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Coastal Prairie Enhancement Recommendations for the Baduwa't Estuary Overlook

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Abstract

The incorporation of native plants into the Baduwa't Estuary overlook encourages the practice of preserving local tribal resources and promotes the valuable ecosystem services provided by the estuary's bluff. The recent restoration and trail development of the Baduwa't Estuary public access area highlighted the importance of collaboration with the Wiyot Tribe for incorporating culturally significant plants into the site. Wiyot tribal input should be utilized going forward in preserving cultural environmental resources and enhancing the native coastal prairie biodiversity of the site. An objective of this project is to create recommendations for the site's further development in collaboration with the Wiyot tribe. To create a preliminary recommendation planting plan in the form of a map and written recommendations for the land managers, the McKinleyville Community Services District, and CalTrout the project proponent for the Baduwa't Estuary Restoration and Public Access project. Our project aims to add to the management of the public access area with a recommended planting plan map to guide future landscaping. Vegetative data was collected during a site inventory analysis (SIA) using the quadrat method along a 300 meter transect tape. Species Diversity and Abundance was calculated through total percent cover and analyzed using the Shannon-Wiener Diversity Index. The UZT produced a species diversity of 2.88 (Table 1), the MZT produced a species diversity of 2.14 (Table 2), and the EZT produced a species diversity of 1.78 (Table 3). Based on the composition of the seed mixes that were spread during site restoration by CalTrout in 2022, we determined the vegetative composition of survivorship from the seed mix and how the herbaceous cover might support coastal prairie enhancement through additional select plantings. Our recommended use of both seeding and direct transplanting of select native coastal prairie flora aims to support cultural and environmental resources.

Introduction

Coastal prairies in California support the highest plant diversity of any grassland in the United States (Coastal Prairies, n.d.). According to the Coastal Prairie Enhancement Feasibility Study, the term "coastal prairie" refers to areas where plants acquire moisture from fog, and are typically within 100 km from the coast and below 350 m in elevation (Coastal Prairies, n.d.). Coastal prairie habitat consists of a biome widely considered an endangered vegetation type (NPS). The National Park Service determined a 90% loss of California's coastal bunchgrasses.

Planting native species can contribute to the ecological integrity of a site by reducing the threat invasive species have on ecosystem structure, function, and potential loss of habitat (Conway et al, 2019). The increased planting of native species increases the biodiversity resilience of that local ecosystem (Lulow, 2006*).* Biodiversity refers to the biological and genetic diversity of plants which helps them adapt to their environmental stressors and disturbance. When planning a restoration site, it is important to consult with nearby tribal nations, so the project can incorporate native and culturally significant plants into the restoration site. Culturally significant plants can be shaped into tools that teach traditional knowledge through ecological design, or by the process it takes to gather these plant species (Shebitz, 2005). Furthermore, the incorporation of these plants into a restoration site encourages the practice of preserving local tribal resources and promotes biodiversity. Native plants offer a wide variety of services that benefit their surrounding ecosystem. Some of the services include, but are not limited to, providing sustenance, enhancing habitat, making areas like the Baduwa't public access area aesthetically pleasing, and able to be shaped into a tool that tells a cultural story. Incorporating vegetative planting in an ecological restoration project, can fortify the health and longevity of a site, and has the potential to cultivate community through project involvement.

The Baduwa't Estuary Restoration and Public Access Project is located within the homelands of the Wiyot tribe, near south-western corner of McKinleyville. This area is where the Baduwa't (also known as the Mad River) reaches its ocean confluence (see Figure 1). The project encompasses the final reach of the river near its widest point as it transitions to an estuary. With ample edge habitat and riparian ecology, there is a lot of positive influence to the aquatic ecosystem. The public access project area exhibits characteristics of coastal prairie habitat. This biome is considered an endangered vegetation type as stated by the National Park Service citing a 90% loss of California's coastal bunchgrasses (NPS). This fact drives the main scope of our project which is enhancing the native coastal prairie morphology of the site. Our project offers the McKinleyville Community Services District (MCSD) a land management plan by creating a Recommended Planting Plan after conducting a Site Inventory Analysis (SIA), which identifies the native and non-native plants in the site, providing a baseline understanding of the current species composition.

In addition to the SIA, a Recommended Planting Plan will be developed, indicating the sensitive native communities in the public access area that need to be protected. Recent land management actions at the upland site involving vegetation maintenance have resulted in the need for this delineation between the sensitive native communities and the invasive or exotic communities. Maintenance thus far has resulted in the heavy mechanized mowing and weed-wacking of the public access area without discretion. Physical implementation of this map will help establish native species that can be denoted with signage or integrated boundaries on the site to help establish low disturbance regimes where necessary. With the same vegetation data from the SIA, this planting design can be made for the public access area of the project. This will be guided by tribal input which influences a preliminary planting plan created by our capstone

group. To create a recommended planting plan in the form of a map and written recommendations for the MCSD land managers of the Baduwa't Estuary Outlook public access area, our team began with an initial site visit to assess the visual appeal of the area and the feasibility of a habitat enhancement project to include additional vegetation.

