Richmond Bay Campus Coastal Terrace Prairie Management Plan

Prepared for

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1.0 Introduction

1.1 Background

This is the first iteration of a comprehensive resource management plan for the Coastal Terrace Prairie at the proposed Richmond Bay Campus (RBC). As of spring 2014, management of the resource has largely consisted of mowing to reduce invasive plant species and efforts to minimize disturbance of the area, along with some notable small scale research and restoration efforts. The Coastal Terrace Prairie is a key feature of the upland portion of the Natural Open Space area in the Richmond Bay Campus 2014 Long Range Development Plan. The Management Plan is intended to help protect and restore this area in keeping with objectives of the Long Range Development Plan to establish an appealing and inspirational character for the new campus, sensitive and responsible to its natural environment.

This Management Plan anticipates that implementation of the Richmond Bay Campus, and implementation of this Management Plan, will occur at varying degrees of intensity over time. During periods of limited development at the RBC and limited resources for stewardship, steps can nonetheless be taken to reduce the threat of invasive plant species, as described elsewhere (Farrell et al. 2007, Cai et al. 2012). As development at the RBC proceeds, as open space areas outside the Natural Open Space are developed or altered, sod salvage and other more intensive management practices can proceed.

Historically, the Richmond Field Station portion of the Richmond Bay Campus housed companies involved in explosives manufacturing, and some contaminants remain in soil and groundwater. Any activity under this Management Plan must be undertaken with full cognizance of the history of the site, and in accordance with soil management plans approved by regulatory agencies. This Management Plan does not provide authority to undertake any action; activities can only be undertaken with full review and approval of the University, which is responsible for ensuring compliance with regulatory requirements.

1.1.a. Definition of the Units for Conservation and Management

The University of California acquired the Richmond Field Station of the Richmond Bay Campus (RBC) lands in the 1950s, and recently is involved in a planning process for development of new facilities. Part of the Richmond Bay Campus land contains relict areas of an assembly of plants in a natural community, an example of a "coastal terrace prairie". Although no federal or state-listed protected species occur on the site, this relict coastal terrace prairie is considered a "sensitive natural community" under widely used CEQA guidelines.

This natural grassland community has been finely divided by past land use, so some consideration should be given to define what is meant by an occurrence of an intact "coastal terrace grassland" and occurrences of small shreds of the natural community, each with only a few native plants.

Immediate shorelines of Richmond, California were open grasslands before European settlement from 1845-1900, and were dominated by a complex of plant species that included California Oat Grass (Danthonia californica) and Purple Needle Grass (Nassella pulchra). A square meter of undisturbed, native coastal terrace prairie may be home to over 20 native plant species, and these grasslands may have over 100 species in a hectare (Stromberg et al. 2001). These dominant grasses are part of a much richer assembly of native flowering plants (Stromberg et al. 2001) that are collectively recognized as a unique plant community, California's "coastal terrace prairie" (Barbour et al. 2007). Plant ecologists in California have used several methods to define and describe native plant communities, largely initiated in the 1940s as the Wieslander Vegetation Type Map ("VTM") survey, with units of about 40 acres (Barbour et al. 2007) grouped into about 23 units. In the 1970s, California used a minimum mapping unit of 400-800 acres in the CalVeg system with 220 distinct plant community names. In the 1990's, California participated in the national GAP analysis system to classify plant communities based on a minimum mapping unit of 247 ac. into many thousand of named map polygons (Barbour et al. 2007). By the late 1990s, an effort led by the California Native Plant Society (CNPS), working with The Nature Conservancy (TNC) and the Ecological Society of America (ESA) developed an integrated vegetation mapping and classification system (Barbour et al. 2007). Based on this work, the International Terrestrial Ecological System Classification was developed based on vegetation community units from 2.5 ac to 2500 acres (NatureServe 2014). By 2011, CNPS developed widely used guidelines for mapping rare vegetation (CNPS 2011) with a minimum mapping unit of 0.25 to 0.5 acre. This reflects the general practice in plant ecology of working from natural units that are large enough to be relatively consistent in relative abundance of the same plant species across what is often called a "stand" or unit of vegetation classification (Mueller-Dombois and Ellenberg 1974).

A re-analysis of data from 32 relict coastal terrace prairies (Stromberg et al. 1996) reveals that representative coastal terrace prairies are defined as those areas where *Nassella pulchra* and/or *Danthonia californica* are the dominant native grasses and average total canopy cover of native plants is 57% (42% grass) and the average total canopy cover of non-native plants is 44% (33% grass). Even the best remaining examples of California coastal terrace prairies are invaded by non-native plants. Coastal terrace prairies are dominated by grasses but can be quite showy in late spring. Grasses provide the matrix and fibrous underpinning of the coastal terrace prairie community.

Within the identified Natural Open Space area, the least disturbed coastal prairie contains 50% cover of native prairie species. In some areas native vegetation constitutes up to 100% of vegetative cover (Wildlife RA 2014).

1.2 Management Goals

UC Berkeley's goal is to restore and manage approximately 15 acres of contiguous relict coastal grassland on the Richmond Bay Campus. The University recognizes that very small polygons (from a few square centimeters to a few square meters) can occur anywhere on the RBC site and may include some of the indicator species for "coastal terrace prairie" but these occurrences are too small to define a "stand" or minimum mapping unit of this "sensitive natural community" (see 1.1.a. above). The decision to distinguish these occurrences from the core "stands" of this named plant community, as done in studies prepared for the University, and reflected in the EIR, is supportable under CEQA, and under CDFW guidance for evaluating impacts to sensitive natural communities.

