Section 5: Project Description

1. **Project Objectives:**

The project objective(s) must identify specific, and where appropriate, quantitative, outcomes that the proposed project is expected to achieve. One or more of the objectives must be specific to achieving net GHG reductions. Each proposal must also include objectives pertinent to expected co-benefits (refer to Part II of the PSN) that will result from project implementation.

The North Campus Open Space (NCOS) Wetlands Restoration Project Phase 1 will restore 34 acres of diverse coastal wetlands and 20 acres of upland habitat in coastal Santa Barbara County (Figure 1, Location map). The project is projected to sequester 549 metric tons (t) of carbon over the first 100 years of establishment and to contribute to the science of quantifying the greenhouse gas (GHG) sequestration potential of intermittently tidal coastal estuary systems through a research and monitoring program. Anticipated fish and wildlife co-benefits include supporting recovery plan recommendations for federal and state threatened and endangered species by providing expanded and improved habitat for the Tidewater Goby (TWG), Western Snowy Plover, California Least Tern, California Red-legged Frog, Ventura Marsh Milk-vetch and Belding's Savannah Sparrow. In addition, expanded habitat for migratory shorebirds and waterfowl and resident wetland and upland bird species will be created. Ecosystem benefits include reducing localized flooding problems and disturbance associated with flood control management activities, improving downstream water quality through expansion of wetlands and bioswale systems within the urban to wetland interface, and supporting expanded carbon sequestration, denitrification and other microbial processes. Educational benefits from this project are significant because of its location on the University of California Santa Barbara (UCSB) campus with its rotating student body of 20,000 students, active academic research, and hands-on restoration implementation and training program run by the Cheadle Center for Biodiversity and Ecological Restoration (CCBER). In addition, the project site borders a relatively dense urban area (City of Goleta and the community of Isla Vista) and 652 acres of recently protected coastal open space. A trail system will be developed through the restoration project site which will connect the community to the recreational amenities of this protected open space and the beach.

Restoration Objective:

The North Campus Open Space (NCOS) Wetlands Restoration Project Phase 1 restoration will restore 34 acres of wetland and 20 acres of upland habitat (Figures 2a-d). The wetland acres include 12 acres of salt marsh, 3 acres of freshwater and brackish marsh, 12 acres of mudflats and 7 acres of sub-tidal habitat where 4 acres of impounded stream and non-native upland currently exist. The upland habitats include 15 acres of native perennial grassland and 5 acres of mixed native grassland, coastal sage scrub and bioswales. This project is the first phase of a larger project to restore more than 50 acres of wetlands that were filled in 1965 to create a golf course within the historic upper arms of Devereux Slough (Figures 3-6). The restoration goals of the first phase will be fulfilled through the excavation of approximately 250,000 cubic yards (cy) of fill with placement on the adjacent borrow site currently dominated by non-native vegetation (Figure 7). Appropriate soils, slopes and grading elevations will be created to support the restoration of a diversity of habitats in this highly variable, intermittently tidal system using seeds sourced from within the immediate local area. UCSB will implement and oversee the restoration and monitoring components of the project in a way that integrates it into the on-going training program.

Deliverable: 34 acres of restored, intermittently tidal coastal lagoon, Santa Barbara, CA.

GHG Sequestration Objective

The Phase 1 project is estimated to sequester 549 net metric tons of carbon over 100 years. This calculation reflects a consideration for climate change impacts and existing soil carbon conditions, construction-related emissions and projected carbon sequestration by native salt marsh and native perennial grassland habitats after 100 years on the project site. Details for this calculation are provided in section 2 below. *Deliverables are described in monitoring objective below.*

Research and Monitoring Objectives

GHG research and monitoring goals: a) Characterize carbon sequestration rates from intermittently tidal marshes, b) document restoration-related carbon sequestration and greenhouse gas mitigation potential, and c) characterize actual emissions from construction phase of project.
a) Data from intermittently tidal systems are lacking in the literature and yet these systems are relatively common up and down the coast of California. Dr. Jennifer King and Dr. Lisa Stratton will characterize the soil carbon content and sequestration rate using Cesium 137 dating techniques within the extant Devereux Slough salt marsh habitat following the methodology of Callaway (2012) and recommended in the approved American Carbon Registry (ACR) (Methodological Module for Carbon Stocks in Soil (CP-S, Tierra Resources 2012).

b) During the restoration process, baseline soil carbon content will be assessed in the existing conditions (no project or 'control') and the bare, newly graded salt marsh restoration site. These data can be used to document the net increase in soil organic carbon with data from future soil core studies. In addition, six locations within the restoration site will be marked using the feldspar marker technique (Cahoon 1994, Cahoon & Turner 1989) to assess accretion rates over two years post restoration. *In situ* trace gas flux measurements of CO_2, CH_4 and N_2O will be measured in the unrestored (control) site, the salt marsh restoration site, and the remnant salt marsh site in Devereux slough after 1.5 years of plant establishment. This sampling project will include replication over space and through three primary environmental conditions that characterize these intermittently tidal systems: saturated, moist and dry.

c) Using approved American Carbon Registry (ACR) techniques, document all fuel use associated with construction of the excavated wetland and calculate actual GHG emissions (American Carbon Registry, 2011). Fuel use for planning and maintenance will be minimal relative to project scale so only the phase using heavy equipment will be documented per recommendations from ACR.

Deliverables: Synthesis of intermittently tidal salt marsh carbon sequestration research and data from Devereux Slough based on dated soil cores, pre- and post restoration soil carbon content and accretion rate data, and real-time trace gas flux data. Baseline measurements of soil carbon in native perennial grassland restoration site to be used in soil carbon assessment after 10 years of plant establishment with UCSB monitoring funds.

Restoration monitoring goals include hydrology and vegetation cover data collection and annual monitoring of recovering wildlife and plant species. Restored native plant communities will be mapped on foot using GPS and summarized with GIS. Wetland water elevation and water quality data will be collected using an *in situ* YSI data sonde (temperature, salinity, pH, dissolved oxygen

and depth sensors). Vegetation monitoring (percent cover by species) will be conducted annually in the spring in each habitat using appropriate techniques.
Deliverables: Two annual monitoring reports beginning one year after restoration project implementation: 2018 and 2019.

Co-benefit Objectives:
1) Provide sea-level-rise adaptation/migration space for habitats and species,
2) Provide habitat for existing population of federally endangered tidewater goby and support recovery of five other threatened and endangered species including California Red-legged Frog, Western Snowy Plover, California Least Tern, Ventura Marsh Milk-vetch and Belding's Savannah Sparrow.
3) Support enhanced use of project site by migratory shorebirds, waterfowl and resident wetland and upland bird species.
4) Provide flood storage capacity of 90 AF in Phase 1, which is modeled to reduce floodwater elevations by a foot.
5) Educate and train UCSB students, community members and K-12 students in techniques of ecological restoration through focused field experience programs.
6) Provide recreational and educational benefits to larger Santa Barbara county region community through trails, interpretive signage and educational videos and guided tours and talks focused on GHG sequestration, wildlife viewing, and restoration ecology.