Figure 1: Locator Map and Aerial Landscape Site Map

Methods

Site description

The Baduwa't Estuary project site is located in McKinleyville, California at the west end of the School Rd. exit along highway 101 north. The specific location of the site that we focused on is the northern public access coastal overlook area that is ADA accessible. Our research was conducted on October 14 and October 28, 2023. Dominant vegetation in the project site includes willows within the riparian area, along with herbaceous and woody species such as California blackberry (*Rubus ursinus*), Himalayan blackberry (*Rubus armeniacus*), and Coyote bush (*Baccharis pilularis*) (Kalt, 2019). Common fish in the Baduwa't estuary include the *Oncorhynchus tshawytscha* (Chinook salmon), *Oncorhynchus kisutch* (coho salmon), *Thaleichthys pacificu*s (eulachon), *Petromyzontiformes* (lamprey), *Osmeridae* (smelt), and *Oncorhynchus mykiss* (steelhead) (Shill et al. 2023). The Baduwa't River (also known as Mad River) has experienced many impacts from western colonial human activities throughout history including timber harvesting, gravel mining, urbanization and residential development, and point source pollution before more recent land use activities such as ranching, recreation, and water supply (Shill et al. 2023).

The Recommended Planting Plan for the Baduwa't Estuary public access area is a continuation of the Baduwa't Estuary Restoration Project by CalTrout. The project's grading phase was completed in late 2022, and revegetation phase was completed between October 2022 and March 2023. That project restored key salmonid off-channel rearing habitat, and provided public access enhancements ("Baduwa't Estuary Restoration," n.d.).

Figure 2: Eastern view of the Upper Zone at the public access overlook facing the trailhead. Planting recommendations are located along both sides of the paved trail. The red patch to the left is the mowed remnants of California blackberry which extends up towards the trailhead and outward toward the trail.

Figure 3: Southeastern view of the Upper, Middle, and East Zones at the public access overlook where planting recommendations are located. In the foreground is the teardrop where geophytes are recommended to be planted.

Details of methods

Using the quadrat method along a 300 meter transect tape, we conducted a SIA of the existing vegetation at the site with a 1m squared quadrat. Separating the project site into three zones allowed us to collect data for a thorough and accurate vegetation analysis. The first set of data for the SIA was collected in the Upper Zone on the northern end of the public access area, the Middle Zone was sampled second, and the East Zone on the southern end was sampled last (see *Figure 4*). The Upper Zone transect (UZT) included total cover data from quadrats sampled at eight random distances along the tape that stretched 62.9 meters in the direction of 211° SW.

The Middle Zone Transect (MZT) stretched 38.7 m in the direction of 177° S and six random distances were sampled with quadrats. Finally, the East Zone Transect (EZT) stretched 48 m in the direction of 201° S and six random distances were sampled with quadrats. Within each quadrat, we identified the number of different plant species, their approximate percent cover class, and the approximate percent cover of bare ground within each quadrant of the sampling areas. Excluding the existing shrubs and bushes from the SIA for mapping later, we randomly generated eight numbers between zero and seventy meters to create eight separate quadrat samples from the northern to southern end of the upper zone sampling area. A coin was then tossed to determine whether the quadrant was to be placed on the left or right side of the transect tape. Once the quadrat was placed at the sampling location along the tape, we collectively identified which plants existed within the quadrat and determined the cover class for each individual species. Cover classes are defined below:

Class 1: (<1%), Class 2: (1-5%), Class 3: (5-10%), Class 4: (10-25%), Class 5: (25-50%), Class 6: (50-75%), Class 7: (75-100%).

Each person made an estimation, then we discussed it together until we agreed on the cover class. This process was repeated for all the individual plant species at each of the selected distances along the transect tape in the middle and east zones. The SIA data set was calculated for Species Diversity and abundance through total percent cover and analyzed using the Shannon-Wiener Diversity Index. We utilized satellite imagery from ArcGIS Pro to provide a base for the vegetation sampling methods map and the Recommended Planting Plan map. Both maps show the locations of the existing bushes and shrubs that were excluded from the SIA.

Figure 4: Vegetation sampling methods map. The UTZ, MTZ, and ETZ are denoted with orange shading and showing the transect lines through each where the SIA was conducted with the quadrat sampling method.

Results

The SIA results show that the species identified are many of the plants that were originally spread in the Coastal Grassland seed mix for the public access site and the Organic Pasture seed mix for the adjacent MCSD pasture that was spread at the public access site in error. Among these seed mixes are three varieties of ryegrass, four varieties of clover (see Appendix

A), then a Coastal Grassland seed mix of yarrow (*Achillea millefolium*), seacoast angelica (*Angelica lucida*), California brome (*Bromus sitchensis var. carinatus*), tufted hair grass (*Deschampsia caespitosa subsp. beringensis*), California poppy (*Eschscholzia californica*), red fescue (*Festuca rubra*), meadow lupine (*Lupinus polyphyllus var. polyphyllus*). The three transects resulted in identification of twenty total herbaceous and woody plant species, many of which were dominated by the Coastal Grassland seed mix.

