ESA

350 Frank H. Ogawa Plaza
Suite 300
Oakland, CA 94612
510.839.5066 phone
510.839.5825 fax

www.esassoc.com

FINAL memorandum

date August 4, 2016

to East Bay Regional Parks District

from Victoria Evans MS, Lindsey Sheehan PE, Hunter Connell and Jeff Caton

subject Carbon Sequestration in East Bay Regional Parks

Executive Summary

As of June 2016, the East Bay Regional Park District (District) manages approximately 120,536 acres in Alameda and Contra Costa Counties. This study provides an estimate of the volume of carbon stored or sequestered in the vegetation and soil on lands and wetlands (i.e., total sinks) managed by the District and updates an earlier study conducted in 2008.[1] Since the 2008 study, additional lands have been acquired and field checks of vegetation types have been collected by District technical staff. Factors that would cause greenhouse gas (GHG) emissions (deductions to carbon sequestration), such as grazing, wildfires, insect outbreaks, storm damage and fuel removal, were not included since adequate data were unavailable.

The terminology and GHG inventory method used are consistent with those of the California Air Resources Board (ARB), the U.S. Environmental Protection Agency (EPA) and the Intergovernmental Panel on Climate Change (IPCC). This inventory provides an estimate of atmospheric CO_2 removal (i.e., total sinks) and methane emissions (CH_4) by forest, grasslands, shrub lands, and wetlands managed by the District.

Note that this study should not be interpreted as an inventory that demonstrates the volume or market value of potential carbon offset credits on District lands.

An inventory is important in tracking the sequestration of atmospheric carbon dioxide (CO_2) by woodlands, urban forests, rangelands, scrublands, and wetlands, and emissions of greenhouse gases to the atmosphere through processes that occur in wetlands and forests and the wood product systems. The forests act as an atmospheric carbon sink, through carbon stored in the trees' biomass, as well as a carbon source, through prescribed and wild fires and the combustion and decomposition of plant residues. Wetlands sequester carbon in biomass, but also in their soils, and emit methane when microorganisms decompose organic matter in wet, poorly aerated soils.

1 ICF 2008. Carbon Sequestration Evaluation for East Bay Regional Park District. http://www.ebparks.org/Assets/files/ebrpd_carbon_seq_study_2008.pdf

The average amount of carbon sequestered annually by the District's lands is estimated to be 300,000 tonnes of CO_2 equivalents (CO_2e). This represents an equivalent to removing 59,300 California passenger cars from the road annually (ARB 2007).

Introduction

This study provides an estimate of the volume of carbon currently stored or sequestered in the vegetation and soil on lands and wetlands (i.e., total carbon sinks) managed by the East Bay Regional Park District (District), and updates an earlier study conducted in 2008 for the District.[2] As of June 2016, the District manages approximately 120,536 acres in Alameda and Contra Costa Counties. Since the 2008 study, additional lands have been acquired and field checks of vegetation types have been collected by District technical staff. The inventory provided herein includes estimates of atmospheric CO_2 removal (i.e., total sinks) and greenhouse gas (GHG) emissions from decomposition of vegetation in freshwater wetlands managed by the District. It does not include GHG emissions from activities on District lands such as grazing, wildfires, insect outbreaks, storm damage and fuel removal, since adequate data were unavailable. Thus, this study does not provide a full accounting of GHG emissions associated with District lands and activities. Nor should this study be interpreted as an inventory that demonstrates the volume or market value of potential carbon offset credits on District lands.

The results of this current study provide an inventory of carbon sequestration (i.e., carbon sinks). The terminology and GHG inventory methodology used are consistent with those of the California Air Resources Board (ARB), the U.S. Environmental Protection Agency (EPA) and the *Intergovernmental Panel on Climate Change* (IPCC).

Types of GHG and Carbon Inventories

Table 1 provides a summary of the five general types of GHG inventories. The Park District is a special district and organizationally fits under the third GHG inventory category: corporate and organization inventory. The results provided here for carbon sequestration (or sinks) represents a portion of the District's overall GHG inventory. To date, the District has not yet conducted a complete GHG emissions inventory of its agency-wide operations.

The Carbon Sequestration Inventory and Its Use

Atmospheric CO_2 is sequestered on District lands by woodlands, urban forests, rangelands, scrublands, and wetlands, while greenhouse gases are released to the atmosphere through processes that occur in wetlands and forests and the wood product systems. The forests act as atmospheric carbon sinks, through carbon in the trees' biomass, as well as sources, through prescribed and wild fires, the combustion and decomposition of plant residues. Wetlands sequester carbon in biomass, but also in their soils, and emit methane when microorganisms decompose organic matter in wet, poorly aerated soils.

Carbon sequestration inventories are developed for multiple purposes, with varying requirements for third-party verification and reporting. The inventory provided by this study is intended to support general planning for

[2] ICF Carbon Sequestration Study for East Bay Regional Park District. http://www.ebparks.org/Assets/files/ebrpd_carbon_seq_study_2008.pdf

climate change. Both the ARB and EPA regularly conduct these general types of carbon inventories of sinks using international standards and agree that an emission inventory that identifies and quantifies the anthropogenic[3] sources and sinks of greenhouse gases is essential for addressing climate change. [4,5]

Planning inventories of this type are not intended to be third-party verified. More robust data and accounting methods are needed for inventories used to quantify carbon offsets or to meet regulatory compliance obligations. Offset registry organizations, including the Climate Action Reserve, American Carbon Registry, Verified Carbon Standard and GHG Rx, require third-party verification against specifically adopted protocols for offset projects. For compliance offsets used in California Cap and Trade program, an additional 3rd party verification is required from the ARB.

Third-party verification is also common for GHG inventories that are voluntarily prepared by governmental agencies and private corporations, especially when the back-up data is available for review and verification, for example, in automated data records for stack sampling of CO_2 emissions, electricity/fuel bills, and refrigerant use records. Third-party verification is required for GHG inventories voluntarily reported to The Climate Registry and optional for reporting to the Carbon Disclosure Project.