Deliverables:
1) *Document describing how grading plan supports adaptation to sea level rise.*
2) *Annual sampling of TWG population in restoration project 2018 and 2019*
3) *Conduct monthly bird surveys. Summarize bird survey data from 2017 – 2018 for avifaunal species.*
4) *From restoration monitoring deliverables: hydrology report above will document water elevations and flooding patterns.*
5) *Offer "Restoration Field Skills" class for 6 quarters during project period. Summary of student attendance over 2017 and 2018 years.*
6) *Create outreach plan, implement and summarize number of tours and educational programs and document recreational use in 2018 through focused study of patterns and practices.*

2. *Background and Conceptual Models:*

This section should include all necessary background information not covered in the Detailed Project Description section below. For example, describe baseline conditions at the proposed project site and sufficient rationale to justify the project need. This may entail referencing historical land use, past practices, local conditions, and other pertinent information. Reference attached figures, tables, maps and photos, if necessary. A conceptual model should be provided that clearly explains the underlying basis of the knowledge that will support the proposed work. Include a conceptual model that describes expected emissions and/or sequestration of relevant GHGs over time. Conceptual models can be presented either graphically or as narrative. Provide sufficient documentation to demonstrate a high likelihood that net GHG reductions and claimed co-benefits will be realized.
Describe how climate change considerations have been taken into account (i.e., how future climate conditions might affect the project's long-term impacts or benefits).
Identify linkages with other relevant, ongoing planning or implementation activities in the region that complement the proposed project (e.g., proposed project is a recommended action in a recovery plan).

The North Campus Open Space Wetlands Restoration Project site encompasses the former upper arms of Devereux Slough Estuary that were filled in 1965 to create the Ocean Meadows Golf Course (see historical aerials, figures 3-6). The wetland was filled by an estimated 3 to 8 feet by scraping soil from adjacent uplands resulting in the creation of a narrow channelized stream and non-native dominated upland. This filled wetland currently contributes to localized flooding and reduced ecological function. State, federal and local grant monies were used to acquire the golf course property in 2013 ($7M) and convey it to UCSB. UCSB was chosen to steward the land because it has a strong ecological restoration program (Cheadle Center for Biodiversity and Ecological Restoration (CCBER)) and actively manages more than 350 acres of open space currently as either Natural Reserves or protected open space with many of those acres directly bordering the project site (see location maps, Figure 1a-c). The proposed full restoration project will create approximately 50 acres of wetlands and re-connect the system to the intermittently tidal Devereux Slough to the south by removing a grade control structure and removing approximately 500,000 cy of soil. This grant will contribute to Phase 1 of that project which will include the restoration of the tidal connection through excavation of 250,000 cy and restoration of 34 acres of wetland, including at least 12 acres of salt marsh. Funding from CDFW will support the excavation of 100,000 cy of soil within the phase 1 project. Excavated soil will be placed within the trail and upland buffer area, as well as on South Parcel, which is a degraded, 68-acre borrow site adjacent to the golf course, also planned for restoration (Figure 7). Non-native annual grasses, invasive weeds and degraded turf grass form the dominant vegetation over the majority of the South Parcel and former golf course. The golf course and adjacent residential areas are subject to localized flooding created by the existing fill (Photo section). The hydrologic model for the full 50-acre wetlands project indicates that, once implemented, it would reduce flood elevations by more than 2 feet in both small (25 year) and large (100 year) storm events (PWA 2013). Phase 1 will likely reduce flooding by 1 foot. This project will be designed in consideration of the impacts of climate change and specifically with predicted sea level rise rates of 0.44 to 1.6 cm/year (NRC 2012).

The 135 acres associated with the full North Campus Open Space (NCOS) Wetlands Restoration Project are all part of 652 acres of land recommended for protection by the Ellwood-Devereux Joint Proposal (March, 2002), (see Figure 8, Ellwood-Devereux Biological resources map). The University of California, Santa Barbara, City of Goleta and County of Santa Barbara worked together for ten years to move proposed development off the coastal bluffs in order to protect these 652 acres of open space. In addition to supporting the vision of restoring this protected coastal open space, localized flooding problems (Fig. 9, Flood Zone map) and the re-colonization of Devereux Slough by the endangered Tidewater Goby also provided impetus to restore the full extent of this unique intermittently tidal coastal lagoon. This restoration project will provide a larger buffer and refugia for Tidewater Goby and greater connectivity to the freshwater tributaries that feed the system. These tributaries are currently funneled into a narrow, channelized creek that is separated from Devereux Slough with a grade control structure.

RESTORATION MODEL

Unlike the situation in the San Joaquin Delta, where dikes, berms and agricultural drainage have caused subsidence of former wetlands, along the south coast of California, most coastal estuaries have been filled and developed as residential and industrial areas (Miller et al. 2008, Shaw 1956). There are few opportunities to recapture lost coastal wetlands, and remnant coastal wetland habitats are caught in the squeeze between the ocean and development and, hence, vulnerable to impacts associated with predicted sea level rise (SLR) and other competing pressures for use of the coast. This project is one of the few cases where there is the opportunity to expand coastal wetland habitat through removal of fill and cost-effective placement on the former borrow site immediately adjacent to the restored wetland. In addition, based on our knowledge of SLR, the grading plan will be designed to support a diverse array of coastal wetlands capable of adapting to SLR through creation of sufficient transgression space. Remnant coastal salt marsh habitat in Devereux Slough has been deprived of sediment for more than 50 years due to a sediment basin, flood control sediment removal practices, and a grade control structure that divides the project site from Devereux Slough (Figure 6). The lack of sediment can reduce salt marsh accretion rates such that they cannot keep pace with SLR, which would make them more vulnerable as SLR accelerates. This project is designed to allow sediment to flow through the system unimpeded, which should make it more adaptive in the face of SLR.

GREENHOUSE GAS SEQUESTRATION MODEL for Phase 1

The greenhouse gas sequestration potential of this project is based on three factors and associated calculations described below. The first factor is that the 'no project' or 'business as usual' condition would effectively release approximately 120 metric tons (t) of carbon (C) into the atmosphere due to the presence of annual vegetation on disturbed soils and that implementing the restoration project will effectively offset that potential loss of soil carbon by replacing dysfunctional uplands with wetland and perennial plant communities more capable of sequestering carbon (US EPA, 2002). The second factor is that this project is likely to include an initial pulse of carbon emissions (23 t C) associated with the construction of the project because it involves moving fill soil from a former wetland to create the appropriate hydrology to support a coastal wetland. The construction-related emissions are significantly lower than they would be if fill had to be trucked off site. The third factor is that carbon sequestration of 452 t C over 100 years will be the result of the establishment of 12 acres of salt marsh and 15 acres of perennial native grassland habitat. We assume that changes in area of open water, mudflat, and fresh and brackish marsh habitats will have a net neutral impact on the atmosphere (PWA-SAIC, 2009). Finally, because the project will facilitate natural sediment transport systems, this project assumes that salt marsh habitat downstream will be better able to accrete and, thus, keep pace with SLR than it would in the no project scenario. While we do not specifically account for future carbon sequestration in the remnant salt marsh, we do propose to assess past sequestration through the research component of the project.

Table 1. Synthesis of project carbon sequestration model. Details explained below.

Source of carbon sequestration or emissions	Carbon sequestration over 100 years. (metric tons, t)	Running total of Carbon sequestered over 100 years (metric ton, t)
Salt marsh habitat (12 ac)	+ 395 t C	395 t C
Perennial grassland (15 ac)	+ 57 t C	452 t C
Annual grassland, no-project condition avoided losses of C.	+ 120 t C	572 t C
Construction related emissions	- 23 t C	549 t C
Project Balance		**549 t C**

Calculations and Assumptions:

a) *Conserved carbon relative to existing, no project, conditions*
Existing habitats include 15 acres of annual non-native grass and weed species, 4 acres of freshwater marsh in the impounded creek channels, and 35 acres of dying turf grass from the former golf course. While freshwater marshes have been shown to sequester carbon at high rates, methane emissions from freshwater marsh habitats are sufficiently high to potentially outweigh the carbon sequestration benefits because of methane's disproportionately large impact on the atmosphere (24 to 31 times more impactful) (PWA-SAIC 2009). The dying turf grass will likely be replaced by colonizing non-native annual grasses and weeds under a no-project scenario.