These small occurrences or patches of native vegetation, which are often too small to contain the broad array of up to 100 plant species that define the coastal terrace prairie community, can continue to have a role in preserving the overall biodiversity of the RBC. These can serve as source plant material for restoration of the 15 acre coastal prairie. Relict coastal prairie anywhere on the RBC with cover of over 50% of native plants and not more than 30% cover of non-native plants, can be salvaged. See section 3.3, Plant Material Salvage, below.

UC Berkeley has committed to maintain as much of the natural diversity and ecosystem processes as possible as the site includes a significant example, however degraded, of the former grassland and marshes that were the pre-settlement natural community. Teaching, research and outreach will be integral parts of the ongoing maintenance of the ecosystem processes of this relict grassland area.

2.0 Project Description

2.1 Land-Use History

From the gold rush in 1849 to rapid urbanization after World War II, a variety of low-density housing and industrial use slowly dissected the larger prairie on the RBC.

This site has been impacted by many roads, industrial waste and building sites since pre-settlement times. From 1840-1950, the site has been a part of gradual change of a broad, open grassland leading directly to tidal marshes and wetlands, into an industrial area. The nature of the area is shown in Figures 1 through 3 during settlement. Note the open grassland leading to the edge of San Francisco Bay. Open spaces, even

where *Danthonia* or *Nassella* may occur, are often previously occupied by buildings, roads, or railroads, and may include soils with various chemical wastes.

Figure 1. Richmond area as seen from UC Berkeley Campus, c. 1880. University of California, Berkeley, Bancroft Library.

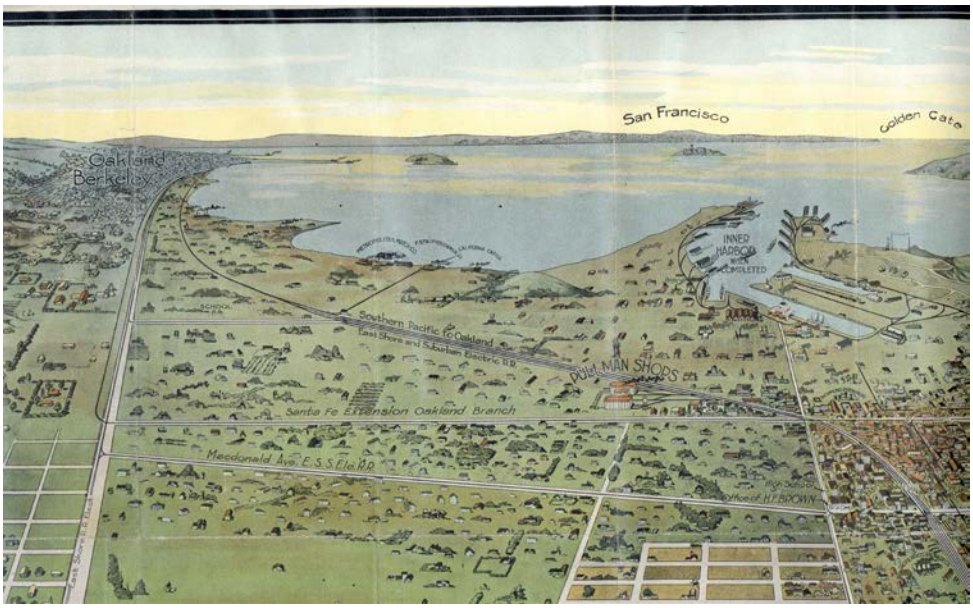

Figure 2. Richmond area, 1911. Bird's eye view painting for real estate development description. Source: UC Berkeley Earth Sciences and Map Library.

Figure 3. Lucol Plant (predecessor to the California Cap Company) on RBC. Source: University of California, Berkeley, Bancroft Library Oliver Family Photographic Collection.

As the land in the current RBC was developed (Figures 2 through 5), it was at various times covered with wagon roads, railroads, buildings and soil disposal sites.

Portions of the RBC were heavily used for housing and industry. This historic land use left small patches of grasslands in the core of the industrial area, often on the scale of urban lawns or small parking lots. Open grassland in this portion of the RBC site was used to store explosives and chemicals, and reported to have pyrite cinders used for fill, berms, and as weed control around buildings (2008 Current Conditions Report, Tetra Tech).