This inventory provides an estimate of carbon storage on District lands. For going beyond planning purposes, the full complement of field data on vegetation density, size, species type, and age along with adjustments for management practices (such as re-planting, enhancement, restoration, fuels removal, fire/storm damage) would be needed. These types of vegetation data for the District were not available for all park properties at this time for use in this inventory. In addition, GHG emissions generated by District management and maintenance activities on park properties are not included; these GHG emissions would be a deduction to the carbon sequestration value on District lands**.**

It is important to recognize that *this inventory does not demonstrate the current carbon offset value of District land or wetland properties*. Rather, it is an inventory of current carbon storage or sequestration on District lands indicating the *status quo* or Business As Usual (BAU) level for carbon storage in soil and vegetation on the District's predominantly natural lands. To qualify as a carbon offset, carbon sequestration must be additional to activities otherwise required by law (i.e., CEQA mitigation or restoration that is an offset required for a permit or under compliance with a legal mandate). This inventory provides an initial screening analysis of the potential for carbon offset credits by identifying which properties to further evaluate for their potential to provide *additional* carbon sequestration for credit. **Table 2** indicates the step wise progression of inventories needed for carbon offset project development along with 3rd party verification requirements.

In a prior report to the District, ESA identified six types of projects that the District could develop to produce additional carbon sequestration that meets requirements to generate marketable offset credits. These six project

3 The term "anthropogenic," in this context, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities (IPCC 2006).

4 U.S.EPA (2015) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013, United States Environmental Protection Agency, # EPA 430-R-15-004.

5 ARB 2014b. 2014 Edition. California Greenhouse Gas Emission Inventory: 2000-2012**.** California Air Resources Board, Air Quality Planning and Science Division. http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-12_report.pdf

ARB 2016 . 2016 Edition. California GHG Emission Inventory. 0F1FCalifornia Greenhouse Gas Emissions for 2000 to 2014. Trends of Emissions and Other Indicators http://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2014/ghg_inventory_trends_00-14_20160617.pdf types include: Avoided Conversion of Forest, Improved Forest Management, Restoration and Enhancement of Coastal Wetlands, Restoration and Enhancement of Tidal Wetlands, Urban Forest Management and Biochar. Appendix A provides a Summary of Steps in Carbon Offset Project Development and Implementation. Third party verification *is* required for the documentation required of carbon offset projects before receiving any credit for the project.

National and State Inventories of GHG Emissions and Carbon Sinks

At an international level, the IPCC develops specific standard international guidance for conducting GHG inventories of emissions and carbon sinks. Countries that have adopted the United Nations Framework Convention on Climate Change (UNFCCC) are to prepare and report inventories of their emissions and sinks of CO_2, CH_4, N_2O, SF_6, PFCs, and HFCs using IPCC methodologies to ensure comparability among national inventories. The IPCC guidelines delineate the sectors and processes for which nations must report their GHG emissions and sinks, and how they should report these emissions. These guidelines also describe various methodologies to estimate emissions depending on the available data sources. [6] The guidelines allow for use of state-specific data and methodologies rather than the more generic international ones when available.

As a nation, the United States follows the IPCC guidelines with EPA acting as the lead agency and submits its national greenhouse gas inventory to UNFCCC Secretariat annually. The EPA supplements the widely applicable IPCC methodologies with more US-specific methodologies and data.[7] In the California inventory, state-specific emissions data were used whenever possible.

Using IPCC compliant methods for GHG inventory calculations, the EPA reports for the nation that land use, land-use change, and forestry activities in 2013 resulted in total GHG emissions of 6,673 million (M) tonnes CO_2 equivalents (CO_2e)[8], with carbon sequestration (i.e., total sinks) amounting to 882 M tonnes CO_2e[9], representing an offset of 13.2 percent. Emissions from land use, land-use change and forestry activities in 2013 represent 0.3 percent of total GHG emissions in the U.S.[10] In the latest inventory of emissions and sinks for California, the ARB reports GHG emissions of 444.4 M tonnes CO_2e for 2013.[11] The Bay Area Air Quality Management District reports GHG emissions of 86.6 M tonnes CO_2e.[12] **Table 3** provides a comparative summary of these inventory results for national emissions and sinks.

Several park land managers have conducted similar carbon sequestration studies. For example, the U.S. National Park Service (NPS) conducted a study in 2014 that shows their lands in the conterminous United States are a net

6 IPCC, 2006

7 U.S. EPA 2008

8 U.S.EPA (2015) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013, United States Environmental Protection Agency, # EPA 430-R-15-004. The total sinks value includes the positive C sequestration reported for *Forest Land Remaining Forest Land, Cropland Remaining Cropland, Land Converted to Grassland, Settlements Remaining Settlements,* and *Other Land* plus the loss in C sequestration reported for *Land Converted to Cropland* and *Grassland Remaining Grassland.*

9 CO_2 equivalents are a way to quantify emissions from various greenhouse gases based on their global warming potential.

10 The emissions value includes the CO_2, CH_4, and N_2O emissions reported for Forest Fires, Forest Soils, Liming of Agricultural Soils, Urea Fertilization, Settlement Soils, and Peatlands Remaining Peatlands.

11 ARB (2014). 2014 Edition. California Greenhouse Gas Emission Inventory: 2000-2012**.** California Air Resources Board, Air Quality Planning and Science Division. http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-12_report.pdf

12 Bay Area Air Quality Management District. 2015. Bay Area Emissions Inventory Summary Report: Greenhouse Gases. Base Year 2011**.** Updated: January 2015. Prepared by Exposure Assessment and Emissions Inventory Section.
http://www.baaqmd.gov/~/media/files/planning-and-research/emission-inventory/by2011_ghgsummary.pdf

carbon sink, sequestering more than 14.8 M tonnes of CO_2e annually.[13] Their analysis provided a broad overview of the annual value of carbon sequestration on NPS lands and was averaged over a five year baseline period due to the variability of the flux of carbon from year to year.

Method

The IPCC's specific standard international guidance is appropriate for a planning level inventory of GHG emissions and atmospheric removals by carbon sinks (sequestration).

