Coyote Ceanothus Mitigation Project, Summary for 2023

Annual planting of Coyote ceanothus, or *Ceanothus ferrisiae* (CEFE), concluded at the mitigation site in winter of 2022. Planting at the site began in 2015 within the four original test plots, or habitat types (Chaparral Edge, Pine, Lower Sage, and Upper Sage), at the site. From 2019 to 2022, annual planting occurred in serpentine grassland located outside the test plots in the larger mitigation site as the test plots reached capacity. Planting consisted of a combination of direct seeded basins and container plants installed in basins. At the time of annual monitoring in summer of 2023, there were a total of 1,295 active basins (basins with at least one living CEFE in them; direct seeded basins are installed with four seeds per basin). Monitoring is conducted annually in June, of all planted basins. Monitoring metrics include recruitment, survivorship, plant height and vigor, and evidence of flowering and seed production.

A major milestone in 2023 was the documentation of natural recruitment of CEFE seedlings in several of the plots near larger and more mature planted CEFE. At the time of annual monitoring in June, 13 seedlings were documented in the Pine plot, 36 seedlings were documented in the Lower Sage plot, and 3 seedlings were documented in the Chaparral Edge plot. One of the Lower Sage seedlings was quite large (>6 inches) indicating it likely germinated in a previous year and was overlooked until 2023. The winter of 2022-2023 was an exceptionally high rainfall year, and coupled with many CEFE plants now mature enough to produce large quantities of flowers and fruit, the seed bank is likely finally large enough that the mitigation site is beginning to experience successful natural recruitment.

Monitoring Results

Statistical analysis of the 2023 monitoring data focused on the following questions: 1). How survival rates change over time based on planting and habitat type; 2). Whether the different planting methods and habitat types significantly affect plant growth (height, health and vigor [plant "condition"], flowering and fruiting rate); 3). The relationship between plant growth (as indicated by plant height) and precipitation.

Results for 2023 indicate that container plants maintained high survival rates over time (between 80-90% survival seven years after planting). While survival rates were higher in 2023 in the Chaparral Edge and Pine plots than in the Lower and Upper Sage plots, there wasn't much difference in survival rates in different habitat types over time. In contrast, direct seeded plants exhibited the opposite pattern, with a much lower average survival rate (42% seven years after planting). There was a substantial difference between habitat types over time for direct seeded plants, ranging from a low of 8% survival rate in Year 7 in the Lower Sage test plot, to a high of 85% survival rate in the Pine test plot. The low survival rate for direct seeded plants in Lower Sage is likely due to intense herbivory and mortality of young seedlings in the plot in the first several years after planting, and its proximity to Ca sagebrush, which likely provides cover to small mammals. The high survival rates seen in the Pine plot were similar to other results seen this year and consistently across years- plants in the Pine plot have done better than in other plots, whether direct seeded or installed by container. Interestingly in the

Lower Sage plot, while survival overall is low for direct seeded plants, it has not changed much over the years since planting- first year survival was 27%; survival in Years 2, 3 and 4 was 10%; and survival in Years 5-8 has remained at 8%. This indicates that as those plants have matured, there is little to no additional mortality. A similar trend was seen in the other test plots- the heaviest losses for direct seeded plants occur when they are very young. With three years of data for direct seeded plants and four years of data for container installed plants in the serpentine grassland area, survival of both types of plantings remain high (72% survival for direct seeded plants at Year 3 and 94% survival for container plants at Year 4).

Average condition scores were high across all years for both direct seeded and container installed plants (2.94 for container plants and 2.77 for direct seeded plants, seven years after planting), with not a lot of difference seen among habitat types. A condition score of 3 is "excellent", and a condition score of 2 is "good" in the health and vigor rating system developed for this project. Condition scores increased slightly over time as plants matured, with the largest increase seen for direct seeded plants. This is to be expected as plants become established.

Flowering and fruiting rates also continued to increase over time as plants matured, with 2023 showing the highest rates regardless of planting method or habitat type. Container plants had higher rates of flowering and fruiting than direct seeded plants (97% of container plants flowered and 88% produced fruit seven years after planting, while for direct seeded plants 84% flowered and 76% produced fruit seven years after planting). As is seen with all the monitoring metrics, direct seeded plants are likely still "catching up" in maturity while container installed plants continue to exhibit an edge after their start in the nursery prior to outplanting.

In order to investigate the effect of rainfall on plant growth, we conducted a comparison between average plant growth by year and method (as evidenced by plant height) and precipitation data. We focused this analysis on more mature plants (those planted between 2015 and 2019). Results indicated a predictable trend and correlation of plant growth to precipitation- as annual precipitation decreases, plant growth slows, and vice versa. The pattern showed the effects of seasonal precipitation on plant growth even when plants were still receiving supplemental summer irrigation (three years for direct seeded plants and two years for container installed plants). The Spearman correlation statistical test indicated a positive correlation between plant growth and precipitation- specifically, direct seeded plants exhibited a strong positive correlation of 0.799 with precipitation, while container plants showed a moderate correlation of 0.399. This analysis corroborates field observations of increased plant growth following high rainfall years, and leaf drop and chlorosis in hot, dry periods with low rainfall. While still a chaparral plant adapted to harsh conditions in a Mediterranean climate, CEFE is highly responsive to changes in moisture and benefits from increased precipitation.

Conclusions

Year 2022 represented the final year of scheduled planting of CEFE in the introduction site, which began in 2015 and has occurred annually since then. Annual planting has allowed the site to develop structural complexity and phenological diversity due to different age classes of plants, mimicking

natural recruitment seen in native populations. The use of different seed collection lots from the Anderson Dam occurrence for the annual planting has been designed to increase genetic diversity and microsite suitability.

At over 1,200 occupied basins, this is the appropriate size of the planted population of CEFE at the introduction site. At this point we are pausing the annual planting activity to see how much natural recruitment will occur and how plants may naturally establish without active planting, which would transition the introduction site to a self-sustaining population of Coyote ceanothus. The natural recruitment documented in 2023 (a total of 52 seedlings) is an incredible achievement for the project.

In future years, an assessment will be made as to whether any additional planting should be performed. Regular monitoring will continue and natural recruitment will be tracked in order to evaluate if the natural recruits are able to mature and sustain the population with minimal future intervention, as well as to ensure that the created population remains healthy. It is estimated that there will be an additional 2-3 years of irrigation to the youngest installed plants, and that ongoing site maintenance will be needed to control weeds and monitor the effects of herbivory. At some point in the future, prescribed burns may be considered to stimulate natural recruitment and maintain the population.