Koteen et al. (2011) measured soil carbon, decomposition and trace gas fluxes in adjacent native and non-native annual grassland patches along the California coast and found that there was a drop of 40 t C (Mg)/ha in the top half meter of soil in the non-native patches relative to the native patches reflecting a net loss of soil carbon stores over the time period since these species were introduced to California (250 years before present). This loss of soil carbon is attributed to the shallower rooting depth, shorter growing season and soil respiration rates that exceed carbon fixation rates in non-native grassland areas. The upland portions of the NCOS project site were once dominated by native perennial grasses (1871 map, Figure 3) and have since been disturbed and colonized by non-native species and, thus, can be assumed to be losing carbon at similar rates. Based on findings in Koteen et al., the estimated rate of soil carbon loss is 20 g C/m^2/year = 0.2 t C/ha/year. Multiplied by 6 ha (15 ac) of existing invasive annuals and over a projected time period of 100 years that loss would total: 0.2 t C/ha/year x 6 ha x 100 year = 120 t C. This total does not include the additional 35 acres of annual grasses that could develop under the no project scenario. This project will bury all vegetation currently on site and thus effectively sequester existing plant carbon on site. The project will also replace existing habitats with perennial grassland upland and functioning wetland habitats, which, over 100 years, will preclude the potential loss of 120 t of carbon and effectively sequester the carbon that would otherwise be lost to the atmosphere as CO_2.

b) **Construction-related GHG emissions**
Estimates for GHG emissions are based on estimates of the distance that soil will be moved to restore the site and emissions per mile associated with heavy equipment used to move the soil. 250,000 cy of fill soil will be moved to adjacent project edge (1/4) and to South Parcel (3/4) (Figure 2) distances of 100 ft and 1000 ft respectively. Soil will be moved either through continuous round trips of an earth grader or in dump trucks capable of holding 12 cy soil making round trips to the two soil deposition destinations (200 and 2000 ft respectively). Carbon emissions for heavy construction dump trucks (ACR (EMFAC 2007)) for travel at 5 mph are 3845 g C/mile.

Calculations:

1. *Distance:*
   i. Soil travelling 100 ft = 250,000 cy x 0.25 = 62,500 cy divided by 12 cy/load = 5,208 rt times 200 ft = 1,041,666 ft divided by 5,280 ft/mile = 197 miles.
   ii. Soil travelling 1000 ft = 250,000 cy x 0.75 = 187,500 cy divided by 12 cy/load = 15,625 rt times

2000 ft = 31,250,000 ft divided by 5,280 ft/mile = 5,918 miles

iii. Total miles = 5,918 + 197 = 6,115 miles

Emissions: 6,115 miles x 3,845 g C/mile = 23,514,330 g = 23 t C

c) Restored System Sequestration Estimates

1) *Salt Marsh*: Carbon sequestration rates in most annual-dominated ecosystems are relatively lower than perennial systems due to shallow roots and a shorter growing season. Carbon sequestration is limited to that within the soil in most cases. In coastal salt marshes, however, the inputs of sediment coupled with sea level rise and the ability of the plants to continue to grow and store carbon in the newly accreting soil means that sequestration can continue over the long term (DeLaune 2012, Crooks et al. 2014). Studies of soil carbon content combined with dating techniques using Lead and Cesium isotopes indicate that coastal salt marshes in California can sequester between 54 and 300 g C/m^2/year (DeLaune et al. 1978, DeLaune and White 2012, Chmura et al. 2003, Morris et al. 2012) and a comprehensive paper by Callaway et al. (2012) recommends a conservative estimate of 79 g C/m^2/year as a safe, long-term number for estimating rates of carbon storage for coastal California. It is common for authors to characterize sequestration in terms of metric tons sequestered over 100 years (PWA-SAIC 2009, Callaway et al. 2012).

   Using the most conservative estimate of carbon sequestration potential for salt marsh habitats of 79 g C/m^2/year (Callaway et al. 2012) for the 12 acres (5 ha), the project is estimated to sequester 395 metric tons of CO_2 over a 100 year time span. 79 g C/m^2/year = 0.79 t C/ha x 5 ha = 3.95 t C x 100 years = 395 t C sequestered in 5 ha of salt marsh. Due to the salinity, methane emissions are not considered a significant factor in salt marsh sequestration calculations (Poffenbarger, et al. 2011, Winfrey et al. 1983). The grading for this habitat will be designed to be sustainable in the face of sea level rise (SLR) over the coming 100 years (see climate change discussion below).

2) *Native Perennial Grassland*: This habitat would be created on fill soil from the golf course. Existing vegetation on the golf course and the borrow site (annual vegetation) will be buried and thus permanently sequester existing plant-based carbon from the atmosphere. Net carbon sequestration is based on the potential increase in soil carbon from existing conditions to the characteristic soil carbon content under established perennial grasslands. Soil carbon content of the soil that will be moved to the grassland restoration site averages 0.9% C based on 40 samples from 30 cores taken throughout the former golf course (Daumal 2013). The soils are 90% sandy clay loams that are similar to those found at Sedgwick Reserve where bulk density is 1.3 g/cm^3 (Molinari et al. 2014). To calculate total carbon in the existing soils we multiply bulk density by % carbon content by a depth of 50 cm. 1.3 g/cm^3 x 0.009 = 0.011 g C/cm^3 x 500,000 cm^3/m^2 (at 50 cm depth) = 5.4 kg/m^2 soil carbon under existing conditions. Analysis of soil under native perennial grassland (*Nassella pulchra*) at Sedgwick Reserve had % soil carbon content of 2.2%, which is 2.4 times more carbon than the 0.9% measured on the unrestored project site. Therefore the carbon content of soil in the top 50 cm of an established perennial grassland would be: (5.4 kg/m^2)*(2.4)= 13 kg C/m^2. Koteen et al. (2011) found soil carbon contents in the top 50 cm under established native perennial bunch grass (*Nassella pulchra*) of 14.5 kg C/m^2, which is very similar to our findings and likely higher than at Sedgwick Reserve due to Koteen's moister coastal field sites.

If we assume that native perennial grass restoration will store carbon up to the point of saturating the soil with carbon and accomplish half of that in the first 100 years, then the total additional carbon that could be stored in these soils would equal (0.5)*(12.9 kg C/m^2) = 6.45 kg C/m^2 minus existing soil carbon (5.4 kg C/m^2) = 0.95 kg C/m^2 = 950 g C/m^2 x 10,000 m^2/ha = 9.5 t C/ha x 6 ha = 57 metric tons (t) of net carbon stored in restored perennial grassland over the first 100 years. Based on Koteen's work, this system will persist in a steady state through time assuming no outside disturbance.

3) *Habitats with no quantification*
Based on characterizations of the carbon sequestration potential in freshwater marshes, channels and mudflats in the PWA-SAIC (2009) comprehensive paper, it appears that the net carbon sequestration for those systems would be neutral when one considers the relatively high rates of methane release from freshwater system and the transitory nature of the carbon in the channel and mudflat habitats (Poffenbarger, et al. 2011). Coastal sage scrub is a fast growing, semi-deciduous plant community with relatively undeveloped root systems, which will likely not sequester sufficient carbon in the acreages proposed for restoration to quantify.