The IPCC 2006 GHG accounting framework is based on the following equation:

$$Emissions = -Sequestration = Activity\ Data * Emissions\ Factor$$

According to IPCC 2006, *activity data* are data on the magnitude of human activity resulting in GHG emissions and removals. For this analysis, the relevant activity data are land cover areas. **Table 4** provides a list of natural and developed land cover types and extent within the East Bay Regional Park District. The land cover data were field checked by District botany staff.

Emissions factors are the rates of GHG emissions and removals associated with a unit of activity data. In this study, the emissions factors represent carbon dioxide (CO_2) and methane (CH_4) fluxes on a per-hectare basis. A removal is a negative emission.[14] **Table 5** summarizes the removal and emission factors by vegetation type within the East Bay Regional Park District.

Figure 1 provides a map of District lands by date of field data collection, and **Figure 2** is a map of land cover types.

Carbon Stocks

The IPCC Wetlands Supplement to the 2006 accounting guidelines (IPCC 2013a) identifies three carbon stocks important to calculating CO_2 removals in coastal wetlands (this also applies to other vegetated land cover types): biomass (aboveground and belowground), dead organic matter (DOM), and soil carbon. To calculate CO_2 removals, each land cover type is assigned an aboveground biomass density, a biomass carbon sequestration factor, and a soil carbon sequestration factor (Table 5). For example, when land is covered with vegetation, there is a stock of carbon in the biomass and the soil. Over time, the biomass increases according to the biomass sequestration rate as vegetation grows and the soil carbon increases according to the soil sequestration rate, due to the incorporation of dead organic matter back into the soil. The soil carbon sequestration rate is assumed to include belowground biomass.

Aboveground Biomass Stock

When vegetation is established, carbon in the form of CO_2 is taken up from the atmosphere to build biomass. The size of the carbon stock depends on the vegetation type and density. If the vegetation type changes, the amount

[13] Richardson, L., C. Huber, Z. Zhu, and L. Koontz. 2014. Terrestrial carbon sequestration in national parks: Values for the conterminous United States. Natural Resource Report NPS/NRSS/EQD/NRR—2014/880. National Park Service, Fort Collins, Colorado. https://www.nature.nps.gov/socialscience/docs/CarbonSequestration.pdf

[14] The terms "sequestration" and "removal" are synonymous.

of biomass will change as well. Biomass densities can be used to calculate aboveground carbon stock (Table 5), using a vegetation type -specific carbon percentage of dry matter for all land covers. The carbon stock is then converted to CO_2 by multiplying by the ratio of molecular weights:

$$ST_A = CF * AB_A * A * \frac{MW_{CO_2}}{MW_C}$$

Where:
ST_A = Aboveground carbon stock (tonnes CO_2)
CF = Carbon fraction of dry matter
AB_A = Aboveground biomass, per area (tonnes dry matter/ha)
A = Vegetation Type area (ha)
MW_{CO2} = Molecular weight of carbon dioxide (44)
MW_C = Molecular weight of carbon (12)

Aboveground Biomass Flux

As vegetation grows, carbon is taken up from the atmosphere to build biomass. The biomass stock can change based on changing vegetation s (e.g. $ST_{A,\ flux} = ST_{A,\ new\ vegetation} – ST_{A,\ previous\ vegetation}$) or as vegetation grows. The change in biomass due to vegetation growth can be calculated by multiplying the biomass sequestration rate for each vegetation type by the area of that vegetation type and then converting to CO_2 by multiplying by the ratio of molecular weights:

$$ST_{A,flux} = BS * A * \frac{MW_{CO_2}}{MW_C}$$

Where:
$ST_{A,\ flux}$ = Aboveground carbon stock flux (tonnes CO_2/yr)
BS = Biomass sequestration rate for vegetation type (tonnes C/ha/yr)

Soil Stock and Belowground Biomass Flux

As vegetation dies, some of the carbon accumulates in the soil, especially in wetlands. Additionally, vegetation has roots, which contribute to belowground biomass in varying degrees (grasses have low belowground biomass, while trees have high belowground biomass). This carbon stock changes over time based on the vegetation type. The change in soil carbon stock can be calculated by multiplying the vegetation type extent (area) by the soil sequestration rate (Table 5). The soil carbon stock is converted from tonnes C to CO_2 by multiplying by the ratio of molecular weights:

$$ST_{B,flux} = SS * A * \frac{MW_{CO_2}}{MW_C}$$

Where:
$ST_{B,\ flux}$ = Belowground carbon stock flux (tonnes CO_2/yr)
SS = Soil sequestration rate for vegetation type (tonnes C/ha/yr)

Methane Emissions

Methane (CH_4) emissions are produced when microorganisms in wet, poorly aerated soils, such as in freshwater marshes, decompose organic matter. However, high salinities reduce this methane production, so salt marsh is assumed to have negligible emissions (Poffenbarger et al 2011). To calculate CH_4 emissions, each wetland land cover type is assigned a methane emission rate. The IPCC recommends using an emission factor of 0 for salinities greater than 18 ppt and a factor of 193.7 kg CH_4/ha/yr for lower salinities (IPCC 2013a, Table 1). Methane has a 100-year Global Warming Potential (GWP) of 28 relative to CO_2, which means the warming effect of each tonne of CH_4 on the atmosphere in 100 years is 28 times greater than that of a tonne of CO_2. The methane emissions can be calculated by multiplying the emission rate by the area for the restored vegetation. To convert to tonnes CO_2, this is multiplied by the GWP.

$$E_{CH4,flux} = ER * A * \frac{tonnes\ CH4}{kg\ CH4} * GWP$$

Where:
$E_{CH4,\ flux}$ = Methane emissions (tonnes CO_2/yr)
ER = Methane emission rate for the vegetation type (kg CH_4/ha/yr)
$\frac{tonnes\ CH4}{kg\ CH4}$ = Unit conversion (0.001)
GWP = Global Warming Potential (28)

Nitrous Oxide Emissions

N_2O is emitted as a by-product of the conversion of ammonia (contained in fish urea) to nitrate. In areas with aquaculture, N_2O emissions need to be included in the GHG accounting. However, since the District's activities do not include aquaculture, analysis of N_2O was not included in this study.