Overall, there were more native plants than non-native or invasive plants in each of the three zones. Of the twenty plants identified in the SIA, four were identified as invasive. The invasive plants were bull thistle (*Cirsium vulgare*), false dandelion (*Hypochaeris radicata*), Himalayan blackberry (*Rubus armeniacus*), and prostrate knotweed (*Polygonum aviculare*). Bare ground was included in our quadrat sampling to determine the extent of herbaceous dispersal and concentration across the site. All graminoids (grasses) and clovers were grouped together and categorized as individual species within the quadrats during cover class determination. According to Figure 2, the UZT samples resulted in grasses and bare ground having the greatest total percent cover throughout the zone, at approximately 28% and 21% respectively. Wild carrot has the third greatest total percent cover at about 14%, and the remaining plants dominating the area were Ribwort plantain and clover with total percent cover between 5 and 10%. The MZT samples resulted in bare ground having the greatest cover at 25%, followed by plantain, yarrow, and wild carrot between 10 and 15% total percent cover (*Figure 3*). Finally, the EZT samples resulted in California Blackberry dominating total cover at approximately 46% and grasses at approximately 19%, while plantain and wild carrot had a total cover between 5 and 10%. The vegetation with consistently the lowest total percent cover across all three transect zones were dandelion, false dandelion, bull thistle, vetch, geranium, scarlet pimpernel, prostrate knotweed,

and meadow lupin. The UZT produced a species diversity of 2.88 (Table 1), the MZT produced a species diversity of 2.14 (Table 2), and the EZT produced a species diversity of 1.78 (Table 3). If the diversity index is closer to 0, there is less diversity. The larger the number is, the higher the diversity of the sampling area is. Species diversity is represented by the H' value found in *Table 1-3* using the equation in *(Figure 5).* Once calculated, it was found that the upper zone had a H' indicating the highest diversity of the three zones. The middle zone was the next most diverse

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

and the east zone had the most homogeneous species diversity.

Table 1: Upper Zone Transect (UZT) species diversity (H') in yellow.

	Species Count	pi	ln(pi)	pi * ln(pi)
Q1	6	0.3	-1.20397	-0.36
Q2	8	0.4	-0.91629	-0.37
Q3	8	0.4	-0.91629	-0.37
Q4	7	0.35	-1.04982	-0.37
Q5	8	0.4	-0.91629	-0.37
Q6	8	0.4	-0.91629	-0.37
Q7	11	0.55	-0.59784	-0.33
Q8	9	0.45	-0.79851	-0.36
Total Number of Species	20		H':	2.88

Table 2: Middle Zone Transect (MZT) species diversity (H') in yellow.

	Species Count	pi	ln(pi)	pi * ln(pi)
Q1	7	0.35	-1.049822124	-0.37
Q2	12	0.60	-0.510825624	-0.31
Q3	8	0.40	-0.916290732	-0.37
Q4	8	0.40	-0.916290732	-0.37
Q5	8	0.40	-0.916290732	-0.37
Q6	8	0.40	-0.916290732	-0.37
Total Number of Species	20		H':	2.14

Table 3: East Zone Transect (EZT) species diversity (H') in yellow.

	Species Count	pi	ln(pi)	pi * ln(pi)
Q1	8	0.4	-0.916290732	-0.37
Q2	11	0.55	-0.597837001	-0.33
Q3	9	0.45	-0.798507696	-0.36
Q4	6	0.3	-1.203972804	-0.36
Q5	9	0.45	-0.798507696	-0.36
Q6	9	0.45	-0.798507696	-0.36
Total Number of Species	20		H':	1.78