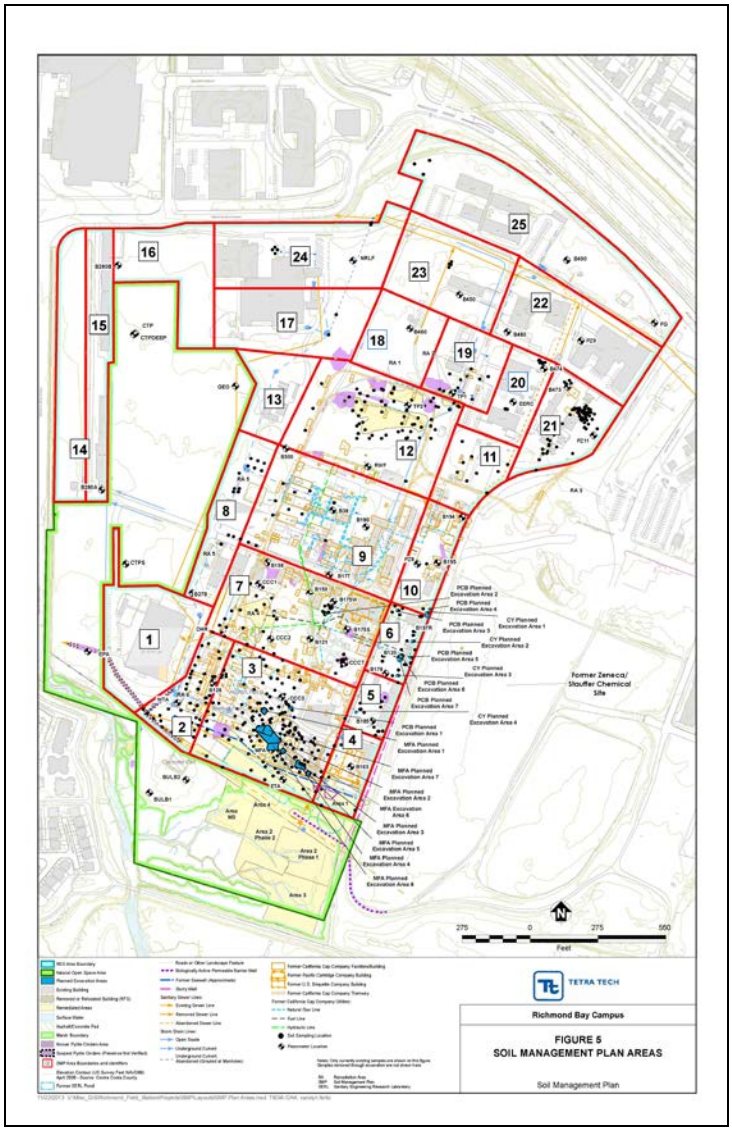

Figure 4. Land-use history of the RBC. Previous and current building and structures are outlined. Some small patches of native species remain in the many small interstitial spaces in the eastern parts of the RBC. One large stand of native coast terrace prairie persists on the western areas of the RBC. Source: Fig 5 "Soil Management Plans Areas" from the Public Draft Removal Action Workplan, Attachment C Soils Management Plan (Tetra Tech November 25, 2013). http://rfs-env.berkeley.edu/documents/PublicDraftRAW_11-25-13_000.pdf

Figure 5. Map showing some historic land uses on the RBC. Source: Figure 2-4 Location of Former and Current Facilities in the Southern and Northern Portions of the Site, from the Public Draft Removal Action Workplan (Tetra Tech November 25, 2013).

2.2 Site Description

A wide variety of non-native plants were introduced to the site, both reflecting the larger invasion of California's grasslands (Biswell 1956, Stromberg et al. 2007a), and the local horticultural practices associated with houses and light industrial parks. Some of these introduced plants are highly competitive and can displace the native grasses

and flowers. Many of these (Farrell et al. 2007) will require ongoing efforts to reduce their relative abundance (e.g. Harding grass, *Phalaris aquatica*).

Hydrology of the site was not substantially altered locally, as the deep drainage ditch and several smaller drains are lined with cement, primarily carrying water through the site from developed sites higher in the watershed. The heavy clay soils were not tiled or drained in the core area of coastal terrace prairie. The stand of coastal terrace prairie ("Big Meadow") is surviving without additional irrigation, and thus suggests that the immediate soil moisture and hydrology regime is still adequate to support the grassland. Elevation varies from about 5 to 15 feet above sea level, and small areas of jurisdictional wetlands, with associated wetland species, have been mapped in the larger stand of coastal terrace prairie. Perched water tables, either on clay or hardpan of rock, are typical of coastal terrace prairies so small included wetlands are common elsewhere in these grasslands.

An area of about 10 acres, with about 6.5 acres of relative intact patches of native grassland exists in the northwest parts of the site (Amme, 2005) (Figure 4). This core area remained relatively undisturbed although bisected by building sites, piles of spoils, roads and cement sidewalks. For the past 20 years, a series of biologists have visited the site and a list of plant and animal species was compiled for both this area and the surrounding patches between the built environment (Figures 4, 5). The dominant native grasses are purple needle grass, *Nassella pulchra*, and California oat grass, *Danthonia californica*. These co-occurrence of these two grasses as dominants is used to classify the community of plants as a native coastal grassland (Barbour et al. 2007). No listed rare or endangered plant or animal species (State of California or Federal) have been observed in this portion of the RBC.

2.2.a. Population and Species Stability

Scattered grassland patches collectively on the site have been thoroughly disturbed since the turn of the century (Amme, 2005), but still include populations of grass plants that are very long-lived. Individuals of *Nassella pulchra* were tagged and followed for 40 years elsewhere in coastal California and there was essentially no death of established individuals. Population analysis suggests that the minimum ages of individual plants exceeds 200 years (Hamilton et al. 2002) and may be much longer, as the population had only been tracked 40 years. Individual patches of flowers and bulbs have been informally tracked and individually marked plants persist at least 10-15 years (e.g., *Sisyrichium bellum*, pers. obs.).