Net GHG Flux

Carbon aboveground biomass, biomass sequestration rates, and soil sequestration rates, as well as emission rates of methane have been collated for Bay Area ecosystems, or their proxy in California. Many of these values were gathered from published literature including the 2008 study and CA Energy Commission 2004. By combining these emission factors with the activity data from the District's data, the GHG emissions and sequestrations can be calculated:

$$GHG_{flux} = ST_{A,flux} + ST_{B,flux} - E_{CH4,flux}$$

Where:
GHG_{flux} = GHG sequestrations (positive) and emissions (negative), (tonnes CO_2)

Table 6 provides GHG emissions and sequestration values by land cover for the District. The average annual amount of carbon sequestered by the District's lands is estimated to be 274,400 tonnes of CO_2e. This represents an equivalent to annually removing 59,300 California passenger cars from the road (ARB 2007). The existing vegetation also contains 52 M tonnes of CO_2e in the biomass.

Discussion

Upland forest provides the greatest biomass stock and also the greatest annual carbon sequestration (approximately 207,000 tonnes CO_2e/yr) due to its high sequestration rate (1.26 tonnes C/ha/yr, Table 5). Grasslands provide the second most carbon sequestration (approximately 45,500 tonnes CO_2e/yr) due to the large area of grassland in the District. Shrubs and salt marsh sequester approximately 8,000 and 2,000 tonnes CO_2e/yr, respectively.

Due to the assumption that uplands sequester minimal carbon in the soils (ICF 2008, see discussion below), soil carbon sequestration was only calculated for salt marsh and brackish marsh and totaled 8,600 tonnes CO_2e/yr. Brackish marsh , as well as open freshwater, was calculated to emit 1,580 tonnes CO_2e/yr through methane emissions.

Comparison to Prior 2008 Study

This study varies from the earlier carbon sequestration estimate developed by ICF in 2008 in multiple ways:

1. The 2008 study was based upon land cover acreages derived from a combination of field data and data that ICF estimated from maps. In 2008, the District managed 98,571 acres, and the ICF study evaluated land cover and vegetation types for 44,539 acres or 44% of District lands. The 2008 study includes estimates of land cover for 52% of the District's acreage based upon 2005 and 1990 satellite imagery for approximately 30,590 acres (31%) and 20,004 (21%) of District lands, respectively. The remaining four percent were not characterized.

   This current study exclusively used field data for vegetation areas based on District surveys through January 2014. As of June 2016, the District manages approximately 120,536 acres in Alameda and Contra Costa Counties. District land cover data were available and analyzed here for 119,485 of these acres or 99% of District lands. The remaining one percent of lands were not included in this study since no data were available.

2. The 2008 report does not explain how the land use categories and vegetation types were determined from the District surveys. Based on the use of IPCC categories, this current study used the vegetation types crosswalk provided in Appendix B. Emission factors in the 2008 study were drawn for grassland and scrubland from a 2004 California Energy Commission study and for forest carbon from a calculator tool from the timber industry published in 2008. The sequestration and emissions factors used in this current study are based upon IPCC standard methods and a review of the literature. Where possible, assumptions similar to those made in the 2008 report were used. A few caveats:

   a. ICF did not include soil sequestration, but this current study does. Soil sequestration in wetlands is an important carbon stock which accounts for three percent of the GHG reductions calculated in this study. This study assumes no soil sequestration occurs in upland areas, which is probably underestimating the carbon sequestration rate. Kroodsma and Field (2006) proposed soil sequestration rates of 0.09 – 0.26 tonnes C/ha/yr for agricultural and rangeland areas; those assumptions were used here.

   b. ICF did not include methane emissions, but this study does. Methane emissions in brackish marshes and open freshwater account for 1,580 tonnes CO_2e/yr.

c. ICF did not include tidal wetlands, but this study does. An additional 2,100 acres of salt marsh was mapped after the 2008 study.

A comparison of the assumptions used in the two studies are summarized in **Table 7**.

Table 8 provides the sequestration and emissions values broken out by the data available prior to the 2008 study and after. ICF did not calculate soil carbon sequestration or methane emissions, so a comparison between the studies should focus on the biomass carbon sequestration (fourth column in Table 8). Based on the data prior to 2008, this study calculated a carbon sequestration rate of 107,900 tonnes CO_2e/yr (for the 42,800 mapped acres), while ICF estimated 91,157 tonnes CO_2e/yr (for the 98,600 mapped and estimated acres). Representing twice the area, ICF values were still less than those calculated in this study. The following factors help explain the difference:

1. ICF estimated 6,175 acres of developed land. Based on the 2014 full dataset (and including agricultural lands), the District only has 1,194 acres of developed land. This overestimate of developed land underestimates the amount of sequestration.
2. Using ICF's acreages with this study's emission factors results in 228,500 tonnes CO_2e/yr (for 98,600 acres). Compared to the full data set (267,372 tonnes CO_2e/yr for 119,485 acres), this seems reasonable. However, this is a much higher value than ICF calculated, implying that ICF's emissions factors were lower than the ones used for this study. Since this study used the same factors ICF used for grassland, shrubs, and wetlands, the primary difference is the emission factor used for upland forest.

For a comparison with carbon sequestration on District lands, the average annual net carbon sink values for U.S. National Parks in northern California include:

- Redwood National Park (Humboldt County) of 369,106 tonnes CO_2e/yr on 75,452 acres
- Golden Gate National Recreation Area (Marin, San Francisco and San Mateo Counties) of 254,425 tonnes CO_2e/yr on 80,002 acres and
- Muir Woods National Monument (Marin County) of 3,656 tonnes CO_2e/yr on 554 acres.

The prime reason for the larger volume of net carbon sequestration per acre in these parks versus the District lands is the number of redwood trees within these parks in the region.

Study Caveats

Some additional caveats should be kept in mind for this analysis:

1. **District land cover and vegetation data were collected over a period of years.** All of the data used by ESA were derived from District data files for each parcel with date stamps from 1997 to 2014. Thus, the extent and the vegetation types most likely changed over time, and those changes are not included in this analysis. In addition, the District annually conducts prescribed burns, thinning activities, and grazing that would change the mix of vegetation over time (which is the District's intention at specific locations).