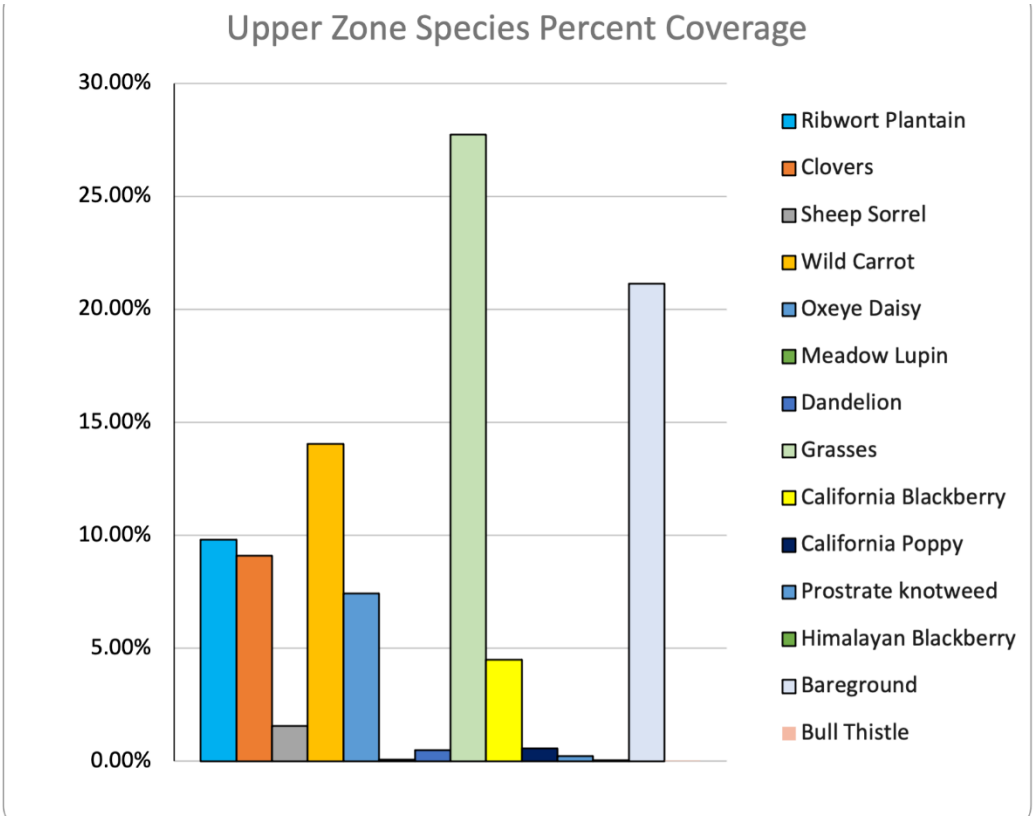
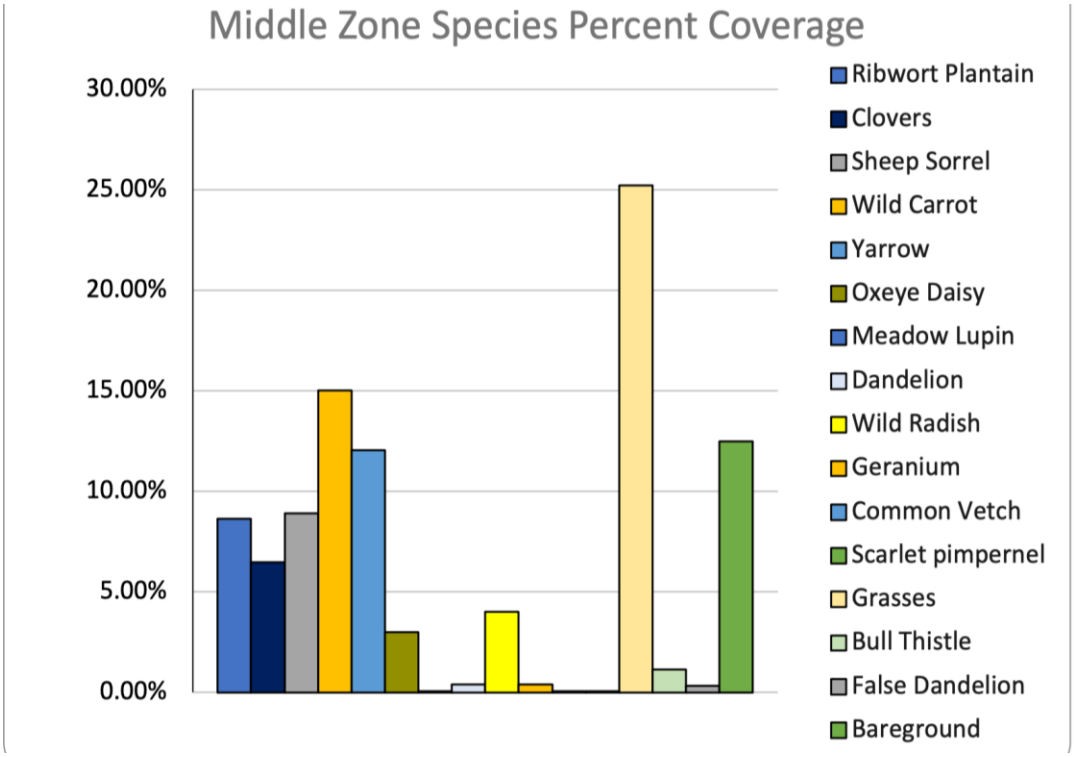


Figure 6: Upper Zone Transect (UZT) total percent coverage representing the cumulative cover classification for each individual plant species along the transect