In addition to being long-lived, the grasses of the coastal terrace prairie can tolerate repeated removal of the above-ground vegetation. The growing points of these native grasses are a few inches below ground. Thus, they are very tolerant of foot traffic and can tolerate frequent fires. Tillage however will destroy the growing point and

eliminate the long-lived individual grass plants. For a long time, California's Indians burned the coastal grasslands, keeping the native shrubs (eg. *Baccharis* spp., coyote brush) and trees (Monterey Pine, Douglas Fir) from invading the grasslands (Greenlee and Langenheim 1990). The long roots of these grasses (up to 6 feet) can reach water deep in even clay soils in the dry seasons (Figure 6). Plowing or discing effectively destroys the native grass sod and they have almost no ability to spread and re-establish, even on reserves over 75 years (Stromberg and Griffin 1996).

Figure 6. *Danthonia californica*, California Oat Grass with roots and above-ground leaves. Smaller fine roots and root hairs could not be recovered, and extended much further into the soil. Specimens from Richmond area. This display, about 2 m. tall, was at the Oakland Museum, Oakland, CA.

2.2.b. Species Diversity

Species diversity is measured by a simple count of different species observed. Thus, either the larger the area one examines, or the more time one spends searching will result in a higher count. Further, California has a highly variable climate with

"good" and "bad" years for specific plants. For example, a dry winter and wet spring might result in an 11-fold increase in one year for lupines (Knops and Barthell 1996) in places where in a previous year very few were seen. Some plants are only seen every few years. Several relatively open areas in the RBC as well as the larger NW meadow have been inventoried over the last 20 years for occurrence of plant species (Lidicker et al. 2003). The number of species in a coastal grassland has been surveyed elsewhere in California (Stromberg et al. 2001) but each of these reference sites were only visited one day for a few hours. The reference areas of other California coastal terrace grasslands where *Danthonia* and *Nassella* occur, were often only large enough to sample about 1 hectare. The Richmond Field Station grasslands at about 10 acres (~4,000 square meters) are far larger. The species/area curve for plants in California coastal prairies, with the RBC, is shown in Figure 9. Keep in mind that the scale is not linear, but jumps from 2 square meters, to 1000 and then 4000. As the smaller reference study areas could not be sampled for many years, and were only visited once, their apparent species abundance appears low (Figure 7). However, if one were to extrapolate the curves from the reference study areas to 4000 sq. meters, they appear to be on track to reach comparable numbers of species as those observed at the RBC.

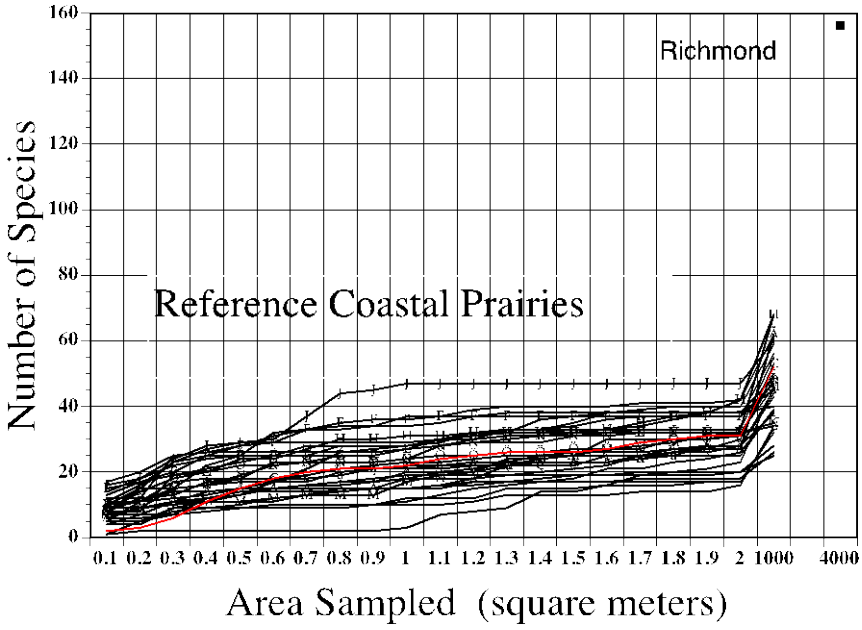

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Figure 7. Species-area curve for reference coastal prairies in California (Stromberg et al. 2001), including the species list for the Richmond Bay Campus (Lidicker et al. 2003). Note that the scale along the x-axis is not linear, but includes a large jump to 4000 sq meters. A projection of the other grasslands to that scale would approximate the overall plant species count at the Richmond Bay Campus.

But a count of all plant species numbers does not give the native perspective of the RBC grassland. Some of the plant species in the total count are non-native, and many are invasive. All of the grasslands in California are heavily invaded by non-native

plant species, with both grass-like plants and flowering, broad-leaf plants ("forbs"). Abundant non-native plants are found at the RBC as well. Thus, a count of the native plant species in coastal terrace prairies can give some idea of the intact nature of a given site.

A plot of the number of native species, classified into grasses and forbs, (Figure 8) shows that the RBC grasslands are not exceptional with regard to diversity of native grass species as compared to other California coastal grasslands (Stromberg et al. 2001). The count of native grass species at RBC comes in at the middle to high end of other similar coastal terrace prairies in California. However, the number of native forb species at the RBC is relatively high.