Climate Change Considerations:
The carbon sequestration potential of the salt marsh can only be realized if it is sustainable in the face of climate change and in this project site the strongest potential impact is from projected sea level rise (SLR). There are two ways that salt marsh habitat is sustainable in the face of SLR: 1) sufficient plant growth and sediment inputs in the system for it to accrete at a rate equal to or exceeding SLR or 2) sufficient adaptation space for inland transgression of the habitat. Local sea-level rise estimates for this portion of the coast are between 0.44 and 1.6 cm/year (NRC 2012). Based on sediment removal rates from the onsite Flood Control sediment basin of approximately 150 cy/year for one of the two main tributaries to the system, we estimate that sediment supply will average two times that, or 300 cy/year, which, when dispersed over the 34 acres of wetland equals 0.16 cm of mineral-sourced accretion per year. This is based on the following calculations: [(300 cy x 27 cf/cy)/ 34 ac x 43500 sf/ac) x 12 in/ft x 2.54 cm/in]. = 0.16 cm

This watershed sediment source (0.16 cm/year) would support 10% of the accretion rate (1.6 cm/year) needed to keep up with the maximum projected rates of SLR and 30% of the accretion rate for the lowest estimates for SLR (0.44 cm/year). For salt marsh species the majority of actual accretion is due to plant growth and not mineral accretion, and plant growth is stimulated by and increases with SLR, up to a point (Callaway et al. 2012, DeLaune and White, 2012). Estimates of total accretion rates for California salt marsh habitats are, on average, 0.6 cm/year (Duarte et al., 2005, Chan et al. 2012, Callaway et al. 2012). At this rate of accretion local saltmarshes could potentially keep pace with the lower projected rates of sea-level rise. However, this system is only intermittently tidal and it is uncertain whether accretion rates will equal those found in fully tidal systems. This makes the sequestration rate assessment of the remnant marsh particularly interesting since such intermittently tidal systems have not been studied.

This project is being designed to accommodate SLR by creating a buffer for inland migration of the habitat through the grading plan. The grading plan will include low slopes above and below the salt marsh zone such that the salt marsh habitat can migrate inland as the water edge becomes flooded, slowly drowning the fringing stands of *Salicornia pacifica*. Because this habitat will be located a half mile inland from the open-ocean and associated risk of wave erosion, the assumption is that carbon sequestered in the soil will remain under the future mudflat, and that new upland areas will continue to sequester at the same rate due to the stable, shallow slopes such that the original 12 acres will be retained over at least the first 100 years. If the rate of accretion is estimated to be 0.5 cm/year and SLR at 1 cm/year, the project would need to accommodate a net SLR of 0.5 cm/year. With anticipated slopes of 30:1, an inland accommodation space of 0.5 cm x 30cm/cm = 15 cm/ year x 100 years = 15 meters of accommodation space that would be required over 100 years to be incorporated into the project design slopes and habitat spatial design.

Relevancy of project to existing regional and conservation plans

This site has long been envisioned as an ideal location to advance multiple management and restoration objectives within the Devereux Slough watershed. This project would result in the realization of a critical component in the larger effort to protect and enhance the Devereux Slough and Ellwood Mesa Open space complex, while accomplishing the goals and objectives of multiple management and planning documents focused on this particular property, Devereux Slough and/or the coastal watersheds of the Gaviota Coast. This project is consistent with the California Coastal Act and Santa Barbara County's state certified Local Coastal Plan and is a commitment certified in 2014 by the California Coastal Commission as part of UCSB 2010 Long Range Development Plan, and advances the goals of the following State, Regional and Local planning efforts:

California Comprehensive Wildlife Conservation Strategy: Growth and development is cited as one of the primary stressors in the Central Coast region in this report by the State Department of Fish and Game. This project addresses this challenge by helping to achieve the regional goal of enhancing and protecting a large habitat area and linking wildlife corridors.

California Outdoor Recreation Plan: This project addresses two key issues of this plan including Access to Public Park and Recreation Resources (Issue 3), Protecting and Managing Natural Resource Values (Issue 4).

Healthy Watersheds: A vision for the future: Since the project will facilitate the restoration of fish and wildlife habitat in coastal watersheds and wetlands, support ground water infiltration and natural sediment dynamics, this project is a natural priority for this 2009 plan. This restoration will further the following beneficial use objectives: estuarine habitat; wildlife habitat; rare, threatened or endangered species; and migration of aquatic organisms. In addition it supports improved water quality in our oceans and natural sediment transfer dynamics.

2014 Safeguarding California: Reducing Climate Risk: This restoration is consistent with climate adaptation objectives outlined in this update of the 2009 California Climate Adaptation Strategy (CAS), created to address projected impacts resulting from increasing levels of greenhouse gas emissions. The CAS recommends that coastal open space and lowlands be managed to allow for inland migration of wetlands expected to occur with increases in sea level rise, storm surges and flooding. In addition the 2014 plan prioritizes projects with multiple benefits that promote sustainable stewardship of our natural resources and which include outreach efforts to build understanding among all Californians.

Enhancement Alternatives for the Ocean Meadows Golf Course Site, UCSB Donald Bren School of Environmental Science and Management (2000): This Master's degree student study analyzed different restoration alternatives and determined that a partial estuarine restoration would create the greatest diversity of wetland habitats without requiring a long-term and costly burden to maintain an open slough mouth. This restoration will protect the federally listed western snowy plover and California least tern populations nesting on nearby beaches.

Joint Proposal for the Ellwood-Devereux Coast (Joint Proposal) and Ellwood-Devereux Coast Open Space and Habitat Management Plan (OSHMP): The Joint Proposal for the Ellwood-Devereux Coast is a collaborative planning effort by the University of California at Santa Barbara and the County of Santa Barbara. It provides a set of comprehensive proposals for development, open space and resource protection, and public access on one of the last remaining opens space coastal lands in western Goleta. The Ellwood-Devereux OSHMP, prepared by the City of Goleta, County of Santa Barbara and UCSB includes actions to preserve and restore sensitive coastal habitats and species, to manage public access and recreation to ensure compatibility with these resources, and to protect scenic resources on the 650-acre contiguous coastal area in the Joint Proposal. This project site is included within the boundaries of the Joint Proposal/OSHMP area. As such, the restoration of the Upper Devereux Slough site advances the open space objectives of these plans, and protects the biological integrity of the other lands and waters within the Joint Proposal/OSHMP area.

University of California, Santa Barbara Campus Wetlands Management Plan (1990): This project site and existing golf course are specifically referenced as a focus of concern and activity for the management strategies of the network of wetland resources through the UC Santa Barbara campus. Restoration of this site clearly addresses USCB's management objectives for enhancing the functionality of Devereux Slough.

Southern California Wetlands Recovery Project Regional Strategy and Work Plan: Restoration of Devereux Slough is specifically listed as a Tier One (high priority) project on the Work Plan of the Southern California Wetlands Recovery Project (WRP), which is administered by the California Coastal Conservancy (project applicant). As such, this restoration is a high priority for the Coastal Conservancy because it will achieve restoration objectives within Devereux Slough.

UCSB Natural Areas Plan: Classification, Inventory and Management Guidelines: This 1995 plan, prepared by wetland ecologists Wayne Ferren and Kathryn Thomas, examines historic imagery and records and points to the importance of restoring the original extent of Devereux Slough. The project plays a critical role in restoring this original extent through the restoration of historic wetlands.

Santa Barbara County General Plan-Conservation Element: Protecting Devereux Slough is specifically referenced in the Conservation Element of the County's General Plan, which calls for efforts to "protect and reserve the size and quality of the three existing South Coast Sloughs" (including Devereux Slough) and to "maintain the size of the [Devereux] Slough."

Devereux Slough Restoration Plan: This Coal Oil Point Reserve plan focuses on controlling non-native plants adjacent to the lower slough. Restoring the project site with native species, and enhancing restoration efforts on South Parcel by replacing original topsoil to remove non-native invasive species and replace them with native plants complements this plan.

Coal Oil Point Management Plan: Restoration of the project site complements the Coal Oil

Point Reserve (COPR) Management Plan, which provides for wildlife and water quality monitoring within and adjacent to Devereux Slough.

