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Authors

Wilhelm-Safian, Claire

Chapman, Wayne

Stratton, Lisa

Publication Date

2025

Data Availability

The data associated with this publication are available upon request.

**Year 2 Establishment of the Endangered Salt Marsh Bird's
Beak (*Chloropyron maritimum* ssp. *maritimum*) at North
Campus Open Space, Santa Barbara, CA**

January 2025



**Cheadle Center for Biodiversity and Ecological Restoration
Claire Wilhelm-Safian, Wayne Chapman, Lisa Stratton**

Introduction

Chloropyron maritimum ssp. *maritimum* is an annual halophytic plant that grows in coastal wetlands and salt marshes from California's south coast to northern Baja California. While it does possess chlorophyll and undergoes a modicum of photosynthesis, it is hemiparasitic, deploying haustoria to steal most of its required nutrients from the root systems of its host plants. It is a decumbent herb with many distal purple branches and leaves which excrete salt crystals. It is listed as endangered both by the USEPA and California, as well as given threatened ("amenazada") status in Mexico, largely due to the historical destruction and fragmentation of coastal salt marsh habitat. The subspecies *C. maritimum* ssp. *palustre* occurs from Morro Bay north to Humboldt county, making NCOS the new northwestern limit of *Chloropyron maritimum* ssp. *maritimum*.

North Campus Open Space has been a successful restoration of intermittently tidal salt marsh in Goleta, California that has created opportunities to introduce regionally appropriate rare and endangered plants into areas where they were formerly absent or extirpated. A key plant of interest was *C. maritimum* ssp. *maritimum*. In the spring of 2023, the Cheadle Center obtained 5,000 seeds from Carpinteria salt marsh via Tidal Influence, LLC with permits from the USFWS. These were spread across North Campus Open Space on March 27 in 96 half meter-square subplots which were paired to test preferred host plant, soil type, elevation, and performance with or without supplemental watering. In the first year, 55 individuals reached adulthood. Germination only occurred in sandy soil with saltgrass (*Distichlis spicata*) as the host plant, and watering did not have a significant effect on germination, height, or plant productivity. See the Year 1 report for further details (Wilhelm-Safian et al., 2024).

The results from the Year 1 experimental trials informed the selection of larger seeding zones in early 2024. The most successful experimental plots (3 and 4) were in the low-elevation intertidal zone just east of Venoco bridge. Salt marsh bird's beak individuals seemed to germinate in higher numbers and have more room to grow in areas of medium-density saltgrass, or on the edges of thicker saltgrass mats. While sparse saltgrass allows space for germination, bird's beak in these areas are generally weak and small. Thicker saltgrass might yield better opportunities for parasitism, but it precludes germination and recruitment. Two zones of medium-density saltgrass were chosen adjacent to plots 3 and 4, and sown with approximately 25,000-30,000 seeds each, provided once again by Tidal Influence LLC, sourced from the Carpinteria Salt Marsh. In order to test the best time for sowing seed, the first zone was seeded in February and the second in March. In addition to monitoring the new seeding zones, we continued to monitor the Year 1 experimental plots. No new seeds were spread at these plots in 2024, so all individuals represent either the offspring of the previous year's population, or delayed germination of the seed spread in 2023.

Methods

In Year 1, fifty seeds were broadcasted in each of 96 half-meter square subplots within eight geographically separate plots for a total of 4,800 seeds (Figures 1 and 2). The subplots were paired together with a binary watering treatment. The watered subplots were given roughly half a gallon of water every other week. The watering treatment was stopped in mid August after it was observed that unwatered plots were doing just as well, if not better, than watered plots. Data analysis at the end of the year confirmed a lack of significant difference, so the watering treatment was not continued in 2024. Plots were also characterized by soil type and dominant host plant. *C. maritimum* ssp. *maritimum* is known to parasitize perennial plants such as saltgrass (*Distichlis sp.*), alkali heath (*Frankenia salina*), pickleweed (*Salicornia pacifica*),

seablite (*Suaeda sp.*), fleshy jaumea (*Jaumea carnosa*), and saltbush (*Atriplex sp.*) In plots 3, 4, and 5, subplots were also separated by elevation (Table 1).

