Kent Island Vegetation Management

PROJECT MONITORING PLAN

Prepared for

Marin County Open Space District

Prepared by

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Kent Island Restoration Project
Monitoring Plan

1.0 LOCATION

Kent Island is a natural emergent (dune-capped) flood tidal delta located within Bolinas Lagoon.

2.0 PROJECT DESCRIPTION

Historically, Kent Island was subject to partial geomorphic stabilization by resilient native salt marsh and dune vegetation, alternating with complete submergence during seismic subsidence events. The dominant vegetation's dynamic response to wind, wave, and tidal current transport of sand is highly important for the natural hydrological and sediment dynamics within the lagoon. However, non-native vegetation now dominates Kent Island, and has displaced suitable habitat for native plants and wildlife, including special-status species. These non-native species compromise the island's resilience to extreme disturbances (e.g., storm over wash and earthquake-related subsidence and submergence).

The proposed project will remove non-native vegetation including all tree seedlings, non-native invasive beachgrass (marram), iceplant, wattle (acacia), French broom, and fennel among others. The primary methods to treat these non-native plants include saltwater irrigation and hand-tool removal. The Marin County Open Space District (MCOSD) will rely on volunteer labor from the local communities to perform vegetation removal, replanting native species, and monitoring.

3.0 PROJECT GOALS AND OBJECTIVES

The goals of modifying Kent Island vegetation are to:

1) Restore ecosystem resilience from significant natural disturbance impacts and allow the island to adapt to accelerated sea level
2) Increase biological diversity of native island vegetation and protect important refuges for rare plants
3) De-anchor the island to improve hydrologic function and sediment transport in Bolinas Lagoon

The objectives of the project are to:

1) Remove non-native vegetation from the island
2) Promote and facilitate expansion of existing native plant populations

4.0 MONITORING

This monitoring plan is designed to evaluate the project's progress in meeting its goals and objectives, and is intended to meet the standards approved by the Estuary Habitat Restoration Council as described in "Science-based Restoration Monitoring of Coastal Habitats" (October 2003, U.S. Department of Commerce, NOAA).

Structural Monitoring Parameters[1]

Structural monitoring parameters will include:

1) Non-native, invasive plant occurrence, cover, and reproductive rate

2) Native vegetation cover and species composition (native species richness)

3) Long-term increase in distribution and abundance of existing rare plants

4) Occurrence of locally extirpated rare plants

The project will be successful if, after five years from the initial manipulation, the treated portions of the island (except for the stand of mature pines and cypress in the center of island):

1) Are dominated by native beach and salt marsh vegetation
2) Show increased diversity and cover of native dune, open sand, and rare plants
3) Show substantially reduced presence of invasive plants

Functional Monitoring Parameters[2]

Functional monitoring parameters will include:

1) Increased habitat suitable for re-colonization
2) Establishment of native plants as measured in the control and treatment plots
3) Increased vegetative re-colonization and sediment stabilization potential, indicated by increased proportion of native clonal perennial plant species along the wave-influenced southern shoreline of Kent Island

4.1 Pre-treatment (baseline) Monitoring

Vegetation

Preliminary surveys classified Kent Island vegetation into eight discrete vegetation management units (VMUs) based on topography, dominant weeds and native vegetation, specific localities of sensitive plants or wildlife, and the corresponding types of weed management and re-vegetation actions indicated (Figure 1). More detailed surveys delineated plant communities, locations of target weeds, and locations of rare plants during peak detection (flowering) (Figures 2-4).

The vegetation communities were first categorized broadly by visual assessment. In July 2012, nineteen relevés[3] were established to collect data on plant species occurrence and relative abundance (cover

[1]Structural parameters here refer to direct spatial measurement of vegetation (cover, frequency, patch size, density, species composition, etc.) that supports ecological functions.
[2] Functional parameters refer to structural indicators of dynamic ecological processes that are episodic or future long-term changes not directly observed during the monitoring period.

class[4]) to describe and categorize the plant communities; the analysis of the relevé data indicated that there are 14 plant communities on the island (Figure 2). The relevés will also provide post-treatment monitoring data on changes in cover class for each species as well as gain or loss of a species from the sample area.

Within each plant community, line intercept transects were established and mapped with GPS. Transects were placed randomly within each community type; GPS was used to generate random points for the start of the transect and a table of random numbers was used to generate the compass bearing for each transect. A total of 34 five-meter transects and one ten-meter transect were established (Figure 5)—the length and number of transects was not predetermined but was based on an evaluation of variance in cover of plant species with transect length. The longer ten-meter transect in the *Festuca-Capobrotus*-Soil community reflects the extremely patchy character of the plant community. The number of transects per vegetation community also depended on the variance in the cover data collected for each community; note however, that some communities do not have any transects because they will not be treated (e.g., *Distichlis, Plantago, Cakile*). Also note that some transects were placed specifically within targeted weed polygons (i.e. *Carpobrotus* dominant, *Drosanthemum,* and *Lotus*) in order to track treatment effects in these high density and high priority weed polygons, which are not distinct vegetation communities. In July 2012, data were collected on the line intercept transects as part of pre-implementation monitoring. These data provide estimates of frequency and cover for each species, and measurements will be repeated each July during the five-year monitoring period.