This larger number of native broad-leafed plants probably reflects both the effects of looking at a larger sampling area and over a longer observation period, including many seasons. Stromberg et al (2001) were only able to visit the reference coastal terrace prairies in one season in one year, while taxonomists at the RBC were able to look for flowering plants over 20 years and over many seasons (Lidicker et al. 2003). There are seasonal changes in flowering, as well as differences between years- on some years, particular flowers are rare or absent, while on others, formerly sparse plant species can be abundant.

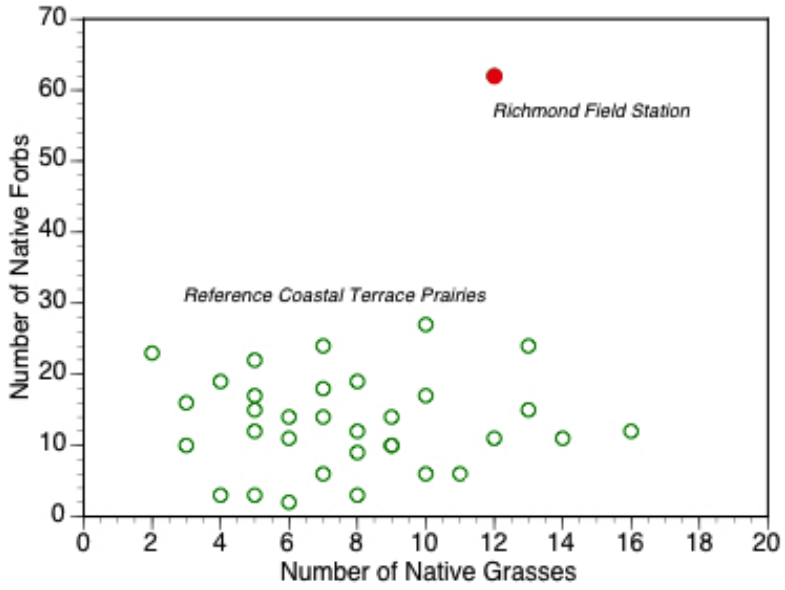

Figure 8. Plot of the number of native grasses and native forbs in various California coastal grasslands and the entire RBC.

3.0 On-Site Re-Establishment

3.1 On-Site Protection Measures

A core area of fifteen acres, contiguous with the restored marsh, including the Big Meadow, EPA Meadow, and West Meadow, will be established as a contiguous coastal terrace prairie (Figure 9). This area is a complex of relict, intact grasslands and disturbed patches. Disturbance includes piles of soil, areas dominated by non-native plants, including aggressive, spreading exotics (e. g., Harding grass, *Phalaris aquatica*, teasel, etc.) (Farrell et al. 2007).

Figure 9. Coastal terrace prairie core area, contiguous to the restored marsh, as indicated in the Illustrative Development Scenario for the RBC 2014 Long Range Development Plan.

The larger, intact patches in this core area will require monitoring for invasive plants, but can be expected to largely persist with ongoing maintenance management (Farrell et al. 2007, Cai et al. 2012). Maintenance management will include a variety of methods, almost all selected to reduce the abundance of non-native, spreading plants that can displace the native species in the coastal terrace prairie. Many of these methods, and associated costs, have been described in detail elsewhere (Farrell et al. 2007, Cai et al. 2012). The restoration objectives for the on-site protection of existing stands of the coastal terrace prairie are presented in Table 1.

Table 1

Summary of broad restoration program objectives, as assessed based on the literature review and data collection in this report (Cai et al. 2012)

Restoration Objective
1. Protect and expand native rare grassland species
2. Reduce cover of non-native and invasive species
3. Resist reinvasion by best practices in the core native remnant
4. Increase community involvement and interest in the RFS prairie.
5. Institute robust, accountable monitoring system for recording the geographic location of all treatments applied to the field, experimental sites, and the subsequent results and analysis.

Based on observations and experience of The Watershed Project with the RBC grasslands, these management objectives should be pursued on the extant stands in the core area. UC will develop a monitoring program that will use quantitative methods (Elzinga et al. 1998) to go beyond the simple measures of presence/absence (Cai et al. 2012) to measure frequency, density and cover of all plants managed in the core area. These data will allow comparisons of abundance over time and allow UC to measure the effectiveness of the conservation and management actions.

Many small patches of coastal terrace grasslands persist in various places on the RBC and can contribute to the larger core site. Plant materials included in a sod layer, as well as soils, can be salvaged on these many small areas and moved to restore disturbed sites in the core area.

3.1.a. Core Area Delineation and Signage

For the foreseeable future the RBC site is fenced and gated, and site controls limit unintentional disruption of natural open space areas; as the RBC develops, landscaping controls would help to define the boundaries of these areas.

Prior to construction activities commencing under the RBC LRDP, a construction specification should ensure contractors are trained to be aware of the sensitivity of the Natural Open Space area. For any construction in the immediate vicinity of the grassland portion of the Natural Open Space area, the core prairie area should be marked at a minimum with temporary fencing and signage.

Temporary construction fencing in the vicinity of the grassland portion of the Natural Open Space area shall consist, at minimum, of steel t-posts and 4' tall red

plastic netting (e.g., Hanes Geo Components Orange Contractor Barrier Fence or equivalent).