Subplot	Elevation	Soil Type	Host Plant
1.1-1.3	~8.5-9	Clay	Distichlis spicata
1.4-1.6	~8.5-9	Clay	Mixed
2.1-2.3	~8.5-9	Clay	Distichlis spicata
2.4-2.6	~8.5-9	Clay	Mixed
3.1-3.3	Low (~ 6.5-7)	Sandy	Distichlis spicata
3.4-3.6	High	Sandy	Distichlis spicata
4.1-4.3	Low (~ 6.5-7)	Sandy	Distichlis spicata
4.4-4.6	High (~8.5-9)	Sandy	Distichlis spicata
5.1-5.6	Low (~ 6.5-7)	Sandy	Distichlis spicata
5.4-5.6	High (~8.5-9)	Sandy	Distichlis spicata
6.1-6.3	~ 9-10	Clay	Distichlis littoralis
6.4-6.6	~ 9-10	Clay	Arthrocnemum subterminale
7.1-7.3	~ 10-11	Clay	Distichlis spicata
7.4-7.6	~ 10-11	Clay	Distichlis littoralis
8.1-8.3	~ 9-10	Clay	Distichlis littoralis
8.4-8.6	~ 9-10	Clay	Distichlis spicata

Table 1. 2023 treatments by subplot (Elevations in ft, NAVD 83)

Experimental Seeding Plots of *C. martimum* ssp. *maritimum* on North Campus Open Space



Figure 1. Map of original bird's beak seeding plots across North Campus Open Space.

Experimental Seeding Plots of *C. maritimum* ssp. *maritimum* on North Campus Open Space



Figure 2. Map of the paired seeding subplots categorized by host plant and treatment, grouped by geographical zone of NCOS.

The Year 1 data indicate that salt marsh bird's beak prefers sandy soils at lower elevations (6-7.5 ft NAVD 83), with *Distichlis spicata* host plants. These results informed the selection of two larger seeding zones adjacent to the most productive experimental plots (3 and 4). Both of these zones were within 6 and 7.5 ft NAVD 83 elevation, with sandy soils and a variable density of saltgrass. Fifty-thousand seeds were provided by Tidal Influence, sourced from Carpinteria Salt Marsh. The seeds were weighed and then divided into two groups of equal mass (18.5 g each) so that each seeding zone was sown with approximately 25,000 seeds each. Seed sowing was staggered by a month, and corresponding phenological differences in flowering and fruiting time were observed. The February zone was sown on 2/1/2024 and the March Zone was sown on 3/5/2024. A small amount of seed left over from the original seeds provided by Tidal Influence in 2023 was also sown just to the north of the March zone on the same date. Above-average precipitation in both the 2022-23 and 2023-24 seasons likely contributed significantly to the success of the *Chloropyron* establishment during these years at NCOS.

A full count of each original experimental plot was conducted in June and August. Reproductive individuals (either flowering or fruiting) were noted. In the seeding zones, hundreds of bird's beak individuals germinated, often in very dense clusters. To reduce the

effects of human error, two or three surveyors each performed a full count, and their results were averaged.

In November, a survey of reproductive plants was conducted to estimate the number of seed pods produced by the population. In each plot, three individuals were chosen using a random number generator, and surveyors counted the number of seedpods produced by those individuals. Additionally, three samples were taken from the mid-elevation zone between subplots 4.1-4.3 and 4.4-4.6, where offspring from the first generation of bird's beak had germinated, and nine samples were taken from each of the seeding zones.

Results

The abundance of bird's beak on site increased from 57 in 2023 to an estimated 1,914 in 2024. Although 1,189 (63.5% of the total) can be attributed to the new seeds spread in February and March of Year 2, there were also many germinants that grew in the original experimental sites. These are either the offspring of the first generation of birds' beak or delayed germinants from the original seeds spread in each plot, a phenomenon we have both observed and had reported (Zahn, personal communication). The latter is certainly the case for the 53 bird's beak that germinated in plots 1 and 2, where there was no germination in Year 1 (Fig 3). Bird's beak also recruited in the space in between the low-elevation subplots 4.1-4.3 and high-elevation subplots 4.4-4.6 (Fig 4). This space filled with water in December and January when Devereux Slough was closed to the ocean. The flooding likely dispersed seed dropped from the previous generation and deposited it in this mid-elevation zone. These individuals were largely attributed to Plot 4 in data collection due to the topography of the site.



Figure 3: Map showing whether or not bird's beak germinated in experimental plots 1 and 2 each project year.