In addition to the methods, project biologists conducted floristic surveys of the entire island to identify location of target weeds and rare plants (see Figure 3 and 4, respectively). Rare plant locations were mapped (aerial extent) using GPS and assigned visual estimates of density class. Point data for invasive trees (outside the primary grove that will be preserved) and shrubs were collected using GPS.

Reference sites: Kent Island represents a unique habitat and there is no relevant model reference site available to inform success criteria. There is, however, less disturbed patches of vegetation on the island and historical data on plant communities, including occurrence of rare plants. These relatively undisturbed plots and control plots (untreated) will be used to compare with treatment plots in order to assess vegetation management efficacy.

Geomorphology

A crucial component of the base-line monitoring program is a LiDAR survey to be conducted by the United States Geological Survey (USGS). The survey will document the bathymetry of the lagoon, including the topography of Kent Island. Bathymetric surveys of the lagoon have been conducted every ten years from 1968 to 1998. A ground based LiDAR survey will provide highly accurate (+/- 2 cm) pre-project data of vertical and horizontal topography and bathymetry of Kent Island and adjacent intertidal

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[3] In A Manual of California Vegetation (Sawyer and Keeler-Wolf 1995), CNPS published a Vegetation Sampling Protocol that was developed as a simple quantitative sampling technique applicable to many vegetation types in California. The relevé is generally considered a "semi-quantitative" method. It relies on ocular estimates of plant cover rather than on counts of the "hits" of a particular species along a transect line. The relevé is particularly useful when observers are trying to classify the range of diversity of plant cover over large units of land.

[4] Cover classes assigned were: R = 1 individual; + = < 1%; 1 = 1-5 %: 2a = 6-15%; 2b = 16-25 %; 3 = 26-50%; 4 = 51-75%; 5 = 76-100%.

mudflat and channel morphology. The LiDAR survey will include RTK[5] transects that run from the higher portions of the island through the various vegetation communities and into the adjacent marsh, tidal flat, and channel habitat in order to assess sand erosion and deposition. RTK transects in years three and five will allow us to evaluate the functional benefits of invasive plant removal on de-anchoring Kent Island and returning it to a dynamic flood-shoal island

4.2 Post-treatment Monitoring

Monitoring will continue for a minimum five years after the initial treatment year; however, invasive species treatment and native species replanting will continue throughout the monitoring period. The annual post-treatment monitoring will include the following:

1) Survey the vegetation relevé plots and the line-intercept monitoring transects to quantify weed and native plant frequency and cover. These surveys will also provide data on native species regeneration and recovery of native species diversity and will be conducted during peak flowering periods. These surveys will provide estimates of population sizes and changes in distribution in relation to eradication of competitor invasive species.
2) Survey the entire island for re-growth of large isolated plants (e.g., pine seedlings, acacia, and broom) as was done in the pre-treatment monitoring.
3) Map the occurrence and aerial extent of rare plants (during appropriate flowering period).
4) Sample weed reproductive or vegetative (clonal) growth to assess the impact of salt water irrigation of native and non-native plants and as an indicator of the rate at which remnant invasive weeds may grow back and spread.

The annual survey of relevé plots and line-intercept transects provide an annual snapshot of how the frequency and percent cover change between years, but not the rate at which what remains can grow back and spread. Frequency and percent cover measurements coupled with those of weed reproductive output and vegetation growth will provide a dynamic and long-term indication of treatment effects. Measurement of static percent cover may indicate dramatic reductions in weeds in treated plots, but high seed production or growth rates from residual weeds can result in rapid recolonization. If monitoring shows that there is a major reduction in cover, frequency, and reproductive rate, it will demonstrate that the project is making real progress in meeting the objectives. These reproductive rate measurements will be conducted at low but meaningful sampling intensity on treatment and control plots. Measures of reproductive rate will be assigned to principal weeds based on species-specific modes of reproduction and spread.[6] Growth and seed reproductive rates at the end of the five-year monitoring period will indicate the potential rate for invasive plants to recover after active treatments cease. The reproductive measurement will also be important for adaptive management to adjust saltwater treatment in the field as marginally stressed plants may respond by increasing allocation to reproduction whereas severe stress will reduce both seed and growth production.

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[5] Real Time Kinematic (RTK) satellite navigation is a technique used in land survey and in hydrographic survey based on the use of carrier phase measurements of the GPS, GLONASS and/or Galileo signals where a single reference station provides the real-time corrections, providing up to centimeter-level accuracy.