As the campus grows, where possible, the boundaries of the grassland portion of the Natural Open Space should be marked with barriers that would deter unauthorized vehicle access. Re-use of materials now stored on the site could provide such landscape barriers. These include the stored granite blocks, logs from eucalyptus as they are removed, etc.

Signage should be developed to explain the presence and significance of this relict of California coastal terrace prairie. In early years of RBC development, relatively simple custom 12" x12" metal signs suitable for mounting on steel posts, wood posts or barrier fencing can be quickly prepared and purchased (eg: Voss Signs); as the campus develops more elaborate signage and curation will be warranted.

3.2 Receiver Site Preparation

The core area includes not only a very high density of native plant species defining a coastal terrace grassland plant community, but also areas that are disturbed. Over the next five to ten years, as funds permit, the disturbed patches in the core area can be prepared for receiving remnants of native sod.

3.2.a. Near-Term Receiver Site Preparation

As development plans progress, salvage sites of native coastal terrace grassland sod will be identified (see below). Now, in the near future, or at the latest prior to any development at the RBC that may alter an open space area with indicator species, disturbed parts of the core area can be identified as receiver sites, cleared of non-native soil and invasive plants, and set up for near-term receivership of high quality sod salvaged from other sites in the RBC. As needed, some small areas should be cleared of spoil piles and prepared to receive sod from areas that will be developed. In the next year, one of the piles of soil on the EPA meadow could be removed to expose native soil, and graded to match the adjacent grassland. A water source is nearby that would allow installation of a small irrigation system. As native sod needs to be salvaged, it can be installed adjacent to the high-quality grassland, in the case on the EPA meadow. The schedule of work to prepare areas for native sod will be based on the immediate needs to salvage relict, intact sod from source sites on the RBC. In general, harvesting the sod relicts should be done only during the dormant season (late summer, fall) when the soil is not saturated and the plants are not actively growing. However, in other seasons, if the area is not saturated with water, sod could also be mowed closely and then moved to a receiver site where it could be placed, rolled and thoroughly irrigated immediately.

Control of non-native invasive plants should be expanded on all disturbed areas now present in the core area, and continued until these disturbed areas can be removed

from the core area. Control of invasive plants is an ongoing management activity in the core area (Cai et al. 2012).

3.2.b . Long-Term Receiver Site Preparation

As funds allow, restoration will be carried out on the disturbed sites in the core area. This may be an activity scheduled over the next five to ten years. Where non-native soil stockpiles are now present, and where non-native plants dominate in patches (Farrell et al. 2007, Cai et al. 2012) they will be removed and the surface excavated to reveal the native clay soils. The surface will be scarified, leveled and contoured to match the surrounding levels of native clay soils. Receiver sites will be treated with herbicides for one growing season, or as needed, to control any rhizomes of invasive, non-native plants left in the soil after site preparation. Salvaged sod from relict patches of will be identified (see below) and moved to these prepared sites as soon as possible during the dormant season.

3.3 Plant Material Salvage

Small patches of the coastal terrace prairie sod, indicative of only a small subset the entire span of diversity in an intact coastal terrace prairie, persist in between building foundations, and along roads, adjacent to spoils piles, etc. Salvaging and relocating these small patches can add to the overall grassland management goal.

Attempting to restore individual species of flowering plants in coastal prairies is extremely difficult unless the seed bank in the soil is included (Holl and Hayes 2006). Furthermore, restoring native grasslands is often limited by the drastic changes in the soil microbial community brought on by tillage and disturbances associated with land development (Eviner and Chapin 2003, Jackson et al. 2003, Potoff et al. 2005).

Many small, relatively undisturbed patches on the RBC have native soil dominated by *Nassella* or *Danthonia* and may include some native flowering plants. We cannot rebuild the coastal terrace grassland (Amme 2005). But at this scale, we can move the best of the remaining patches to assemble a grassland on native soils in the core protected area after those receiver sites are cleared and prepared. We can move patches of relict native sod and soil to places with clean native soil where it can thrive. This salvage of the small relicts is comparable to commercial sod farms where they grow sod in one area to install in other areas.

A biologist able to identify *Nassella* and *Danthonia* from vegetative characteristics will be hired to identify the relicts outside the core area for salvage. Patches that qualify would be defined as those areas where basal cover of *Nassella* and /or *Danthonia* are largely continuous and cover of native plants exceeds 60%; further, cover of non-native plants would not exceed 30%. These values were derived from estimates of native and non-native cover in reference coastal terrace prairies (see section 1.1.1 above). Using

these criteria, salvage areas can be surveyed and marked. To delineate the areas to be salvaged, a biologist able to recognize the plants from vegetative characteristics should use standard methods for measuring plant canopy cover (Daubenmire 1959, Bonham 1989, Elzinga et al. 1998) with a stratified and or randomized sampling design.

3.4 Salvage Sod Planting

During the dormant season, these relatively undisturbed relicts of coastal terrace grassland sod can be excavated in lifts including a 10" deep layer of soil and plant material, and placed on prepared sites in the core area. Salvaged sod will be placed adjacent to high quality grassland, and then rolled (ring roller, sod roller) into the receiving site. Vehicles with appropriate tire pressure on the soil will be used to roll the sod to provide good sod/soil contact, but not creating pressures that would harm the sod. Where larger areas of clean soil can be prepared, salvaged sod can be broken up into plugs that can be installed at 6" to 12" spacing, irrigated and allowed to grow together over time.