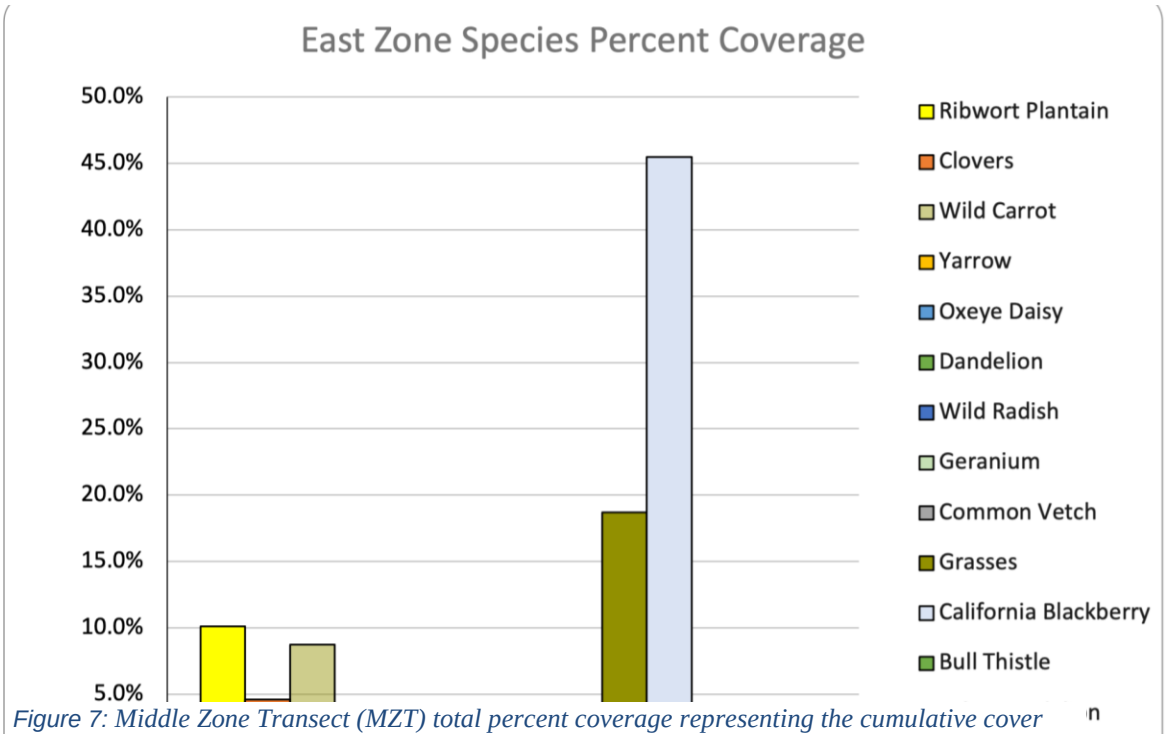


Figure 7: Middle Zone Transect (MZT) total percent coverage representing the cumulative cover

Figure 8: East Zone Transect (EZT) total percent coverage representing the cumulative cover classification for each individual plant species along the transect.

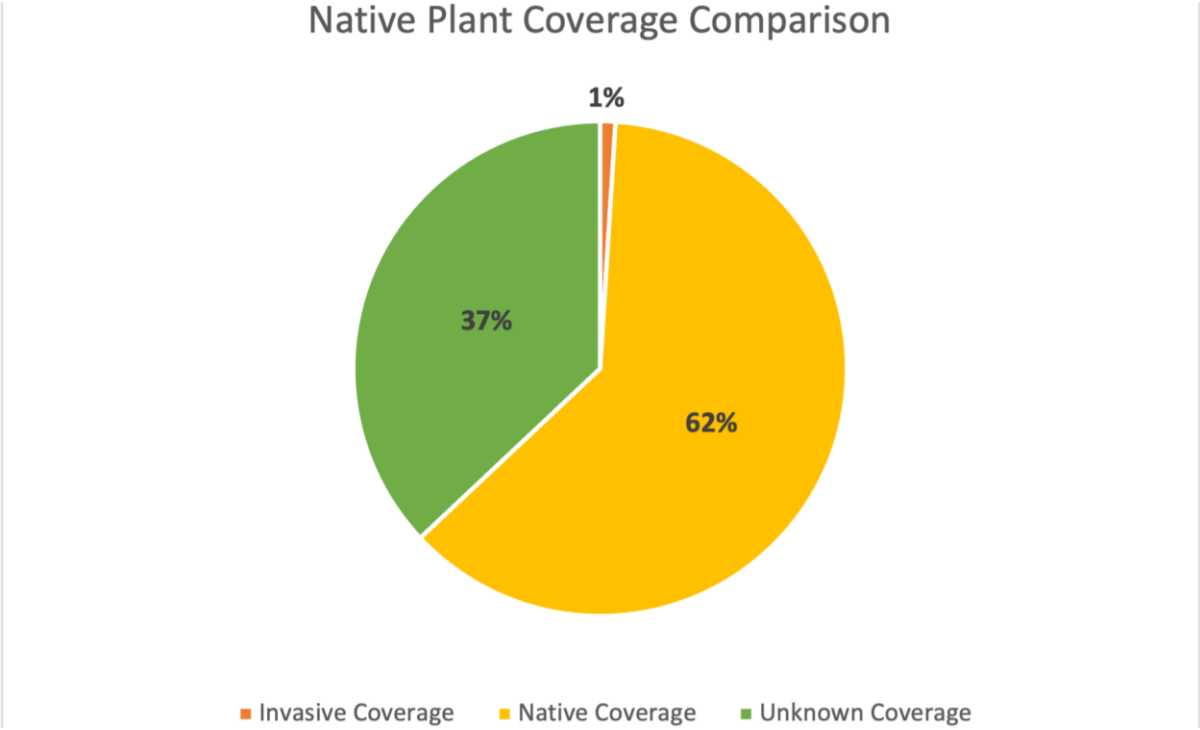


Figure 9: Pie chart representing the total percent over of native plants and invasive plants identified in the SIA.

Discussion

The SIA was conducted to get a baseline understanding of the current composition of the flora on the site. Using the transect data (UZT, MZT, EZT), the results showed the percent cover classification for the native and non-native species which we expect to find based on the composition of the seed mixes that were spread. Calculating percent cover gave us an idea of how to organize our planting recommendations spatially. This influences the selection process of the native plants as well as the location of the plantings. Based on the composition of the seed mixes that were spread during site construction in 2022, we determined the vegetative composition of what survived from the seed mix and how the herbaceous cover might support coastal prairie enhancement through additional planting of select vegetation. Our recommended use of both seeding and direct transplanting of native coastal prairie flora aims to support cultural

and environmental resources. For example, incorporating perennial bunchgrasses on the site will inform the delineation of coastal prairie, thus enhancing this remnant ecosystem along the Baduwa't River (Barbour et al., 2007). The Unknown Coverage in *Figure 9* refers to grasses and clovers. Because there weren't any flowers at the time of sampling, and so many different types were seeded during site construction, we couldn't identify all of the individual grasses and clovers. We decided to group all grasses and all clovers as two species during the SIA, then later grouped them together as one classification of Unknown Coverage in the statistical analysis. The large woody plants such as the trees and the coyote bush on the site were not included in the SIA. This process resulted in the creation of our multi-purpose objectives including the enhancement of a coastal prairie reference ecosystem.