City of Goleta Devereux Open Space Habitat Protection and Enhancement Plan: This plan, part of the City of Goleta's General Plan/Coastal Land Use Plan, stresses the importance of maintaining the project site as open space. It also outlines exotic grass removal areas, native grass reintroduction and enhancement areas, vernal pool enhancement areas, and public access for the Sperling Preserve, immediately west of the Upper Devereux Slough.

Confidence in ability of project to support co-benefits of project

1) *Provide flood storage capacity of 90 AF in Phase 1 and reduce floodwater elevations by a foot and provide additional ecosystem benefits*.
The two coastal estuaries in Santa Barbara County, Goleta and Devereux Sloughs, have both been heavily impacted by development pressure over the past 100 years, including extensive filling to create a golf course (Devereux) and an airport (Goleta). The City of Goleta experiences regular flooding due to the lack of accommodation space in these important wetlands. The water holding capacity of the newly restored and expanded Devereux Slough will increase from 171 AF to 260 AF with Phase 1 of this project and flood elevations are modeled to fall by more than a foot (PWA 2013). This could result in the eventual removal of private land from the Federal Emergency Management Agency's (FEMA) 100 year flood zone maps, providing a substantial benefit to those property owners. The restored system will provide ecosystem function benefits such as enhanced and natural sediment transfer to the ocean that will reduce disruptive Flood Control maintenance requirements (see SB County Flood Control Letter of Intent). Expanded freshwater habitats at the interface between tributaries and the expanded slough can enhance water quality by providing opportunities for denitrification and filtration.

2) *Support sensitive species*. Project will support a population of federally endangered Tidewater Goby on the site and support recovery of five other threatened and endangered species including California Red-legged Frog, Western Snowy Plover, California Least Tern, Ventura Marsh Milk-vetch and Belding's Savannah Sparrow. The endangered Tidewater Goby has intermittently colonized Devereux Slough and was rediscovered in 2004. The site is part of the critical habitat for this species and USFWS representatives support the expansion and restoration of this system to provide enhanced refugia and connectivity to the upper tributaries of the system so that fish can locate zones with the proper substrate and salinity to support breeding. California Least Tern and Western Snowy Plover forage with their young in Devereux Slough and the Western Snowy Plover nests adjacent to the project site. The restoration project will expand foraging and nesting habitat for these species. California Red-legged Frog occurs in adjacent watersheds (Bell and Tecolote Canyons) within migratory distance (less than 2 miles) of the project site. Heavy use of upland areas adjacent to the channelized creek makes this habitat currently unsuitable for this species. Ventura Marsh Milk-vetch populations have been successfully established adjacent to Devereux Slough and its 'Dune Pond.' There is, therefore, the potential to provide expanded opportunities for this endangered species within the ecotone of habitats to be created. The state-listed threatened Belding's Savannah Sparrow breeds in coastal salt marsh habitat, which has declined by 90% over the past century. Details for all of the species to benefit from this project are contained within the funded USFWS National Coastal Wetland Conservation Program grant received in 2013 and

excerpted as an attached section on wildlife support (Exhibit A).

3) *Support enhanced use of project site by migratory shorebirds, waterfowl and resident wetland and upland bird species.* Mediterranean systems are chronically limited in their ability to support birds by the lack of accessible water for birds. This project will expand wetland habitat by 34 acres and create a mosaic of wetland types that will include freshwater marsh, salt marsh, shallow mudflats, open channel, salt pannes and riparian habitats. The Pacific Flyway along the coast supports a diversity of grebes, coots, ducks, greater yellow legs, long-billed dowitchers, marbled godwit, willet, black-necked stilt, western and least sandpiper, spotted sandpiper and killdeer, among other species. Resident wetland birds that will benefit from the enhanced habitat include Virginia rail, sora, green heron, great and snowy egret, great blue heron and black-crowned night heron. Details provided in wildlife support exhibit.

4) Provide sea-level-rise adaptation space for habitats and species. Intermittently tidal salt marshes tend to have expansive mudflats and narrower portions of salt marsh habitat. Devereux Slough is no exception with just 17% of the habitat remaining as salt marsh that has no room to migrate inland due to relatively steep inland slopes. With SLR, these habitats could become flooded more often and be lost as well as the drier mudflats that are currently being used for nesting by the Western Snowy Plover. The restoration project removes fill from the historic upper arms of the slough and will be designed with salt marsh elevations that will be extensive enough to expand the acreage of salt marsh and provide inland accommodation space for this habitat as the sea rises.

5) *Educate and train UCSB students, community members and K-12 students* in the field of ecological restoration through focused field experience programs.
CCBER is an institute on the UCSB campus that provides several academic and practical courses in conservation and ecological restoration. These courses train more than 130 students a year and provide additional students with hands-on working and research experience through the intern and student worker program. The restoration project will provide an important opportunity for these students to participate in the recovery of obliterated ecosystems and to study and facilitate their recovery. Many more students will participate through their labs that currently use other adjacent Campus open space habitats, including a Field Ecology course that trains 90 students a year, an Ecological Management Course and Environmental Anthropology course that study land use practices on campus. In addition, courses in ornithology, vertebrate taxonomy and invertebrate field and laboratory identification course make use of campus restoration sites.

6) *Provide recreational and educational benefits* to local community as well as the larger Central Coast community and visitors through trails, interpretive signage and educational videos and guided tours and talks focused on GHG sequestration, wildlife viewing, and restoration ecology. CCBER has designed and installed more than 20 educational signs around campus focusing on wildlife, ecosystem function, land use management and history, plant adaptations and water quality (ccber.ucsb.edu). These signs are based on research and management programs regarding our natural areas and help the broader UC and coastal Santa Barbara residents appreciate the value of coastal habitats and wetlands. This project site sits at a crucial intersection between bicycle, bus and walking routes and a larger 652 acre coastal open space protected in 2004. This open space already draws visitors from a broader sphere because of the populations of migratory Monarch butterflies and beaches. The intention is to incorporate public access trails, bridges, viewing areas

and interpretive signage within the restoration project. A year-long community based planning process integrated the values and priorities of the community with the needs of the habitat and resulted in a synthesized set of recommendations for this aspect of the larger project.

The larger restoration project will create an opportunity to provide recreational benefits to neighborhoods surrounding the project site. This restored property will serve the densely populated community of Isla Vista—a one-half square mile community with a small commercial area and approximately 23,000 residents. While the Isla Vista Recreation and Park District, formed in 1972, has substantially increased parks and open space in the community of Isla Vista for the past 40 years, residents of this densely populated community have less open space than in other nearby neighborhoods. For example, the community of Isla Vista has 4.4 acres of park and open space per 1000 population while the adjacent City of Goleta has 16 acres of parks and open space per 1000 population (State Parks Community Fact Finder).

The project site is easily accessible from both Isla Vista and several multi-family residential neighborhoods in the City of Goleta by walking, bicycling and public transit. Once fully restored, a ~1.5 mile trail and boardwalk system will link to an existing extensive trail network on the surrounding protected properties, including the California Coastal Trail (Figure 10, Trails Map). Since bus stops and bike paths are also adjacent to the property, restoration and enhancement of public trails will provide a direct connection between these transportation corridors and the coastal trails and open space. The full project will provide these public access opportunities less than one mile from one of Goleta's primary shopping and recreation areas (Camino Real Shopping Center, Storke Road and Girsh Park, respectively).

Restoring this property will increase access to green space amenities by providing public walking trails on land where access was once limited to golf course patrons. These trails will link the community and visitors to two significant recreational amenities—public beach access points and the well-known Ellwood Main Monarch Butterfly Grove, an overwintering site located on the adjacent Sperling Preserve. When combined with the highly scenic values of the property, this restoration project will provide a significant ecological asset to the local community and to the region, in perpetuity.