2. **Field data for land cover and vegetation types were available for 99% of District lands.** District data available for land cover used in this study covered 119,485 or 99% of District lands.

3. **Carbon losses and GHG emissions were not deducted**. Similar to the ICF study, this study does not include carbon losses and GHG emissions from grazing, fire, fuel removal, and any insect damage. The District conducts prescribed burns and thinning activities on over 1,000 acres of lands per year, based upon the fuels management summary.[15] Prescribed burns are conducted to remove fuel and maintain biodiversity. Thinning dense eucalyptus and pine and removing hazard trees occurs under the District's Wildfire Hazard Reduction and Resource Management Plan. Also the District leases about 60,000 acres annually for grazing on grasslands between March and August for several reasons including fire fuel load reduction. Thus, neither the earlier 2008 study nor this study included consideration of grazing, prescribed burns or wildfire and fuels removal as well as insect outbreak damage.[16]

Future Offset Project Potential

1. **Increases in stored carbon on District lands that are considered *additional* and *surplus* to mitigations/reductions that are required by law can provide a net benefit and are incentivized in the carbon offset market place.** Potential offset-generating activities on District lands include management activities that increase carbon stored over the long term, such as avoiding conversion of forest, instead conveying them to a new conservation easement or to a land bank. When the District *increases* carbon sequestration and maintains that increase over time, this provides a net reduction in atmospheric CO_2, and creates a situation where the carbon offset could be monetized. In a separate study ESA evaluated the preliminary feasibility for carbon offset projects that could be developed on District lands to generate credits for sale in the carbon marketplace.[17] Carbon offsets can typically be generated by sequestration activities on natural or working (agricultural) lands (privately owned) where there is a clear demonstration of additional carbon storage in soils and vegetation.

2. **Offsets for land management activities for vegetation and soil are approved for avoidance of conversion, reforestation, restoration and enhancement of carbon sinks to provide a *net* carbon sequestration benefit.** Since the most rapid carbon sequestration occurs in new vegetation from reforestation, restoration, and enhancement (including wetlands), the carbon marketplace provides monetary incentives for encouraging new vegetative growth, supplementing soil carbon and improving other biological processes to provide for *additional* carbon sequestration to remove carbon dioxide from the atmosphere. See Appendix A for a list of steps to develop Carbon Offset projects, irrespective of the type of project (forestry, wetland, etc.).

   Assessing the District's opportunity for carbon offset credits would involve compiling specific information by parcel and characterizing individual properties for evaluation; this typically occurs in a pre-feasibility study. The potential for generating offset credit is available to the District for parcels meeting eligibility criteria including some that are specific to each offset project type. Carbon offset project types that are specifically applicable to District lands were discussed in detail and protocols for calculation of the carbon offset value of each project type were referenced in an earlier Technical Memo prepared by ESA (ESA

---

[15] EBRPD ND. Fuels Management Summary. http://www.ebparks.org/Assets/_Nav_Categories/About_Us/Fire/Redwood+Burn+Plan+-+2015.pdf

[16] East Bay Regional Park District Fire History. http://www.ebparks.org/Assets/_Nav_Categories/About_Us/Fire/History+All+Fires.pdf

[17] ESA 2016. Potential for Producing Carbon Offsets on East Bay Regional Park District Land. Draft technical memo prepared for EBRPD

2016). Below is a summary discussion of the eligibility criteria for carbon offset projects, regardless of the project type.

Eligibility Criteria for Carbon Offset Projects

- **Requirements for Additionality:** To ensure that projects create reductions that are "*additional*", objective criteria distinguish additional projects from those that would have happened anyway (i.e. in the absence of an offset market). Standards and criteria are established separately for each offset project type. These are designed to exclude non-additional (or "Business As Usual") projects from eligibility. These criteria fall into two categories: (1) a legal requirement test, and (2) a performance standard test.

    (1) **<u>A legal requirement test</u>:** In all cases, projects that are required by law or regulation are excluded, since they are non-additional. There are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions or other legally binding mandates requiring project implementation, or requiring the implementation of similar measures that would achieve equivalent levels of GHG emission reductions.

    (2) **<u>A performance standard test</u>:** Incentives created by the carbon market must have played a critical role in the decision to implement the offset project. Projects that pass a performance standard test should be those that – in the absence of a carbon offset market – would have insufficient financial returns or would face other types of insurmountable implementation barriers.

- **Requirements for Regulatory Compliance and Environmental and Social Safeguards.** This requirement is to ensure that projects adhere to all applicable laws and do not cause adverse environmental, social or economic impacts. Project developers are to demonstrate that their projects will not undermine progress on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice. The project developer must attest that the project was in material compliance with all applicable laws, including environmental regulations, during the offset verification period.

These criteria include eligibility for lands on which the project activity can have *started two years prior* (under Verified Carbon Standard's project protocol). This eligibility criterion would enable consideration of eligible historical land management activity, for example, land conveyance(s) to the District for avoided conversion [forestry] in mid-2014 or 2015, or a wetlands restoration in progress. This would enable credit for carbon offset project types discussed in detail in an earlier Technical Memo prepared by ESA (ESA 2016).

Recommendations and Next Steps

This study provides a rough estimate of the carbon sequestration and emissions from District lands. To refine this estimate, the following data could be collected and analyzed:

- A complete land use and vegetation type dataset. Mapping the remaining lands in the District would provide a more complete view of the carbon sequestration occurring on District lands. Refinement of existing data for identification of vegetation types by subcategory would also be valuable.
- Carbon factors field data. The carbon stock and emissions factors used in this report are based on literature values that are not specific to the East Bay. Conducting field work to determine biomass stock, carbon density, rates of growth, soil sequestration rates, and methane emission rates would improve the accuracy of a carbon sequestration estimate.

- Land use and vegetation data over time. If land use and vegetation data was collected and mapped at regular intervals (every 3 years, for example), these data could be used to calculate the change in carbon stocks over time.
- The results of this latest inventory of sinks for District lands will be of interest to both the ARB and the Bay Area Air Quality Management District for each of their GHG program planning. Thus, we recommend the District share this report with these two agencies.