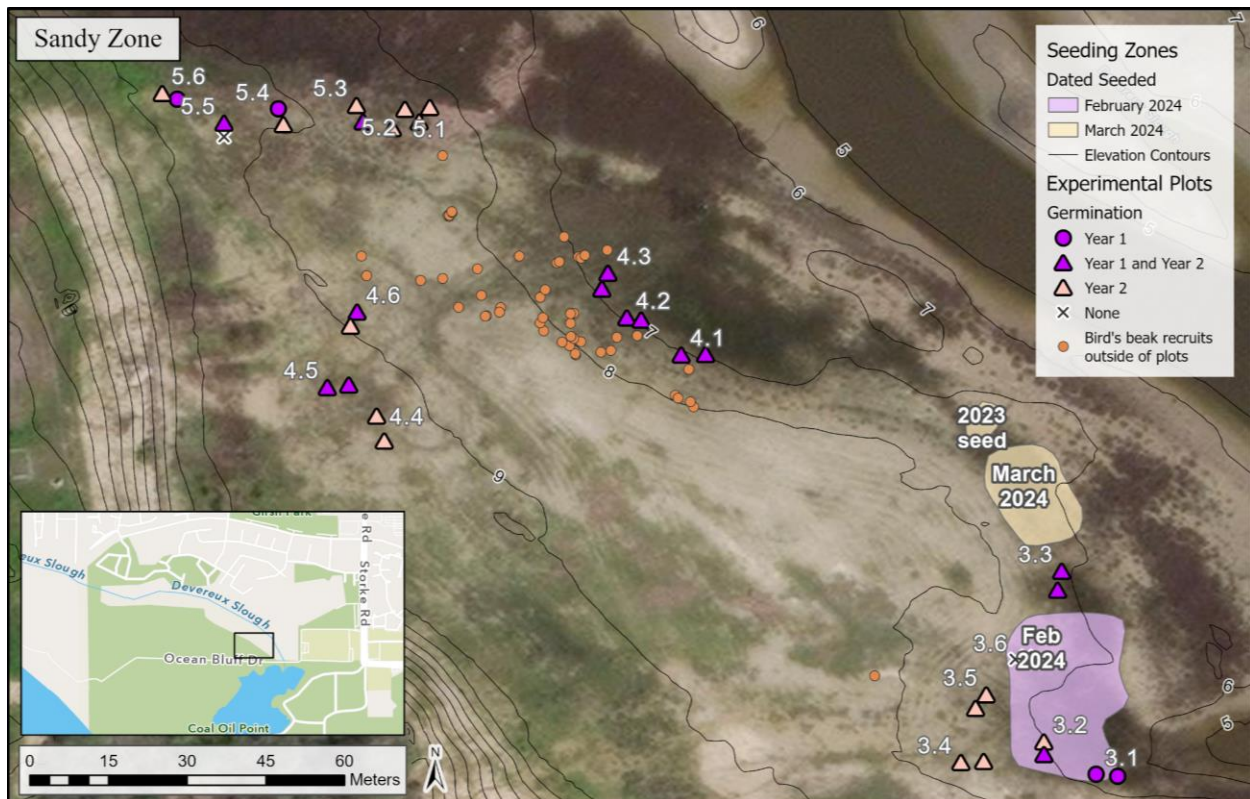


Figure 4: Map of experimental plots 3, 4, and 5 and the 2024 seeding zones. The map shows whether bird's beak germinated in a given experimental plot in the first project year, second, both, or neither. Mid-elevation recruits outside between subplots 4.1-4.3 and 4.4-4.6 are also depicted.

Abundance increased across all experimental plots (Fig 5), by as much as 1,451% in plot 4. In 2023, 1.14% of the seed spread germinated. The seed produced from the first generation of plants was not quantified, so it is difficult to know the percent germination in the experimental seeding plots in Year 2; however, percent germination was only slightly higher in the new seeding zones (2.38%). It is possible that seed benefited by a full winter of cold stratification, microbial activity in the soil, and/or the second consecutive wet, rainy winter of 2023-24. The importance of a full winter of cold stratification is also supported by the much greater abundance of bird's beak in the February seeding zone (1,055 individuals), compared to the March zone (134).