[6] For example, reproductive rate in *Carbobrotus* may include fruit density (number of fruits/unit area) and current year shoot growth (length, radial spread of colonies, marked shoot tip positions over growing season) whereas *Ammophila* may include only measures of live rhizomes (length and number/plant or density (unit line-intercept) as it spreads almost exclusively by vegetative growth in this part of its range.

Overall, as weed abundance and distribution diminishes over time (more sample plots extirpated) and the number of weed-free plots increases, the project biologists will reduce sampling effort.

5.0 PERFORMANCE CRITERIA AND ADAPTIVE MANAGEMENT

Analysis and reporting of monitoring data for vegetation change will include simple linear regression of:

1) Weed abundance, frequency, and cover
2) Weed patch size distribution (clonal or continuously distributed species/local monotypic stands)
3) Total weed cover

For specific weed treatment effect analysis, repeat-measures analysis of variance (ANOVA) or paired t-tests will be used be used to determine the significance of treatment effects or years. The frequency of weed-cleared (extirpated) larger sized plots (chi-square test) within weed-treated areas, and on the island overall, will allow measurement of treatment efficacy.

Vegetation performance criteria for invasive and native plants are shown in Tables 1 and 2, respectively. The highest priority for assessment of overall project success would be:

1) To establish the largest possible contiguous areas (within and among VMUs) with either extirpated target weeds, or marginal and narrowly distributed populations of target weeds with significantly reduced rates of reproduction or vegetative spread
2) To increase distribution of native species, including rare plants

Performance standards for invasive plants vary based on the reproductive strategy of each species in relation to Kent Island environments and ecosystem dynamics, as well as local and regional population structure (off-island population interactions). Performance standards for native plants are based on the course of succession during the treatment period (influenced by temporary disturbances such as artificial saltwater irrigation, manual removal, etc.) and the long-term naturally variable composition of native plant communities in response to rainfall variability, storm events, and other ecosystem dynamics. Because native coastal plant communities should be dynamic, only the overall composition of key dominant species (allowing variable proportions of their contribution to overall cover) are specified, and the overall contribution of native vegetation cover during the treatment period (milestones for progress of vegetation recovery) are prescribed. Percent cover targets for native species are relative to total vegetation cover, not absolute vegetation cover, because the total percent vegetation cover of the native plant communities is not complete or static: it ranges from sparse to dense, and varies in response to coastal processes and climate variability. Additional criteria for reintroduced and existing special-status species are also prescribed, allowing for variability.

Adaptive management would be implemented by modifying the location, duration, intensity or type of vegetation management actions based on review of current-year and previous data on weed reduction and recruitment, and rates of recovery of native vegetation. The overall vegetation monitoring data would be interpreted for management action modification in real time (not after monitoring reports are completed after the treatment season) by comparing with real-time treatment efficacy measurements.

For example, marram and iceplant response to soil salinization with high foliar dieback rates but low mortality rates, and low soil salt concentrations within the lower end of the root zone, would indicate a need for longer salt water irrigation times and deeper sand penetration. This and other practical adaptive management actions are reliant on complex professional judgment as well as data, and are not efficiently reduced to formulaic or rigid programmatic principles.

Measuring weed reproduction and growth rates, combined with vegetation cover and frequency data, will provide a biologically meaningful assessment of project efficacy at the end of the monitoring period, and would provide important information for long-term adaptive management.

6.0 Reporting

Monitoring reports will be submitted annually in July 2014 through 2018 and will include a summary of:

- Project activity
- Data summary and analyses
- Milestones
- Performance standards

These reports will be submitted to the U.S. Army Corps of Engineers, San Francisco District, which will oversee monitoring efforts and ensure that project data is entered into the National Estuaries Restoration Inventory.