Longer-term restoration can include the addition of native, local plant species appropriate for the coastal terrace grassland. This can involve citizen volunteers and/or educational groups. For example, at Russian Ridge, where costs were monitored for ongoing non-native plant control, volunteers hand-collected seeds from 20 species at adjacent grasslands and these were planted in seed production plots to produce enough seed to use a no-till native grass drill (tractor-mounted) to re-introduce the native flowering plants to areas treated to remove non-native invasive plants (Kephart 2001).

3.4.a. Irrigation

Salvaged sod, or areas planted with plugs from salvaged sod will be established using supplemental irrigation during summer/spring periods of dry weather and especially during the first summer after installation. Irrigation events are anticipated to occur on a weekly basis during the summer and as needed during dry periods during the winter/spring. Plants will be watered via a temporary installation of irrigation piping and overhead sprinkler system (Figure 10).

Figure 10. An example of temporary irrigation pipes and sprinklers for establishing plant material in prepared soil.

3.5 Erosion Control

Development at the Richmond Bay Campus will be subject to both the Construction General Stormwater Permit and to the General Permit for Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (Small MS4s) which UC Berkeley became subject to (including the Richmond Field Station) in July 2013 as a non-traditional small MS4. These permits are required by State and Federal Clean Water Acts and are administered by the State of California Water Resources Control Board (SWRCB) and the San Francisco Bay Regional Water Quality Control Board They require the University to prevent stormwater pollution in operations and construction and to implement post-construction low-impact development design measures to reduce runoff and pollution. Implementation of programs through these permits will improve runoff conditions to Western Stege Marsh and the San Francisco Bay.

All areas cleared of non-native vegetation will follow the existing stormwater runoff control protocols. Any remaining stockpiles with steep slopes will require protection from erosion during the winter, particularly following any final grading activities.

In general, only small, nearly level areas will be prepared as receiver sites. These will need only minimal erosion control efforts. As plant material plantings may be delayed due to project conditions, any erosion control must be in place by October 15th, well before winter storms. Temporary erosion control measures may include the following:

- On slopes, installation of jute netting: Jute will be secured at top by laying at least 6 inches of material below grade at least 6 inches deep and secured with staples

spacing staples every 18 to 24 inches on center. The steeper the slope, the closer the staples should be placed. Jute netting will be applied by unrolling it down the slope and terminate at a 12-foot contour terrace and install 6 inches of netting under itself and secured with staples. All seams will overlap at least 2 to 6 inches.

- Installation of straw wattles: Straw wattles shall be placed along each 12- foot contour of the slope and anchored with 12-inch wooden stakes placed at 4-foot-intervals. One wattle shall be installed for every 20 feet of slope length and each shall be keyed in to a shallow trench in order to prevent water from flowing beneath. Wooden stakes shall extend above the top of the wattle by 2 inches.

3.5.a. Mulch Top Dressing

The top two inches of prepared receiver sites that are not immediately to be planted and remaining as tilled soil surface during winter rains, shall be top-dressed with organic sterile composted mulch. The top dressing will be hydraulically blown in place with a mulch blower truck. By placing this top dressing on the surface, any weeds in the cleared, scarified soil will be adequately buried yet the profile will allow for remnant native grass rhizomes to establish. The top dressing will also augment erosion control.

3.6 Fertilization

Fertilization often favors non-native, annual invasive plant species in native California grasslands (Weiss 1999, Cai et al. 2012) and in the coastal native grasslands, high levels of carbon or nitrogen do are not necessarily related to dominance of native species (Corbin et al. 2004, Corbin and D'Antonio 2011).

Fertilizers or nutrient additions are not necessary or helpful and should not be applied unless new data and ongoing monitoring suggests otherwise.

4.0 Ongoing Invasive Plant Species Control

4.1 Overview of Ecological Processes for Prairie Maintenance

Coastal grasslands in California are subject to invasion by a wide variety of native shrubs and trees. Historically, the open landscape (Figures 1, 2 and 3) was maintained by California Indians by low-intensity fires conducted every 1-5 years (Greenlee and Langenheim 1990, Tyler et al. 2007). In nearby Tilden Park, the effects of fire suppression, even with some ongoing grazing, is dramatic (Figures 11 through 15). Mowing can largely replace fire in reducing both native and non-native woody plant invasions (DiTomaso et al. 2007).

Figure 11. Tilden Park, c 1880. Note open grasslands with oaks only on north-facing slopes and along creeks. Source: Tilden Park archives.

Figure 12. Tilden Park, 1951. Open grasslands are invaded. Source: Tilden Park archives.

Figure 13. Tilden Park, 1971. Invasion by woody vegetation continues. Source: Tilden Park archives.

Figure 14. Tilden Park, 1994. Open grasslands are only small patches. Source: Tilden Park archives.

Figure 15. Tilden Park, 2014. Conversion to woody vegetation. Source: Google Earth.

4.2 Current Prairie Maintenance Program

Control of non-native invasive plants should be continued on all disturbed areas now present in the core area, and continued until these disturbed areas can be removed from the core area. Control of invasive plants is an ongoing management activity in the

core area (Cai et al. 2012) and can be undertaken with varying degrees of intensity sensitive to resource constraints and opportunities.