TABLE 1
TYPES OF GHG INVENTORIES

National inventory
- include all human-caused emissions and removals within a country.

Subnational inventory
- represents emissions attributable to a subnational government or region (e.g., state, tribal nation, county, city).

Corporate or Organization inventory
- provides a company or organization's direct emissions (from sources owned and controlled by the company or organization) plus indirect emissions.
- Inventories can include both emissions and removals of GHGs (sequestration).

Facility inventory
- includes emissions from a specific industrial or organizaitonal installation.

Product life cycle inventory
- documents emissions associated with a specific good throughout its life cycle of production, use and disposal.

Adapted from: Singh, N., T. Damassa, S. Alarcón-Díaz, and M. Sotos. 2014. World Resources Institute. "Exploring Linkages Between National and Corporate/Facility Greenhouse Gas Inventories." Working Paper. Washington, DC: World Resources Institute. Available online at http://www.wri.org/publication/nationalcorporate-ghg-inventories.

TABLE 2
TYPE OF CARBON INVENTORIES OF LAND AND WETLANDS AND VERIFICATION REQUIREMENTS

Inventory type	Data used	Result	Use	3rd party verification
Carbon Sequestration – GHG Emissions Sinks: Land	GIS data for vegetation types converted to biomass stock by ac or ha; Emission Factors for C content	Biomass stock less dead organic matter (DOM) stock = net C sequestered	Planning	No
Carbon Sequestration - GHG Emissions Sinks: Wetlands	GIS data for vegetation types converted to biomass stock by ac or ha. Emission Factors for C content by veg type less deduction for Methane emissions	Biomass stock less dead organic matter stock* less methane emissions = net C sequestered	Planning	No
Pre-feasibility Carbon Offset Project Inventory (parcel specific)	Field data for existing representative vegetation type and age GIS data for vegetation types; Emission Factors for C and methane emissions	Methods from specific Offset Protocol. Biomass stock less dead organic matter stock (all types) and methane emissions (for wetlands) less other GHG emissions per protocol = net C offset	Project	No
Feasibility Carbon Offset Project Inventory (parcel specific)	Field data for existing representative vegetation type and age GIS data for vegetation types; Emission Factors for C and methane emissions	Methods from specific Offset Protocol. Biomass stock less dead organic matter stock (all types) and methane emissions (for wetlands) less other GHG emissions per protocol = net C offset	Project	No
Project Development Document	Field data from plots for representative vegetation type and age GIS data for vegetation types; Emission Factors for C and methane emissions	Methods from specific Offset Protocol. Biomass stock less dead organic matter stock (all types) and methane emissions (for wetlands) less other GHG emissions per protocol = net C offset	Project Development	Yes

* Where data are available from the District for the annual vegetation management activities of thinning and fuels removal, this would enable the calculation of this carbon removal to disaggregate DOM (Dead Organic Matter) stock for dead trees/standing stock remaining.

TABLE 3
RECENT TRENDS IN U.S. GREENHOUSE GAS EMISSIONS AND SINKS, U.S. AND CALIFORNIA
(M TONNES CO_{2E})

	1990	2005	2009	2010	2011	2012	2013
US							
Total Emissions	6,301.1	7,350.2	6,722.7	6,898.8	6,776.6	6,545.1	6,673.0
Total Sinks[a]	(775.8)	(911.9)	(870.9)	(871.6)	(881.0)	(880.4)	(881.7)
Net Emissions (Sources less Sinks)	5,525.2	6,438.3	5,851.9	6,027.2	5,895.6	5,664.7	5,791.2
California							
Total Emissions[b]		485.1	458.4	453.1	450.9	458.7	444.35
SF Bay Area*							
Total Emissions	67.1	85.8	-	-	86.6	-	-

M = Million
* BAAQMD compiles this inventory every 3 years
a. Sinks (i.e., CO2 removals) are included in Net Emissions total.
b. Sinks were not calculated using IPCC comparable factors by the ARB and not calculated by BAAQMD.

SOURCE: US EPA 2015. ARB 2016. BAAQMD 2015.

TABLE 4
NATURAL AND DEVELOPED LAND COVER TYPES AND EXTENT WITHIN THE EAST BAY REGIONAL PARK DISTRICT

Land Use or Cover/Vegetation Type	Acreage
Agriculture - Cropland and Pastureland	310
Agriculture - Tree Crops	18
Developed - Low Intensity	30
Developed - Mid/High Intensity	836
Rangeland - Grassland/Herbaceous/Open Land	53,978
Rangeland - Shrub and Brushland	8,804
Upland Forest - Upland Forest	44,896
Upland Forest - Tree Plantations	8
Wetlands - Salt Marsh	2,335
Wetlands - Brackish Marsh	247
Wetlands - Mudflat	0.03
Wetlands - Open Freshwater	44
Beach - Dune	2
Subtidal - Subtidal	7,977
Total	**119,485**