Table 1: Performance Standards for Invasive Plant Eradication

Species	Target YR1	Target YR3	Target YR5
Pine and Cypress: Seedlings and saplings within VMU-2; all individuals outside VMU-2	100% **eradication** (complete removal of saplings & adults)	100% **eradication** of seedlings, saplings	100%. No recruitment of seedlings >100 m outside VMU-2; 100% eradication of saplings & reproductively trees outside VMU-2
Iceplant	**cover** >50% reduction (live); **growth rate and reproductive output** > 50% decline (no frequency standard)	**cover** >75% reduction (live); **shoot growth rate** > 50% decline; **reproductive output** > 80% decline; **frequency** < 80% (100 m^2)	**cover** >95% reduction (live); **shoot growth rate** > 50% decline; **reproductive output** >95% decline; **frequency** <30% (100 m^2)
Rose iceplant	N/A (no data feasible with treatment)	90% reduction in cover; **reproductive output** > 80% decline; **frequency** < 20% (100 m^2)	100% reduction in cover; **reproductive output** 100% decline (0 seed); **frequency** < 1% (100 m^2) (trace)
Marram	**live shoot density** >50% reduction; **growth rate (shoots/shoot)** > 50% decline**; seed reproductive output** <100 seeds/100 m^2) (no frequency standard)	**cover** >75% reduction (live); **shoot growth rate** > 50% decline; **seed reproductive output** = 0 decline; **frequency** < 80% (100 m^2)	>99% reduction in cover (trace); **reproductive output** 0% decline (0 seed); **frequency** < 5% (100 m^2) (trace)
Acacia	80% mortality (density; dead/inviable stumps, no resprouts)	95% mortality (dead/inviable stumps, no resprouts)	100% 95% mortality (dead/inviable stumps, no resprouts)
Broom	80% adult/juvenile mortality (density; dead/inviable stumps, no resprouts)	95% adult/.juvenile mortality	100% adult/juvenile mortality, no reproduction [permanent seed bank precludes seedling recruitment standard]
Fennel	95% adult/juvenile mortality	>99% adult/juvenile mortality; reproduction = 0	100% adult/juvenile mortality; reproduction = 0; seedling frequency < 1% (trace)
Bush lupine	80% adult/juvenile mortality (dead/inviable stumps, no resprouts)	95% adult/juvenile mortality	100% adult/juvenile mortality, no reproduction)[permanent seed bank precludes seedling recruitment standard]
Bird's-foot trefoil	80% adult/juvenile mortality (dead/inviable stumps, no resprouts)	95% adult/juvenile mortality	95% adult/juvenile mortality, no reproduction) [permanent seed bank precludes seedling/juvenile recruitment standard] cover < 1%
Algerian sea lavender	99% mortality adult/juvenile; seed reproduction = 0	99% mortality adult/juvenile; seed reproduction = 0	seed reproduction = 0; cover = 0 (trace); density = 0 (trace due to persistent seed bank)
Other invasive non-native spp. colonization (*Salsola*, *Tetragonia*, etc.)	95% mortality	99% mortality (trace)	99% mortality (trace)

Table 2: Performance Standards for Native Plant Re-establishment

VMU	target dominant species composition	Target relative % native cover YR1	Target % relative native cover YR3	Target YR5
All VMU:				>99% dominance native salt marsh, beach, & dune vegetation (trace non-native
VMU-1 west shore fringing salt marsh	Saltgrass, pickleweed, alkali-heath, gumplant, with associated spp. including marsh milkvetch	> 60%	>90%	>99% (perennial species; non-native long-distance dispersal annuals spearscale, *Atriplex prostrata*, sea-rocket, *Cakile maritima*, excluded from cover standard); self-reproducing population of marsh milk-vetch > 100 adults with reproductive rate (seedheads/plant) > 50% reference Point Reyes population.
VMU-2 western conifer woodland	N/A; shrub layer removal only	N/A (no ground layer standard)	N/A	N/A
VMU-3 central foredune terrace	successional saltgrass; Vancouver & beach wildrye, red fescue, beach-bur; with associated pink sand-verbena	>60%	>90%	>99% (trace non-native); reproductive population of pink sand-verbena present most years (>50% all years sampled)
VMU-4 central beach-salt marsh ecotone	saltgrass, pickleweed, alkali-heath, seaside plantain, Jaumea, with associated spp.	>90%	>95%	>99% (perennial species; non-native long-distance dispersal annuals spearscale, *Atriplex prostrata*, sea-rocket, *Cakile maritima*, excluded from cover standard)
VMU-5 central terrestrial grassland	successional saltgrass; Vancouver & beach wildrye, red fescue	>75%	>90%	>99% (trace non-native)
VMU-6 backbarrier salt marsh ecotone	saltgrass, pickleweed, alkali-heath, gumplant; with (subdominant) salt-marsh owl's-clover	>75%	>90%	>99% (trace non-native); salt marsh owl's-clover density not significantly different among treated and intact (no bird's-foot trefoil pre-treatment) plots.
VMU-7 eastern grassland terrace	successional saltgrass; Vancouver & beach wildrye, red fescue	>75%	>90%	>99% (trace non-native)
VMU-8 Southeastern beach-salt marsh ecotone	saltgrass, Vancouver & beach wildrye, red fescue, beach-bur, alkali-heath, saltbush, with associated marsh milkvetch, pink sand-verbena	>75%	>90%	>99% (perennial species; non-native long-distance dispersal annuals spearscale, *Atriplex prostrata*, sea-rocket, *Cakile maritima*, excluded from cover standard) self-reproducing population of marsh milk-vetch > 100 adults with reproductive rate (seedheads/plant) > 50% reference Point Reyes population.