4.2.a. Mowing

Currently, the primary grassland management activity implemented to maintain the open grassland is mowing, as prescribed by The Watershed Project (Project 2007). This prescription will be continued and is adequately detailed and addresses issues related to protected areas, timing and scheduling. In addition to the mowing operation, additional work should be done to control exotic plants.

4.2.b. Other Maintenance Options (Tree, Brush Control)

Where various native and non-native invasive shrubs or small trees have been established, they should be removed. Coyote brush (*Baccharis pilularis*), Monterey Cypress (*Cupressus macrocarpa*) and a variety of shrubs and small trees of various species, often established from trimmings and debris from urban garden refuse dumped on site must be removed. The brush and trees can be trimmed back, and when new growth emerges, the plants can be sprayed with RoundUp at label rates. When dead, the plant stem can be cut level with the soil and the area mowed as a part of the ongoing program to eliminate seedling regrowth. Wherever possible on the relict grassland, soil disturbance should be minimized. Thus, digging out root balls, or excavation of Harding grass should be avoided. Where Harding grass occurs in a patch as the only species in the core area, it should be mowed as close as possible and allowed to regrow. When it reaches about 3" of height, it should be treated with RoundUp at label rates. Where Harding grass grows as interstitial in the native prairie plants, RoundUp can be selectively applied to only Harding grass shoots with either hand-held or tractor mounted saturated ropes. In such infestations in the native grassland, Harding grass can be allowed to grow above and over the native prairie sod, and can then be treated with a contact herbicide that only is applied to the emergent, taller Harding grass shoots and leaves. Other means of Harding grass control will be explored in the ongoing research into restoration methodology and needs. These control methods should be initiated at a small scale, in up to 10 square yards, and results observed and methods modified as indicated.

Avoidance of soil disturbance is not an issue on the piles of soil tailings. There, plants can be grubbed out. Herbicide and manual weeding of the spoils pile can be effective for catching small populations of invasive weeds including *Oxalis pes-caprae*. Plants like this can spread into the native grassland and are extremely difficult to remove. The *Oxalis* should be grubbed out as soon as possible from adjacent soil spoils piles. Although not as aggressive, the Blackberries (*Rubus* spp.) can be a serious pest and should be eliminated as soon as possible. In noncrop areas, tebuthiuron (Spike) is registered for use by licensed applicators for brush control. Tebuthiuron is a

nonselective urea herbicide that is used for total control (i.e., it eliminates other vegetation in the treatment area) of shrubs, trees, and other weeds. It can be applied in a pelleted formulation at the base of the plant to provide long-term control of wild blackberries (IPM 2014).

5.0 Monitoring

Adaptive management must include observations of the past and ongoing results towards a landscape model. These ongoing observations must include the relative costs and effectiveness for all of the management activities.

Parts of the grasslands can be zoned for research into the most cost-effective tools for non-native plant species management. If possible, small research grants could be made available to research faculty at UC Berkeley and elsewhere for graduate and undergraduate explorations in restoration tools.

Monitoring of plant species is necessary each year, and a long-term relationship with visiting classes and volunteer groups could provide learning experiences and long-term data sets on plant responses to management. RBC's coastal terrace grassland is an ideal place for undergraduate research and training (Hodder 2009).

Monitoring the edges of the grassland core area, along the roadsides and paths should be a high priority. Roadsides serve as routes of introduction of non-native, invasive plants into California grasslands (Gelbard and Harrison 2005). As a part of the ongoing mowing program for fire management, the roadsides should be walked each spring to detect any new plant invasions. Monitoring the roadsides could be a project that would appeal to volunteers and others who might be walking or running along the roadside for other reasons.

Tools for managing the native grassland should include as many as possible, without any a-priori restrictions. Mowing, timed grazing, hand-weeding, targeted and controlled herbicides, fire, and many other techniques can be tried and evaluated to address the primary threat of non-native invasive plants. (Stromberg et al. 2007b). An ongoing relationship with the grassland restoration community and California agronomy researchers should be pursued to keep up with the most current understanding of the mechanisms and ecological processes that are underway in the grassland(Cai et al. 2012).

Detailed management activities and methodology have been worked out with the current Richmond Field Station staff with ongoing management plans. Invasive plant control, monitoring and continued management recommendations are presented in detail elsewhere (Farrell et al. 2007).

5.1 Photo-Documentation

Time series photos, taken from a series of fixed points with the same camera and lens over a long period of time have proven very useful for seeing long-term changes in ways that are otherwise difficult in tables or statistical comparisons (Hastings and Turner 1965, Browning et al. 2008). Further, such sequences of photos are often useful in public education programs and interpretive signage.

5.2 Plant Abundance Measures

Previous management plans for the RBC coastal terrace prairie have relied on monitoring based on presence/absence of plants in quadrats. This is a relatively fast method (Cai et al. 2012).

To provide a basis for quantitative measures in a long-term data set that would be adequate for formal publication in the ecological literature, methods to measure the abundance of the grasslands plants should be more quantitative (Elzinga et al. 1998). Measures of density, cover and frequency should be collected every year for the dominant 25-30 plant species. Qualified biologists should be hired to conduct these surveys in the core area on several transects that are re-located each year. Data should be archived both on-site and in digital archives (UC Digital Library, Merritt Repository).

Over time, these data would form a unique and deep contribution to the understanding of one of the most diverse natural communities of California. And of course, changes observed would inform ongoing management activities.

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