Originally, our team had a rough estimation of what plant communities were currently established at the site due to our initial site visit and debrief with the CalTrout Project Manager. In order to see what was established from the planting of seed mixes (see Appendix A), and to see what improvements could be made to the site, our team conducted an SIA. This data collection and analysis, combined with the on-site interview with the Wiyot Natural Resource Director, led to the development of the recommended planting plan. This planting plan was not only designed to support the coastal prairie by planting native plant species, but by also planting native species that are culturally important to the local Wiyot tribe. This would allow for a place for tribal members to preserve their cultural practices. The planting plan for the public access area seeks to provide landscaping recommendations for the MCSD and CalTrout as a starting point for further meaningful management of the overlook.

The implementation of the recommended planting plan would allow for a more complex coastal prairie ecosystem, which is aesthetically pleasing to the public and also a cultural

resource for local Wiyot community members. The placement of the plants in the recommended planting also provide a service for those utilizing the ADA accessible site, and the surrounding neighborhood. Some services from these plants include, and are not limited to, windbreaks from coastal winds and providing a privacy screen for nearby adjacent residences.

Recommendations

The goal of this capstone project was to provide a draft vegetation plan for the public access area at the Baduwa't Estuary Overlook. Future developments and planning for the trajectory of this restoration effort should be in collaboration with the Wiyot people in order to validate the importance of the site's restoration. While we have grown to know this ecosystem analytically, we do not have the same relationship with the land, or the experiential and scientific knowledge held by the Wiyot. Along with the recommendations from the Wiyot's Natural Resource Director, Adam Canter, tribal collaboration, and guidance from CalTrout and MCSD the Recommended Planting Plan can be further developed and implemented. For now, the planting plan we have developed will provide a baseline composition of coastal prairie species.

The current species diversity found and classified on the site has influenced the placement and density of native plantings. While the planting map contains forbes, grasses, shrubs, and geophytes that are nursery grown and transplanted, the continued use of seeding is recommended for maximum native ground cover of herbaceous flowering plants and forbs. In *Figure 11: Recommended Plants for Public Access Area*, this table outlines the coastal prairie habitat enhancing flora recommended for the site. The Recommended Planting Plan outlines the use of hazel along the fence line separating the public access site and the adjacent neighborhood. This will provide a privacy screen while still allowing a view shed into the property, as well as

acting as a windbreak and a similar natural fence will be planted along the east property line that is shared with the MCSD. Hardy shrubs such as Nootka rose and hazel will be planted along this property line to help create a buffer zone to non-native seed dispersal from the adjoining pasture; indicated with the 'Hedge Row' symbol.

After these multi-functional planting areas are implemented along the borders of the public access area the interior of the site is organized based on abiotic factors such as sun and wind exposure as well as minor topographic fluctuations that influence water availability. Bunch grasses such as Pacific reed grass are recommended for the edge of the river's bluff since they provide bank stabilization with their extensive fibrous root system. These bunch grasses should be 1 gallon nursery plants in order to facilitate the fastest and most successful establishment. These grasses are focused into the top corner of the site, so they do not block the viewshed of the river. Low growing forb species such as coast angelic, beach strawberry, and sword fern are suggested for this area. Specially designated areas are classified as geophyte nursery areas. The use of said areas aim to provide a space to cultivate culturally significant bulb species. The endangered Western Lily would be a possible species of interest for these geophyte gardens. The map also includes other species included in *Figure 10* that will provide a baseline establishment of culturally significant and appropriate plants for the coastal prairie habitat enhancement on site.

Recommended Plants for Public Access Area	
Common Name	**Scientific Name**
California Blackberry	Rubus ursinus
Willow Tree	Salix sitchensis
Sitka Spruce	Picea sitchensis
Coyote Bush	Baccharis pilularis
Geophytes	TBD (Discressonary)
Pacific Reedgrass	Calamagrostis nutakaensis
Coastal Hazelnut Scrub	Corylus cornuta ssp. californica
Sword Fern	Polysticum munitum
Nootka Roses	Rosa nutkana
California GoldenRod	Solidago velutina ssp. californica
Evergreen Huckleberry	Vaccinium ovatum
Coastal Silktassel	Garrya elliptica
Douglas Iris	Iris douglasiana
Beach Strawberry	Fragaria chiloensis
Coast Angelica	*Angelica hendersonii*