Figure 1: Vegetation Management Units on Kent Island

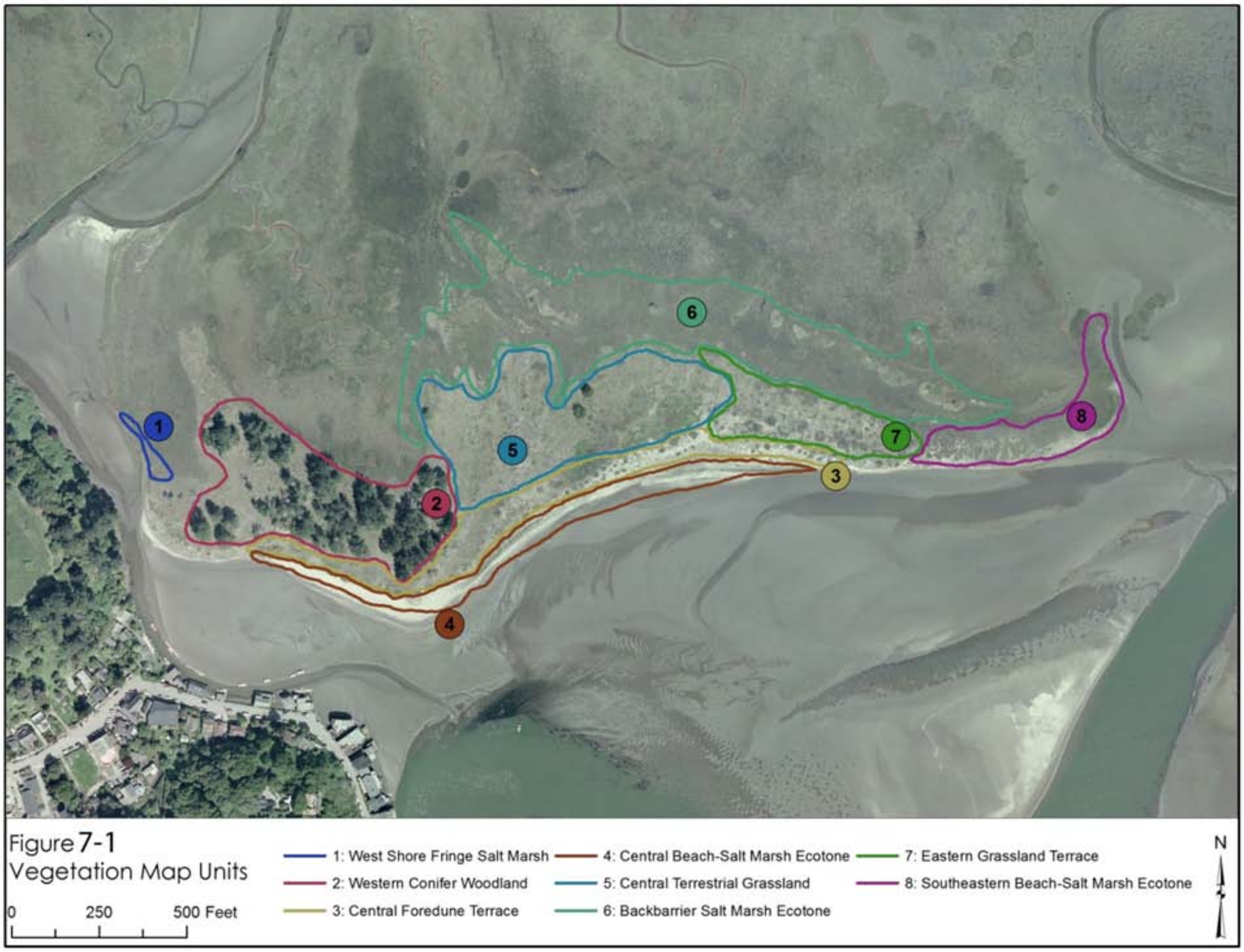
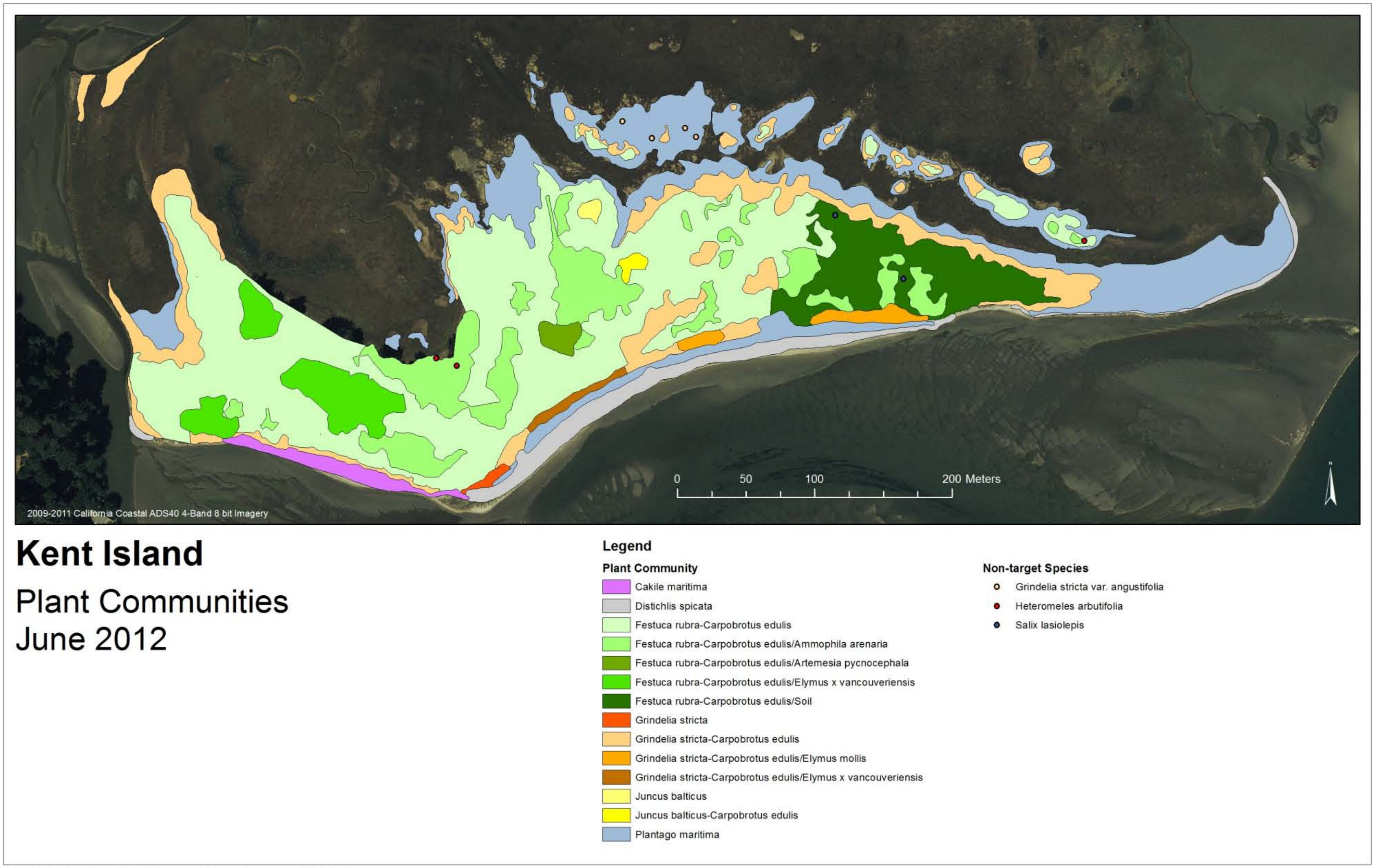