For the second year in a row, plot 4 had the highest abundance (624), excluding the seeding zones. Although abundance increased in plot 5, from 6 in Year 1 to a total of 32 in Year 2, the bird's beak did not grow as tall as those in other plots, and many died early before setting seed. The abundance at plot 3 roughly doubled from the previous year. There was no germination in subplot 3.1, which had been the most successful in Year 1. Subplot 3.1 had puddled standing water throughout most of the spring and summer, even after the water level in the slough dropped. The standing water followed by the resulting filamentous algae growing in the area may have precluded further germination, or the seed produced in year 1 may have floated to adjacent areas.

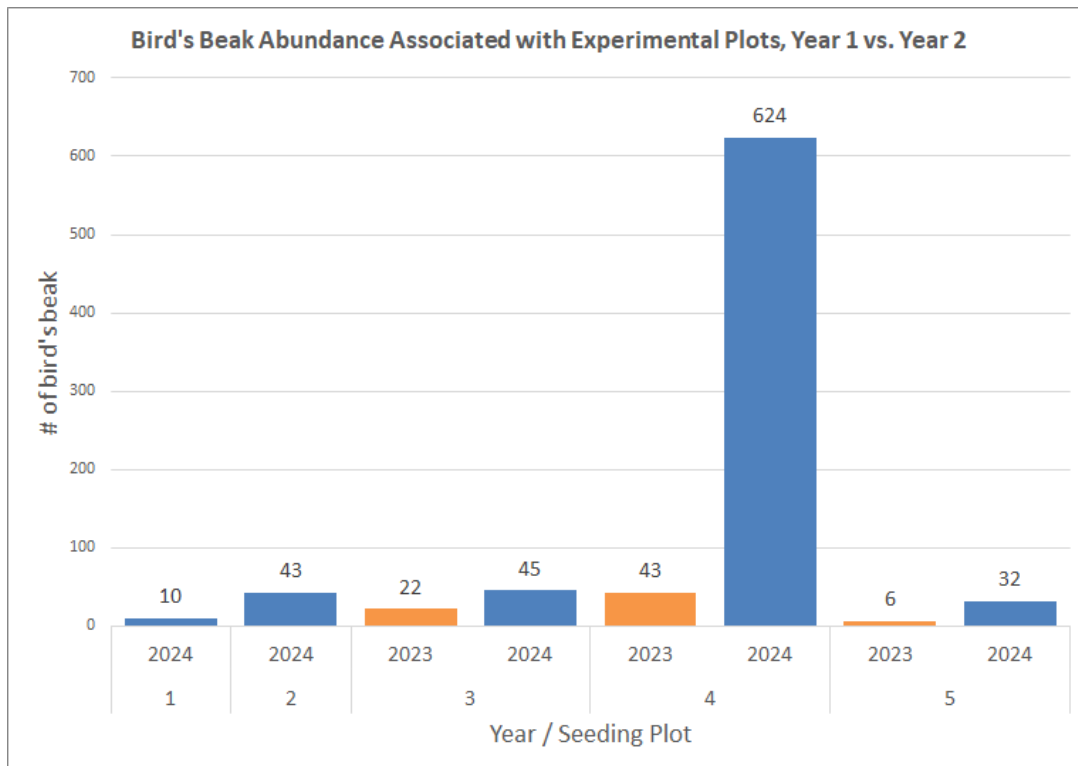


Figure 5: Column chart showing the abundance of bird's beak individuals at each experimental plot in each year of the introduction project.



Figure 6: Map showing whether or not bird's beak germinated in experimental plots 6, 7, and 8 each project year.

There was still no germination at the original experimental plots 6, 7, and 8 along the western arm of the slough (Fig 6). These plots have heavier clay soils than the successful plots in the sandy zone, and the dominant vegetation was largely *Arthrocnemum subterminale* and *Distichlis littoralis* rather than *D. spicata*. Finally, elevation may be a factor: plots 6, 7, and 8 are found between 9 and 12 feet NAVD 83, several feet higher than the sandy zone plots.

The average number of seed pods per individual varied between 0 at plot 5 and 67.9 at plot 4 (Fig 7). Although most of the plants at plot 5 had flowered earlier in the year, by the time seed pods were counted in November none had produced seeds. Plot 4 generally had larger, more vigorous bird's beak, producing a higher than average amount of seed. Comparing the zones seeded in 2024, not only did the zone seeded in February have a higher abundance of bird's beak, those individuals produced more seed pods on average (40 seeds per individual versus 22 in the March zone). The average number of seed pods was multiplied by the total number of bird's beak in each plot, and each result was summed to estimate the total number of fruits produced across NCOS in 2024: 87,122. If we assume each seed pod produces between 15 and 20 seeds (Wetherwex & Tank, 2012), there were between 1.3 and 1.7 million seeds added to the soil seedbank in year 2.