Figure 10: Recommended Plants for the Public Access Area

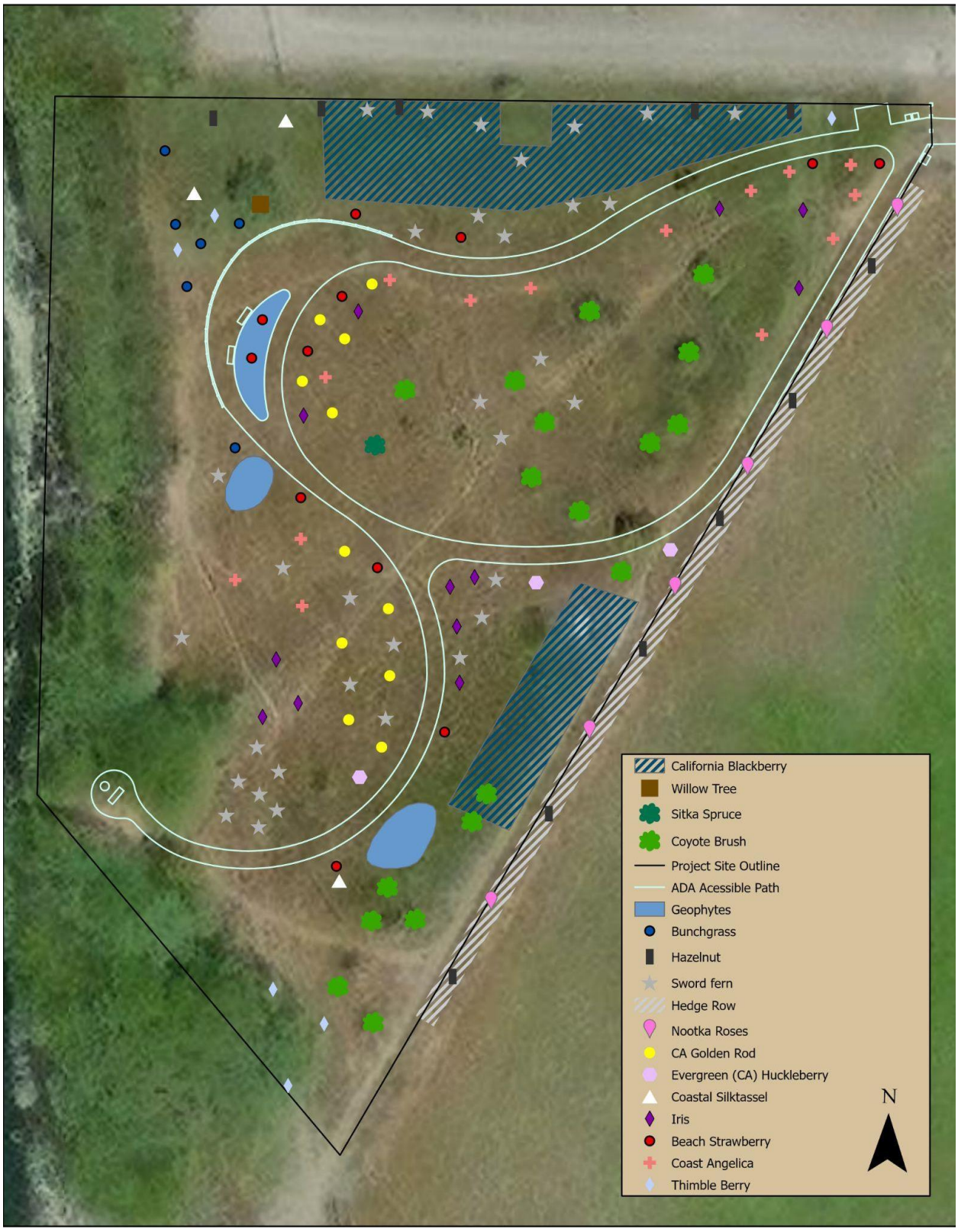


Figure 11: Recommended Planting Plan Site Map

Acknowledgments

A special thanks to Mary Burke of CalTrout. Her guidance as our community partner has been instrumental in our project. We also thank CalTrout's North Coast Project Assistant, Ashley Shannon, for her support. Another special thanks to Adam Canter for his input on the native plants to incorporate on our project site. As the Wiyot tribe's Natural Resources Director, his information during our on-site interview was invaluable and largely influenced the creation of our planting recommendations map. Finally, we thank our course instructor Daniel Lipe for his continuous support and encouragement.

Appendix

Appendix A.

SEED MIXES McKinleyville Community Services District & California Trout 2022 Baduwa't Estuary Restoration and Public Access Enhancement Project

Table 1. Backwater Channel Seed Mix

Scientific Name	Common Name	Pounds Seed/Acre
Achillea millefolium	yarrow	6.0
Bromus sitchensis var. carinatus	California brome	12.0
Festuca rubra	red fescue	12.0
sterile wheat	sterile wheat	8.0
TOTAL lbs/acre		38.0

Table 2. Pond Channel Seed Mix

Scientific Name	Common Name	Lbs Seed/Acre
Achillea millefolium	yarrow	5.0
Bromus sitchensis var. carinatus	California brome	14.0
Deschampsia caespitosa subsp. beringensis	tufted hair grass	10.0
Festuca rubra	red fescue	12.0
~~*Lupinus rivularis* unavailable~~	~~riverbank lupine~~	~~2.0~~
Potentilla anserina	silverweed	
Artemisia douglasiana	CA mugwort	
TOTAL lbs/acre		43.0

Table 3. Organic Pasture Seed Mix for MCSD pasture, was spread at public access site in error

Scientific Name	Common Name	Pounds of Seed/Acre
Lolium perenne[1]	tetraploid perennial ryegrass	8.0
Trifolium michelianum	Bolansa clover	5.0
Trifolium pratense	Barduro red clover	5.0
Trifolium repens	white clover (ladino type)	3.0
Trifolium fragiferum	Salina clover	2.0
Lolium perenne multiflorum[1]	Italian ryegrass	4.0
Lolium multiflorum[1]	tetraploid annual ryegrass	3.0
TOTAL lbs/acre		30.0