TABLE 5
REMOVALS AND EMISSION FACTORS

Land Cover/Vegetation type		Biomass Stock		Carbon Conversion		Biomass Removals		Soil Carbon Removals		Methane Emissions	
		Biomass Stock (tonnes DM[1]/ha)	Reference/ Assumptions	% Carbon in Dry Matter	Reference/ Assumption	Rate of Biomass growth (tonnes C/ha/yr)	Reference/ Assumption	C Removal Rate (tonnes C/ha/yr)	Reference/ Assumptions	CH_4 Emission Rate (kg Ch_4/ha/yr)	Reference
Agriculture	**Cropland and Pastureland**	2.1	IPCC 2006 V4 Chap 5 -Table 5.9 (for temperate)	0.47	IPCC 2006 Chap 4 - Table 4.3	0	Assumed equal to biomass losses	0	Assumed- similar to ICF 2008 assumption	0	Assumed
	Tree Crops	2.1	IPCC 2006 V4 Chap 5 -Table 5.9 (for temperate)	0.47	IPCC 2006 Chap 4 - Table 4.3	0	Assumed equal to biomass losses	0	Assumed- similar to ICF 2008 assumption	0	Assumed
	Vineyards	2.1	IPCC 2006 V4 Chap 5 -Table 5.9 (for temperate)	0.47	IPCC 2006 Chap 4 - Table 4.3	0	Assumed equal to biomass losses	0	Assumed- similar to ICF 2008 assumption	0	Assumed
Developed	**Low Intensity**	1.75	Assume half the stock of grassland	0.47	IPCC 2006 Chap 4 - Table 4.3	0	Assumed	0	Assumed- similar to ICF 2008 assumption	0	Assumed
	Mid/High Intensity	0	Assumed	0.47	IPCC 2006 Chap 4 - Table 4.3	0	Assumed	0	Assumed	0	Assumed
Rangeland	**Grassland/Herbaceous/Open Land**	3.5	CA Energy Commission 2004 Section 1.3.1 (grassland with 100% cover)	0.47	IPCC 2006 Chap 4 - Table 4.3	0.25	ICF 2008 Table 2 (converted)	0	Assumed- similar to ICF 2008 assumption	0	Assumed
	Shrub and Brushland	40	CA Energy Commission 2004 Section 1.3.1 (Shrubs in North Coast region)	0.47	IPCC 2006 Chap 4 - Table 4.3	0.25	ICF 2008 Table 2 (converted)	0	Assumed- similar to ICF 2008 assumption	0	Assumed
Upland Forest	**Upland Forest (All)**	660	IPCC 2006 V4 Chap 4 - Table 4.7 (for temperate oceanic forest)	0.47	IPCC 2006 Chap 4 - Table 4.3	1.26	Weighted average of evergreens, redwoods, mixed, and oak woodland in ICF 2008 Table 2. Also see Section 1.3.3. of CA Energy Commission 2004.	0	Assumed, based on Section 4.2.3.1 of IPCC 2006 and Tier 1 analysis	0	Assumed
	Tree Plantations	175	IPCC 2006 V4 Chap 4 - Table 4.8 (for temperate oceanic forest)	0.47	IPCC 2006 Chap 4 - Table 4.3	1.26	Assumed same as forest	0	Assumed, based on Section 4.2.3.1 of IPCC 2006 and Tier 1 analysis	0	Assumed
Wetlands	**Salt Marsh**	5.5	Onuf 1987, Figure 31: Mean biomass of salt marsh plants in Mugu Lagoon (1977-1981)	0.45	IPCC 2014 Chap 4 - Table 4.11	0.25	ICF 2008 Table 2 (converted)	0.91	IPCC 2013 Table 4.12	0	Assumed
	Salt Barren	0.4	Assumed 7% salt marsh cover	0.45	Assumed same as salt marsh	0	Assumed equal to biomass losses (IPCC 2013 Section 4.2.1.1)	0.32	Assume 20% of salt marsh	0	Assumed
	Freshwater Marsh	5.5	Assumed same as salt marsh	0.45	IPCC 2014 Chap 4 - Table 4.11	0.25	ICF 2008 Table 2 (converted)	1.6	Assumed same as salt marsh	193.7	IPCC 2013 Table 4.14
	Brackish Marsh	5.5	Assumed same as salt marsh	0.45	Assumed same as salt marsh	0.25	Assumed same as salt marsh	0.91	Assumed same as salt marsh	193.7	IPCC 2013 Table 4.14
	Mudflats	0	Assumed	0	Assumed	0	Assumed equal to biomass losses (IPCC 2013 Section 4.2.1.1)	0	Assumed	0	Assumed
	Open Freshwater	0	Assumed	0.45	IPCC 2014 Chap 4 - Table 4.10	0	Assumed equal to biomass losses (IPCC 2013 Section 4.2.1.1)	0	Assumed	193.7	IPCC 2013 Table 4.14
Beach	**Dune**	1.6	Assumed same as grassland	0.45	IPCC 2014 Chap 4 - Table 4.10	0	Assumed equal to biomass losses (IPCC 2013 Section 4.2.1.1)	0	Assumed	0	Assumed
Subtidal	**Subtidal**	0	Assumed	0.45	IPCC 2014 Chap 4 - Table 4.11	0	Assumed equal to biomass losses (IPCC 2013 Section 4.2.1.1)	0	Assumed	0	Assumed

TABLE 6
GHG EMISSIONS AND SEQUESTRATION BY LAND COVER, EAST BAY REGIONAL PARK DISTRICT

Land Cover and Vegetation Type (IPCC categories)	Acreage	Existing Carbon Stock in Aboveground Biomass (tonnes CO_2e)	Biomass Carbon Sequestration (tonnes CO_2e/yr)	Soil Carbon Sequestration (tonnes CO_2e/yr)	Methane Emissions (tonnes CO_2e/yr)	Net Annual GHG Flux (tonnes CO_2e/yr)
Agriculture - Cropland and Pastureland	310	1,120	-	-	-	-
Agriculture - Tree Crops	18	66	-	-	-	-
Developed - Low Intensity	30	90	-	-	-	-
Developed - Mid/High Intensity	836	-	-	-	-	-
Rangeland - Grassland/Herbaceous/Open Land	53,978	325,580	49,480	-	-	67,290
Rangeland - Shrub and Brushland	8,804	606,870	8,070	-	-	15,820
Upland Forest - Upland Forest	44,896	51,064,820	207,420	-	-	207,420
Upland Forest - Tree Plantations	8	2,310	35	-	-	35
Wetlands - Salt Marsh	2,335	21,190	2,140	7,790	-	9,930
Wetlands - Brackish Marsh	247	2,240	230	820	1,340	(290)
Wetlands - Mudflat	0.03	-	-	-	-	-
Wetlands - Open Freshwater	44	-	-	-	240	(240)
Beach - Dune	2	6	-	-	-	-
Subtidal - Subtidal	7,977	-	-	-	-	-
Total	**119,485**	**52,024,294**	**267,400**	**8,600**	**1,580**	**274,400**

NOTE: Values are rounded.