Plot	# of reproductive individuals	# of non-reproductive individuals	total # of bird's beak	% reproductive	average # of seed pods	estimated total seed pods
plot 1	8	2	10	80.0%	35.7	357
plot 2	30	13	43	69.8%	15.3	659
plot 3	32	13	45	71.1%	15.3	690
plot 4	595	1	596	99.8%	67.9	40,443
plot 5	29	2	31	93.5%	0	0
February Zone	1,016	39	1,055	96.3%	39.8	41,966
March Zone	134	0	134	100.0%	22.4	3,008
Total	1,844	70	1,914	96.3%	28.1	87,122

Figure 7: A table of the abundance and average seed pods per individual at each seeding plot.

Photos

Photo monitoring of pollination activity on salt marsh bird's beak was conducted by Cheadle Center staff member Jeremiah Bender. Several species of native bee were recorded visiting the flowers, including California bumblebee (*Bombus californicus*), yellow-faced bumblebee (*B. vosnesenskii*), and *Diadasia* sp.



Figure 8. Salt marsh bird's beak at NCOS being pollinated by a California bumble bee (*Bombus californicus*).



Figure 9. Salt marsh bird's beak being pollinated by a yellow-faced bumble bee (*Bombus vosnesenskii*). Photo credit Jeremiah Bender.



Figure 10. Salt marsh bird's beak being pollinated by *Diadasia* sp. Photo credit Jeremiah Bender.

Discussion

Chloropyron maritimum ssp. *maritimum* experienced a large population increase in 2024 at NCOS. While the largest population seemed to result from the sowing of roughly 55,000 seeds obtained from Tidal Influence (collected at Carpinteria salt marsh in 2023), and sown in the area of plot 3, a significant population increase also occurred in plot 4, where no seed was sown in 2024, indicating these plants all germinated from seed produced naturally from the original plants first documented in 2023 or from the originally spread seed. Despite only a portion of the 43 plants producing seed in plot 4 during 2023, and significant caterpillar damage herbivory on the developing fruits, the recruitment and number of flowering plants that were observed from what seed was produced in 2024 was significant. With approximately 1,800 plants producing seed in 2024 across NCOS and the subsequent seed production that should entail, the potential for further population growth, including into the lower half of the estuary at Coal Oil Point Reserve, is high. However, La Niña climate fluctuations and the unprecedented low precipitation to date may result in a much drier rain year in 2025 compared to the two previous wet winters, putting a damper on the bird's beak's rapid population growth.

Polypogon monspeliensis and *Parapholis incurva*, two non-native invasive grasses that are not good hosts for *Chloropyron*, are also expanding their ranges and densities on site and may be increasingly problematic management concerns moving forward.

Further Conservation Efforts

Tidal Influence, LLC provided the Cheadle Center with another bag of seeds in November of 2024. The total number of seeds was estimated by counting individual seeds in a dozen subsamples (each around 0.1 g), finding the average seeds per gram (1090.49), and multiplying by the total mass of the seeds provided (28.657 g).

$$\frac{1090.49 \text{ seeds}}{1 \text{ g}} * 28.657 \text{ g} = 31,250 \text{ seeds}$$

The total number of seeds was estimated to be 31,250 (Figure [^]). The seed was then divided into nine groups of equal weight, and each was sown at nine new seeding plots on North Campus Open Space (Figure 11). These plots were selected because they had appropriate soil texture and elevation, with medium-density mats of *Distichlis spicata* to serve as host plants. The seed was sown on 1/23/2025. La Niña conditions have developed over the winter of 2024-2025, with very low rainfall expected throughout the usual rainy season. Although the sown seed may receive adequate cold stratification for germination, we are not expecting a long period of inundation. Germination may be lower in 2025 than in the previous year due to inadequate rainfall. Salt marsh bird's beak is an annual plant with a natural boom and bust population cycle dependent on many environmental factors, such as

Sample	Mass (g)	Number of Seeds	Seeds per g
1	0.255	359	1407.84
2	0.113	136	1203.54
3	0.126	109	865.08
4	0.100	135	1350.00
5	0.154	212	1376.62
6	0.1002	115	1147.70
7	0.1001	66	659.34
8	0.0998	69	691.38
9	0.1002	93	928.14

10	0.1000	103	1030.00
11	0.1000	116	1160.00
12	0.1003	127	1266.20

Figure 11. Table showing the mass of each seed sample and the number of seeds counted within it.