Figure 2: Kent Island Plant Communities



Created by: Shelly Benson, Contact information: shelly.benson@yahoo.com, 707-479-6777

Figure 3: Kent Island Target Weeds

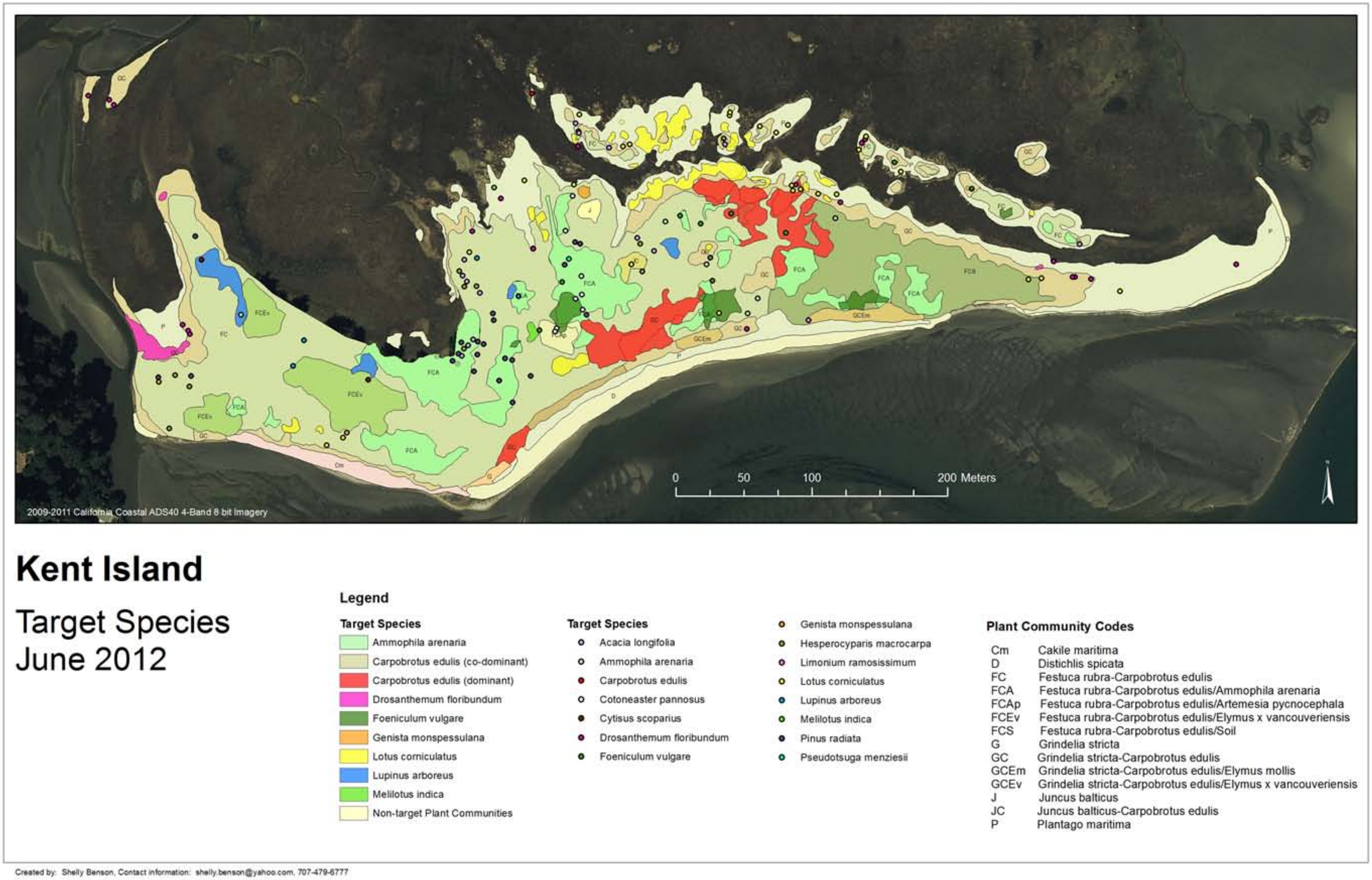
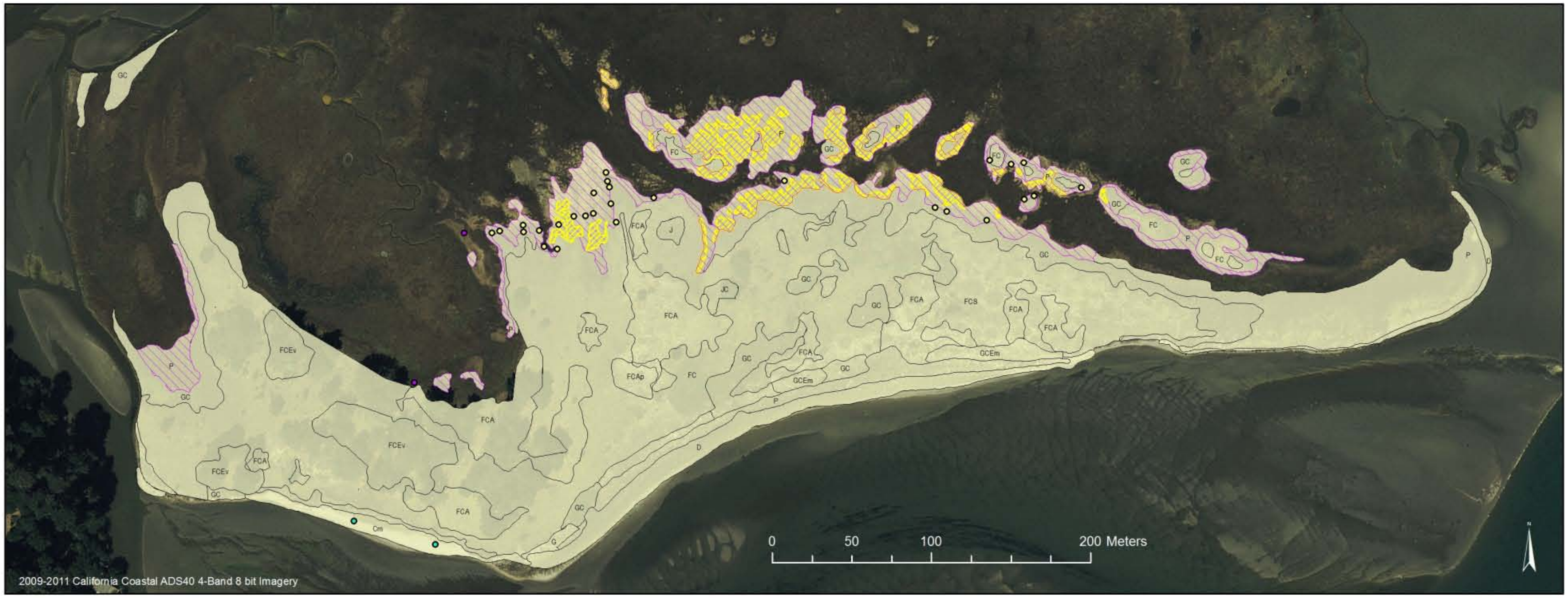