3. *Detailed project description, including all tasks to be performed:*

Write a detailed project description, including all tasks to be performed. It should include a description of how the proposed approach addresses the project objectives. Describe each restoration element being proposed and how each element will be implemented (e.g., methods/techniques used, materials and equipment used, etc.). This should include plans for monitoring the project to demonstrate that net GHG reductions have occurred and effectiveness of project actions at achieving the co-benefit objectives. For mountain meadow ecosystem projects, describe the proposed research component that is designed to advance understanding of carbon sequestration potential in mountain meadows. Also describe who will be implementing the project and who will be completing each project task. If personnel are not discussed in this section they cannot be included in the personnel section of the budget. This description should be detailed enough to write a Statement of Work.

This grant will fund 1) the excavation of 100,000 cy of the 250,000 cy of fill to be removed from this historic wetland, 2) a portion of the restoration of 34 acres of coastal wetlands and 20 acres of diverse upland habitat, including native perennial grassland, 3) the documentation of GHG emissions associated with the construction of a restoration project of this magnitude, 4) a study of carbon storage and an estimation of annual rates of sequestration in an intermittently tidal coastal salt marsh, 5) a comparative trace gas emissions study of filled (control site), newly restored and remnant salt marsh sites over multiple moisture and temperature conditions, 6) restoration and co-benefit monitoring, and 7) educational and outreach programs associated with the topic of the functional values of wetlands in California.

Task 1. Excavation of fill: Construction

Funding from CDFW, in combination with secured funding from the USFWS National Coastal Wetlands Conservation Grant Program (NCWCG) through the State Coastal Conservancy (SCC) and from the California Natural Resources Agency through the Urban Greening Program, will be used to excavate 250,000 cy of fill from the historic upper arms of Devereux Slough. Fill soil has been studied and characterized (texture, salinity, pH, hazardous materials, soil moisture, % organic matter) and has been found suitable for placement on one of the borrow sites (South Parcel) adjacent to the historic wetland. South Parcel is a degraded site characterized by non-native invasive plants (Figure 6) and has been found suitable for receipt of fill soils. All vegetation on the former golf course and the degraded South Parcel will be buried during the soil excavation and placement process. CDFW funds will support transfer of 100,000 cy of that fill. Fill removal will follow grading plans which are being refined to consider SLR and how subtle variations in elevation can support a diversity of habitats based on studied hydrology-driven variations in fluvial and tidal flow, ground water levels, and resulting salinity. Grading will be contracted through UCSB Design and Construction Services, following permitting. Moving the soil within the project site provides economic benefits and limits GHG emissions by saving costs that would otherwise be associated with the off-site transfer of fill soils from the site.

Task 2. Restoration of 34 acres of wetland and 20 acres of upland habitat. The project is designed to support at least 12 acres of saltmarsh vegetation, 12 acres of mudflats, 7 acres of subtidal and 3 acres of freshwater marsh plus 15 acres of native perennial grassland and 5 acres of coastal sage scrub, other native grasslands and bioswales. UCSB's CCBER staff will collect and oversee additional collection of locally derived native seed and will propagate and directly oversee additional propagation of native plants by local native plant nurseries (see species list, Figure 11). CCBER has restored more than 45 acres of campus land and manages 250 acres of land for its ecological and educational values and will implement restoration on site (www.ccber.ucsb.edu). Due to the low nutrient quality of the existing fill soils, humate and mulch will be integrated in with the upland restoration components of the project. Salt marsh habitat will be restored with seeds, individual plants and dispersed sprigs and plant parts, depending on the species. Staff and students will be employed to implement the planting portions of the project depending on the timing requirements for the project. Weed control (primarily manual) will be an important part of the implementation and management of the project although the wetland portions should be self-sustaining native habitats due to stressful moisture and salinity conditions. CDFW funds will fund restoration of salt marsh habitat primarily.

Task 3. Documentation of Carbon Emissions during Construction

GHG emissions from all heavy equipment vehicles to be used on the construction project will be monitored using the ACR protocol. Vehicle logs will be used to document mileage and fuel use associated with each vehicle used for construction components of the project. Data will be synthesized monthly and compiled into a summary report. Emissions are expected to be the result of fill transfer within the site. CCBER will designate a GHG emissions monitor for this task.

Task 4. Characterize GHG sequestration rates of intermittently tidal system.

Following Callaway et al. (2012), 5 soil cores to 50 cm will be extracted from the remnant salt marsh in Devereux Slough. Soil will be sliced into two cm slices and analyzed for bulk density and soil % carbon. A subset of samples will be analyzed at Louisiana State University or by R. DeLaune for isotopes of Lead and Cesium which are used to date the soil core so that estimates of soil accretion and carbon sequestration rates can be derived. A synthesis paper comparing those data to other studies of southern California coastal salt marsh habitat (e.g. Elgin 2012) will be prepared by Professor Jennifer King and Dr. Lisa Stratton with assistance from a graduate student under Dr. Jennifer King who will implement monitoring and sampling with assistance from a lab technician (asst. specialist 1) and undergraduate student assistants.

Task 5. Compare *in situ* chamber measurements of trace gas fluxes post restoration.

Project will document the baseline soil carbon conditions of restored salt marsh and native perennial grasslands using soil cores and Loss on Ignition (LOI) techniques to document baseline conditions. Sampling will include newly restored salt marsh GHG emissions (CO_2, CH_4, N_2O) which will be compared to emissions from un-restored (no project/ 'control') sites and existing remnant salt marsh sites using static chamber methods (Hutchinson and Mosier, 1981; and e.g. Van Vleck and King 2011). Placement of gas flux chambers will take into account topographic variability and vegetation cover. Replicate measurements will be made in each land use type. Flux measurements will be collected at several time points in each season to capture saturated, moist, and dry conditions. Gas samples will be analyzed by gas chromatography by Jennifer King at UCSB. Ancillary measurements will include air and soil temperature, gravimetric soil moisture, soil carbon and nitrogen, and soil available nitrogen as warranted. Measurements will be conducted by graduate student researchers under the supervision of Jennifer King and with assistance from undergraduate assistants and a lab technician. A paper comparing the relative fluxes under the three typical environmental conditions found in an intermittently tidal system will be prepared that will help explain the carbon sequestration rates identified in the existing system and will help provide estimates of net greenhouse gas exchange. This task will be fully funded by CDFW and be implemented by those listed in task 4, above.

Task 6. Monitoring of Restoration and Co-benefits

Restoration monitoring includes GIS mapping of restored habitat aerial extent and vegetation sampling within habitat polygons to assess percent cover by species through line-intercept, line and quadrat and random quadrat sampling strategies depending on the habitat type. In addition, baseline soil carbon conditions in the native perennial grassland restoration site will be assessed for use in later characterization of the soil carbon sequestration potential of these long-lived plant communities. Monitoring will be conducted immediately after initial planting to characterize baseline conditions and annually each spring for five years. Success criteria will vary by habitat and be based on reference habitats for diversity and cover. Hydrological monitoring to document flood control co-benefit and to characterize the hydrological function of the system will be based on pressure transducer measurements of water stage and continuous monitoring of water quality variables such as temperature, salinity, pH and dissolved oxygen levels. Monitoring information will be used in an adaptive management approach to ensure success of the restoration and identify changes that may need to be made in the design of the second phase of restoration which is intended to significantly increase the scale of the project through the excavation of an additional

150,000 to 250,000 cy of fill to the south and west of Phase 1. Additional co-benefits include support for birds, rare species, and recreation. Avifauna will be monitored through a monthly bird survey to be conducted by CCBER staff and volunteers. Tidewater goby sampling will be conducted annually under the guidance of a permitted researcher (Kevin Lafferty, USGS). Recreational use will be documented by CCBER through a focused study on public use of the trails and habitat in order to limit off-leash dogs, and off-trail use that could cause habitat destruction such as by mountain bikes or un-authorized motorized vehicles. This portion of the project will be implemented by CCBER GIS, monitoring and restoration staffs.