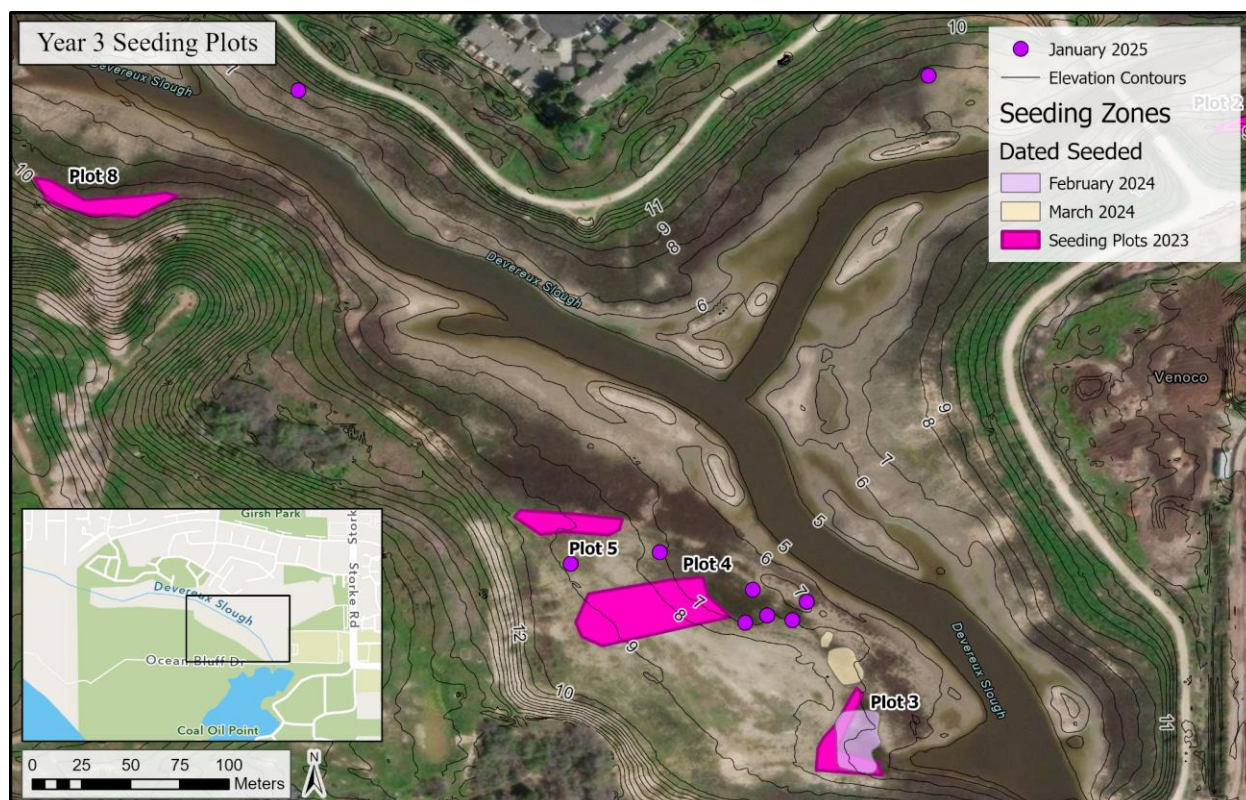


Figure 12. Map of the January 2025 seeding plots, also showing their proximity to the Year 1 and 2 plots.

Monitoring will continue in early 2025 a month after seed has been sown. We are also planning on surveying along the banks of the lower arm of the Devereux Slough on Coal Oil Point Reserve, to track the dispersal of bird's beak seed through the watershed. In addition, we are developing a hydrological model of the slough from bathymetric cross-sections measured in late 2024. This model, combined with the mapped bird's beak individuals, should allow us to determine any potential correlation between the period of inundation and germination from seed. Results will be discussed in forthcoming reports.

Acknowledgements

Thank you to Tidal Influence, LLC for donating seed to spread at NCOS under their permit. Data collection was conducted by Claire Wilhelm-Safian, Wayne Chapman, and Lauren

Rappa. Jeremiah Bender provided photography of pollination activity on salt marsh bird's beak.

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