Figure 4: Kent Island Rare Plant Locations



Kent Island

Rare Plants
June 2012

Legend

Plant Communities

Rare Plants

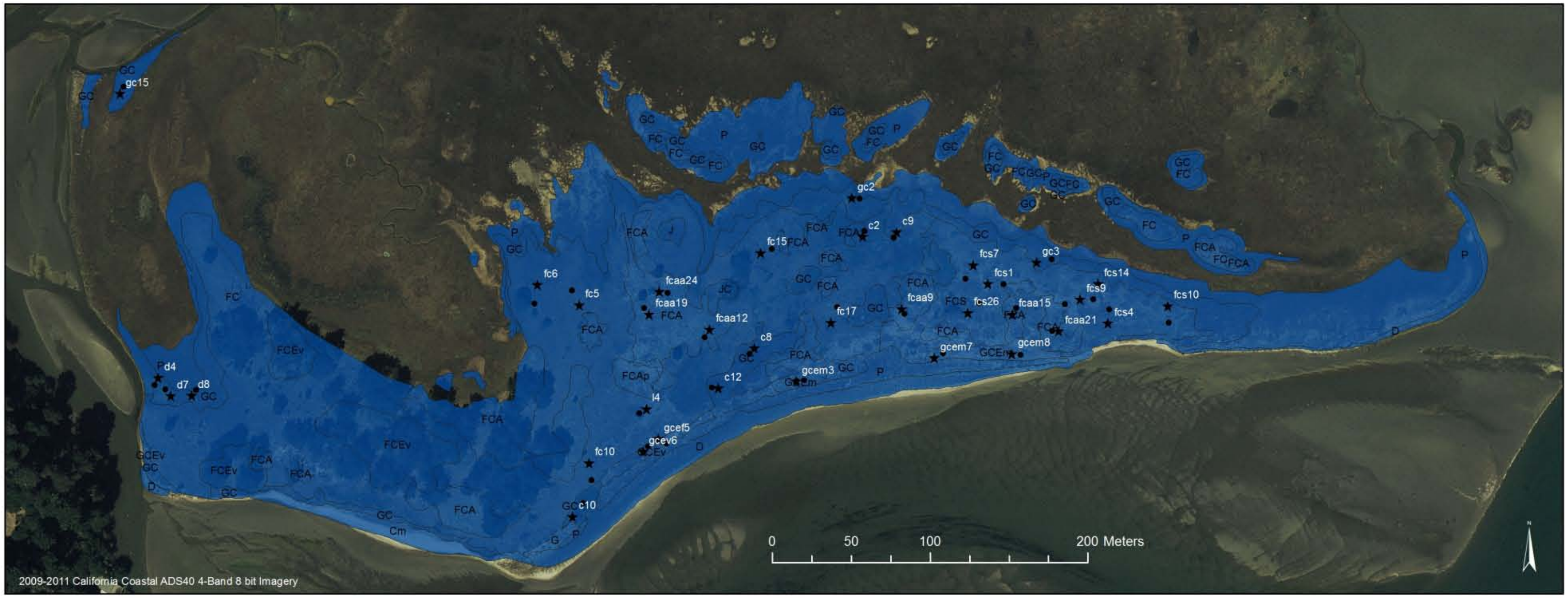
- Castilleja ambigua ssp. ambigua (hatched area)
- Chloropyron maritimum ssp. palustre (hatched area)
- Abronia umbellata var. breviflora (point)
- Castilleja ambigua ssp. ambigua (point)
- Chloropyron maritimum ssp. palustre (point)

Plant Community Codes

Cm	Cakile maritima
D	Distichlis spicata
FC	Festuca rubra-Carpobrotus edulis
FCA	Festuca rubra-Carpobrotus edulis/Ammophila arenaria
FCEv	Festuca rubra-Carpobrotus edulis/Elymus x vancouveriensis
FCS	Festuca rubra-Carpobrotus edulis/Soil
G	Grindelia stricta
GC	Grindelia stricta-Carpobrotus edulis
GCEm	Grindelia stricta-Carpobrotus edulis/Elymus mollis
GCEv	Grindelia stricta-Carpobrotus edulis/Elymus x vancouveriensis
J	Juncus balticus
JC	Juncus balticus-Carpobrotus edulis
P	Plantago maritima

Created by: Shelly Benson, Contact information: shelly.benson@yahoo.com, 707-479-6777

Figure 5: Kent Island Line-Intercept Transect Locations



Kent Island

Vegetation Monitoring Transects July 2012

Legend

★ Start of transect

• End of transect

Plant Communities

Plant Community Codes

Cm	Cakile maritima
D	Distichlis spicata
FC	Festuca rubra-Carpobrotus edulis
FCA	Festuca rubra-Carpobrotus edulis/Ammophila arenaria
FCEv	Festuca rubra-Carpobrotus edulis/Elymus x vancouveriensis
FCS	Festuca rubra-Carpobrotus edulis/Soil
G	Grindelia stricta
GC	Grindelia stricta-Carpobrotus edulis
GCEm	Grindelia stricta-Carpobrotus edulis/Elymus mollis
GCEv	Grindelia stricta-Carpobrotus edulis/Elymus x vancouveriensis
J	Juncus balticus
JC	Juncus balticus-Carpobrotus edulis
P	Plantago maritima

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