Task 7. Education and Outreach Program

Training programs in Restoration Ecology Field Skills offered 2016 – 2019 training 30 students per quarter x 3 quarters/year will be offered by CCBER. Quarterly tours and restoration opportunities will be offered to the community during 2017-2019 years. Interpretive signage will be designed by CCBER and installed characterizing ecosystem services component of wetland function. Educational video about the restoration process will be completed by UCSB. Website will be maintained with up-to-date information about project by UCSB. This task will be implemented by CCBER Restoration coordinator and Dr. Lisa Stratton.

Task 8. Grant and Project Management

UCSB grants accounting and CCBER Project manager will ensure that all tasks are completed and proper reporting and accounting is conducted. This task will be implemented by UCSB Grant administrator and by Dr. Lisa Stratton. Deliverables: quarterly accounting and semi-annual progress reports.

<u>Timeline:</u>

Provide estimated timeline for each project task described in the Project Description from the start date until the project is completed. Time frame must include final report submission and final invoice. Make sure this time frame corresponds to the time frame listed in box 20 of Section 1. Grant agreements will not be in place until June of 2015 and cannot go past March 1 of 2020. Plan project time lines accordingly.

Timeline:

Task	2015 (4th Q)	2016	2017	2018	2019	2020, (1st Q)
1. Construction						
2.1 Restoration: Plant propagation						
2.2 Restoration: Plant installation & maintenance						
3. GHG Construction Emissions study						
4. Reference system GHG sequestration rate study						
5. Baseline & Comparative Trace Gas Flux Study						
6. Restoration and Co-benefit monitoring						
7. Education & Outreach						
8. Management (grant and project)						

4. ***Deliverables:***

Project proposals must include a clear list of the deliverables that the project will produce and submit. List and describe all reports, maps, databases and other products to be prepared and delivered to CDFW. All completed projects must submit a Final Report as a deliverable. Any project that creates/compiles GIS or GPS data will need to submit these data with accompaning meta data as project deliverables on compact disc. Proposals must also outline means by which data collected by the project will be stored and made publicly available.

Synthesis of deliverables described in section 1. All deliverables, except financial records, will be made available on the CCBER website (ccber.ucsb.edu).

1) Baseline, pre-project conditions report related to plant habitat distribution and cover, topography, and soil carbon content in top 50 cm; components of CEQA/NEPA document.
2) Post grading (as-built) conditions report related to plant habitat distribution and cover, topography and soil carbon content in the top 50 cm.
3) Final project report to include
   a) GIS layer with vegetation cover of baseline, as-built and conditions at end of grant period (includes CD of GIS data).
   b) Synthesis of GHG studies of existing intermittently tidal wetland (Devereux slough) and restored wetland soil carbon and sequestration rates, construction-related emissions, and baseline soil carbon data to support future studies in salt marsh and perennial native grassland restoration sites.
   c) Synthesis of monitoring from co-benefit components of project:
      i. Sensitive species monitoring report: Tidewater Goby, Bird Surveys, Ventura Marsh Milk-vetch analysis.
      ii. Hydrological monitoring report: water stage and water quality parameters of temperature, salinity, pH and dissolved oxygen.
      iii. Public use survey report: Summary of 3 month focused study on site use by people to assess impacts and management considerations.
   d) Synthesis of accounting for grant which will be a summary of quarterly reports.
4) Interpretive sign on funding and GHG sequestration function of wetlands installed on project site.

5. ***Expected quantitative results (project summary):***

All project proposals must include a projection of total net GHG reductions/sequestrations expected as a result of restoration activities. If methane and/or nitrous oxide measurements are excluded from the project, justification must be provided as to why they do not merit inclusion. Describe the approach by which baseline and post-project GHG emissions, including carbon stock changes, were estimated. In addition, include a clear description of areas of uncertainty and how those influence the predicted values.

Each proposal must also describe how these reductions will be achieved through restoration activities or enhancement of wetlands or mountain meadows. The methods used to measure and record actual reduction amounts following project implementation must also be outlined in the Protocols section of the proposal.

Proposals must demonstrate that GHG reductions will be additional, or deemed to occur in addition to a conservative Business-As-Usual Scenario. Outline expected longevity of the emission reductions, potential reversal risks, and plans to address these risks in perpetuity.

The projection of carbon sequestration and GHG emissions are described in detail in earlier sections. Details about restoration activities are discussed in earlier sections as well.

Discussion here focuses on reasons for not including methane and nitrous oxide emissions in estimates, areas of uncertainty and why the 'business as usual' scenario will lead to much lower carbon sequestration on the project site.

1. *Methane and Nitrous Oxide Emissions Discussion*

Methane emissions from freshwater marshes are documented to be relatively high (PWA-SAIC, 2009) and so, although this project will retain the total acreage of freshwater marsh, no credits are claimed nor are emissions declared for this component of the project. Methane emissions from salt marsh restoration are generally discounted because methanogenic bacteria are outcompeted by sulfate-reducing bacteria in those systems (Poffenbarger et al. 2011); see table below from PWA-SAIC, 2009.

Because the Devereux Slough system is intermittently tidal, we are proposing to study whether the variable salinity (5 to 80 ppt) affects either the sequestration rate of carbon or the methane emissions. This area of uncertainty will be addressed through ACR approved methods for sampling and dating soil cores from the extant, remnant salt marsh in Devereux Slough. In addition, direct measurement of trace gas fluxes of CO_2, CH_4 and N_2O will be conducted during the second year of plant establishment in the restoration project and compared to the control or no-project alternative (undisturbed former golf course) and the remnant Devereux Slough salt marsh site. Together, these data will add to the literature about the GHG sequestration potential of intermittently tidal systems. This information will provide a valuable supplement to work being done in San Francisco, San Joaquin Delta and other coastal wetlands in California.

Summary of Carbon Sequestration and Methane Production Across the Salinity Interface (PWA-SAIC 2009)

Wetland Type	**Carbon Sequestration Potential ($gC\ m^{-2}\ yr^{-1}$, $gCO_2e\ m^{-2}\ yr^{-1}$)**	**Methane Production Potential ($gCH_4\ m^{-2}\ yr^{-1}$, $gCO_2e\ m^{-2}\ yr^{-1}$)**	**Net Balance**
Mudflat	Low (<50, 184)	Low (<2, 50)	Low C sequestration
Salt Marsh	High (50-250, 184-917)	Low (<2, 50)	High C sequestration
Mangrove	High (50-250, 184-917)	Low – High	Depends on salinity
Brackish Tidal Marsh	High (250-450, 183.3-1650)	High (5-100, 125-2,500)	Unclear[48]
Freshwater Tidal Marsh	Very High (500-1000, 1,833-3700)	High - Very High (40-100+, 1,000-2,500+)	Unclear – potential very high C
Estuarine Forest	High (100-250, 366.7-916.7)	Low (<10, 250)	High C sequestration

1gC ≡ 3.67 gCO_2e; 1gCH_4 ≡ 25 gCO_2e

2. *Uncertainty related to intermittently tidal marsh system*

As described above, the studies of the extant marsh soil carbon and the instantaneous trace gas measurements will together shed light on how these systems operate with the variation in flooding and desiccation and variations in salinity that are characteristic of these intermittently tidal systems (Goodman, 2008).