[1]*Jepson Manual* (2012) recognizes *Festuca perennis however* aka *Lolium perenne* and *L. multiflorum*

Table 4. Coastal Grassland Seed Mix – for Public Access Site

Scientific Name	Common Name	Lbs of Seed/Acre
Achillea millefolium	yarrow	2
Angelica lucida	seacoast angelica	2
Bromus sitchensis var. *carinatus*	California brome	7
Deschampsia caespitosa subsp. *beringensis*	tufted hair grass	7
Eschscholzia californica	California poppy	1
Festuca rubra	red fescue	12
~~*Lupinus rivularis* unavailable~~	~~riverbank lupine~~	~~2~~
Sumphyotrichum chilense	Pacific aster	
Artemisia douglasiana	CA mugwort	
Lupinus polyphyllus var. *polyphyllus*	meadow lupine	2
TOTAL lbs/acre		35.0

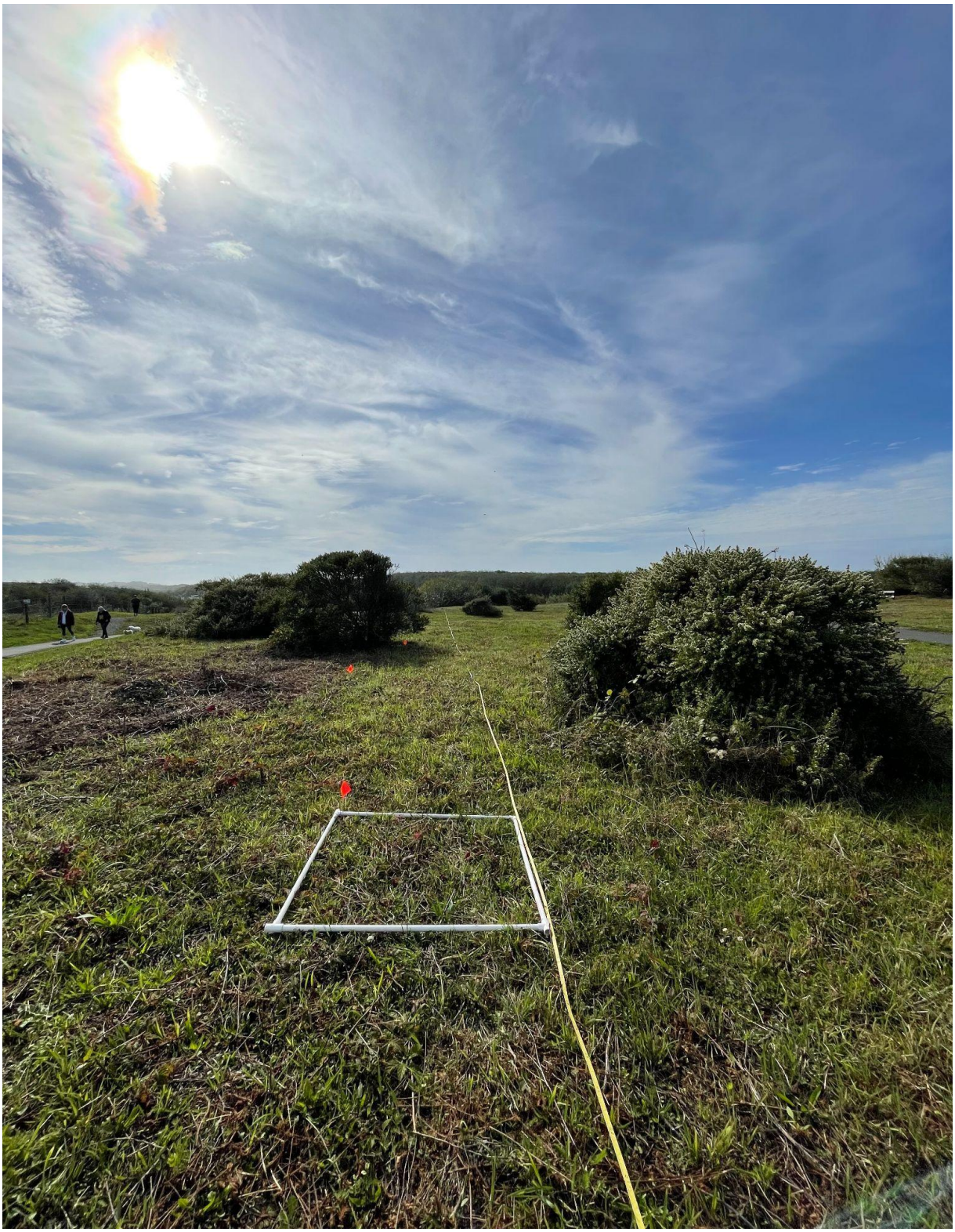
Appendix B.

Eastern view of the Upper Zone at the public access overlook where planting recommendations are located.

Appendix C.

The view of the Baduwa’t (Mad River) from the northernmost overlook bench at the public access area.

Appendix D.



Quadrat method process along the Upper Zone Transect.

Appendix E.

Coyote Bush at the north end of the East Zone.

Appendix F.

Sitka Spruce in the Upper Zone.

Appendix G.

Example of quadrat method sample along a transect.

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