposure of the open sandy site would create stressful conditions for the plants, which prompted us to plant 50 mulefat (*Baccharis salicifolia*) seedlings. However, it was soon determined that the VMMV seedlings were thriving and that the mulefat were potentially going to outcompete or shade out the VMMV plants. Therefore, we subsequently removed the majority of the mulefat seedlings from the site.

Seedlings from the seed germination by soil type experiment were later outplanted on additional newly created mounds and ridges adjacent to the plover area outplanting site. These seedlings were planted in the summer and irrigated, which attracted gophers who managed to kill 20 percent of the seedlings. However, the seedlings that were not affected by gophers are thriving.

Weed competition was not a significant issue at the site. However, *Melilotus indica, M. alba*, *Medicago polymorpha,* and *Distichlis spicata* (saltgrass) were pulled from the site in spring 2020 and 2021. There were some minor infestations of spider mites and minor herbivory, but overall the plants are thriving and resisting insect infestations without significant protective action. A gopher trapping effort was initiated in late November for the seedlings planted in the summer that required irrigation, which may have drawn gophers to their roots.

Future plans and monitoring goals

The next assessment of plant height, reproduction, and seedling survival within the plover area will be conducted in August 2021. Seedling survival in remote seeding areas will be conducted on a monthly basis. We hope to secure additional funding to install a piezometer and a pressure transducer to monitor ground water levels at the Coal Oil Point Reserve dune pond and conduct a comparison of soil salinity and surface moisture over time to assess why long term survivorship of VMMV has been poor at that location.

References

Chapman, Wayne and Lisa Stratton, Ventura Marsh Milk-vetch Propagation Procedures: 2018-19, CCBER, UCSB 12/10/2019

Stratton, Lisa and Wayne Chapman, Ventura Marsh Milk-vetch, North Campus Open Space Outplanting and Baseline Monitoring Survey, CCBER, UCSB. 12/2020.