3. Sea level rise related uncertainty

The estimates for sea level rise (SLR) locally vary from 0.44 to 1.6 cm per year (NRC 2012). The project will be designed to accommodate SLR at its highest rate with an assumption that the system will accrete at an average rate described for southern California estuaries (Elgin, 2012, Callaway et al. 1996), however, actual SLR and accretion rates may vary. There is the potential that the remnant salt marsh within the existing Devereux Slough may not keep up with SLR, in which case up to 15 acres of existing salt marsh could be lost. If this loss occurs, its potential future sequestration will be mitigated by the proposed project due to the creation of higher elevation salt marsh or, if the remanant marsh is able to keep pace with SLR, future sequestration will effectively double as a result of the restoration project. In the event that neither the remnant nor the restored marsh can accrete in place at a pace sufficient to keep pace with actual SLR, this project is being designed to accommodate inland migration of the salt marsh habitat at the maximum SLR projection over 100 years.

4. Native and non-native grassland sequestration potential uncertainty

The calculations for the potential loss of soil carbon from the no-project alternative are based on findings in Koteen (2011) in which she found soil carbon levels below non-native annual grasslands that had colonized former native grasslands to be approximately 40 t C/ha lower than in remnant native grassland patches. From her close measurements of respiration and decomposition, she found that annual, non-native grass respiration and loss of carbon from the soil was significantly higher, more than double, that from the perennial grasses. The soils on this restoration project site were largely disturbed in 1965 and so the carbon content of soils on site is lower (5.4 kg/m^2) compared to those of native grasslands (12 – 17 kg/m^2) (Koteen, 2011, Molinari, 2014), thus the loss of carbon due to annual existing non-native annual grass cover may not be occurring at as high a rate as found by Koteen et al. Nevertheless, the restoration of native perennial grasses on these low soil carbon sites will sequester significant stores of carbon due to the dense, fibrous root structure of *Nassella pulchra* (and other native species planned for the site) which supports longer growth periods and deeper sequestration of carbon. Baseline measurements of soil carbon before restoration in the native grassland site will provide data that will support a future analysis of soil carbon after five years of plant establishment to contribute to the literature about the importance of native perennial grasslands to California's carbon budget. Studies in rangeland management are being conducted now in order to identify the carbon sequestration potential of these habitats which cover extensive areas of the California foothills (DeLonge et al., 2014).

6. ***Protocols:***

Provide overview of protocols to be used in project development, implementation and measurement of net GHG reductions. Define approach to measure and quantify total net GHG reductions. Performance measures and the types of analyses that will be used to evaluate project performance must be adequately defined.

Performance evaluation of co-benefits must be outlined as well. Define approach to monitoring the effectiveness of project actions at achieving the co-benefits. Monitoring must be consistent with CDFW guidance where appropriate. Define assessment approach and the types of analyses that will be used to evaluate project performance.

1. *Carbon sequestration in Devereux Slough, an intermittently tidal salt marsh*.

Project will follow protocols described by Tierra Resources, 2012 and Callaway et al., 2012. The mean carbon stock in the wetland soils above specific known time horizons will be estimated based on field measurements at fixed locations. Cesium137 analysis of cores will be used to establish baseline soil carbon stock, while feldspar marker horizons will be used to monitor soil carbon stock through the project lifetime.

Five replicate sediment cores will be collected from Devereux Slough salt marsh from an area that is, upon visual inspection, determined to be representative of vegetation. Cores will be collected by driving PVC coring tubes (10 cm diameter) at a depth of 60 to 90 cm into the sediments. Cores will be capped in the field and stored in a vertical position until they are returned to the laboratory. Cores will be frozen to facilitate extraction and slicing. Extracted, frozen cores will be sectioned into 2 cm increments and dried at 60°C for at least 96 hours to determine bulk density. Subsamples of each section will be ground to a fine powder in a Wiley Mill for the determination of percent organic matter, percent carbon, and radioisotope ^{210}Pb (lead) and ^{137}Cs activity. Bulk density will be calculated as the ratio of the oven-dried weight of each 2 cm core section to the known wet volume of that section. Percent organic matter, by weight, of each 2 cm oven-dried section will be determined by loss on ignition. Percent mineral matter, by weight, will be calculated as the remainder.

Sections from each soil core will be analyzed for carbon content using a FlashEA 1112 nitrogen and carbon analyzer (Thermo Electron Corp.). Approximately 150 mg of each dried soil sample will be packaged in a tin capsule, with some adjustment of sample amounts to allow the mass of carbon to fall within the range appropriate for the carbon calibration curve. A chemical standard and soil standard will be analyzed for quality control at the start of each day. The quality control soil standard will also be analyzed after every 10 samples. Approximately 5% of the samples will be randomly selected and reanalyzed on a different day.

Soil cores for Cesium 137 (^{137}Cs) isotope analysis will be taken from the undisturbed, remnant Devereux Slough to establish long-term background carbon accumulation rates. The cores will be collected, frozen, sliced and handled as described above. Accretion rate is calculated from the height of material above the peak ^{137}Cs activity, which correlates to circa 1964 when above-ground nuclear testing was banned. If a peak cannot be distinguished, the height of the material above the start of the ^{137}Cs activity may be used which correlates to circa 1950, the year of the first significant ^{137}Cs fallout. The carbon fraction of the core samples will be analyzed using elemental analysis. Soil carbon accumulation rates can then be calculated as a product of the average accretion rates and average carbon fraction. Decay of isotopes of lead, ^{210}Pb may also be used to support dating study.

2. *Post project carbon sequestration*

Baseline soil carbon content will be assessed from five 50 cm deep cores in the wetland restoration area and the native grassland restoration areas. Following protocols in Tierra Resources Methodology Manual (2012), % carbon in 2 cm slices will be analyzed as above and described for the site. In 10 locations in the wetland, feldspar marking material will be placed in a 50 x 50 cm area to 1 cm depth and marked with a tall stake for future sampling (Cahoon, 1994). This layer of white feldspar will be used to document the depth of sedimentation and accretion post-project.

The depth of soil above the feldspar layer will be measured and shallow soil samples from adjacent to the feldspar marking spot will be taken and the relevant portion analyzed for its carbon content to document project related carbon sequestration over time (USGS, 1993).

3. *Carbon emissions quantification*

Following protocols on the American Carbon Registry website, fuel type and gallons of usage will be documented during the construction phase and GHG estimates will be based on calculations describe in the "Tools for estimations of stocks in carbon pools and emissions from emissions sources", http://americancarbonregistry.org/carbon-accounting/tools-templates. These calculations assume 100% combustion and have specific conversion factors for each fuel type.

4. *Synthesis of results*

Restoration project carbon sequestration can be measured after two years of establishment according to protocols described in Tierra Resources Methodologies Manuals and by Cahoon. These will primarily document accretion of sediment and organic matter above the existing soil conditions. The baseline soil cores will provide additional information about whether carbon is also stored below the accretion zone. Both of these sources of information will be more robust in their ability to predict long-term patterns of carbon sequestration after a longer period of establishment. Because this project is located on a UCSB campus with a robust research program and an active, long-term, open space management program (CCBER), this project provides the opportunity to re-sample the remnant and restored salt marshes at 10 and 20 years. This information will be important because of the integration over time and under actual SLR conditions. Predictions about whether intermittently tidal, sandbar type coastal lagoons will become more impounded or more tidal with SLR are still uncertain. This important research will support studies related to SLR, GHG sequestration and the function of intermittently tidal marshes for these and multiple additional co-benefits.

Literature Cited:

All proposals must include a list of references for all peer-reviewed publications, other scientific reports, project reports, or other supporting information cited in the proposal.

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