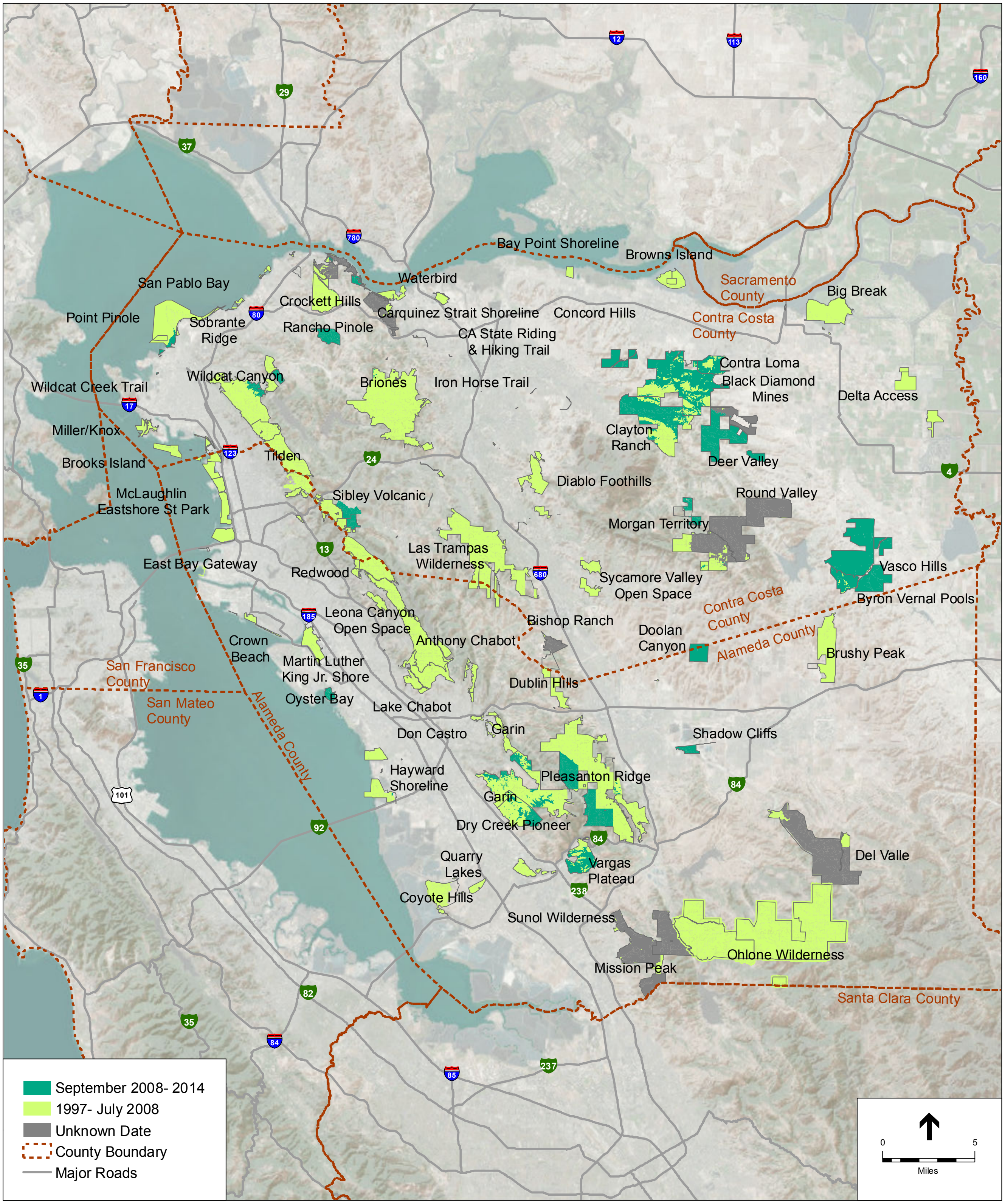
TABLE 7
COMPARISON OF ASSUMPTIONS AND METHODS USED IN CARBON SEQUESTRATION EVALUATION

ICF 2008	ESA 2016
Carbon Factors	
For 18 land cover types, carbon stock factors for grassland, scrublands from CEC 2004, 2006 and forest factors from NCASI 2008. NCASI's stock value includes both soil and non-soil carbon.	IPCC factors and values from the literature were used
Where there was not a clear match, the closest land cover type was used. Sequestration and carbon stock for developed land, lawns, and open water was assumed to be zero. Carbon sequestration by cultivated soils was assumed to be zero. Fertilizer application also results in emissions.	Where there was not a clear match, the closest land cover type was used. Sequestration stock for developed land, lawns, and open water was assumed to be zero. Carbon sequestration by cultivated soils was assumed to be zero.
For wetland land cover types, only carbon sequestration was looked at, not methane production.	Appropriate carbon factors for both atmospheric removals and methane emissions from inland and tidal wetlands were used to provide a net C sequestration value. Soil carbon was also included.
Developed land covers included cultivated, developed, golf course/irrigated lawns, and rural residential and carbon value was assumed to be zero.	Developed land covers included cultivated, developed, golf course/irrigated lawns, and rural residential and carbon value was assumed to be zero
Data on Vegetation and Land Cover Types	
Open bay included tidal wetlands, since the quality of the data did not allow for differentiation between open bay and tidal wetlands.	ESA applied the District-provided data files for tidal wetlands, inland wetlands, and open water.
As of July 2008 approximately 43,539 acres (44%) of District lands had been mapped in the field by District staff.	As of July 2016 approximately 119,485 acres (99%) of District lands had data available by vegetation type dated 1997 to 2014.
For 30,590 acres (31%) of District lands, maps were developed through on-screen digitizing and classification of aerial photographs from an Air Photo USA San Francisco Bay imagery dataset (November 2005) and a USDA National Agriculture Imagery Program imagery dataset (May 2005) and limited field verification.	As noted above, ESA used District -provided GIS-based data.
For 20,004 acres (20%) of District lands, data from 1990 Landsat satellite imagery guided by high-altitude aerial photography, vector overlays of existing vegetation and land use maps, and forest inventory data were used.	As noted above, ESA used District -provided GIS-based data.

TABLE 8
GHG EMISSIONS AND SEQUESTRATION, EAST BAY REGIONAL PARK DISTRICT

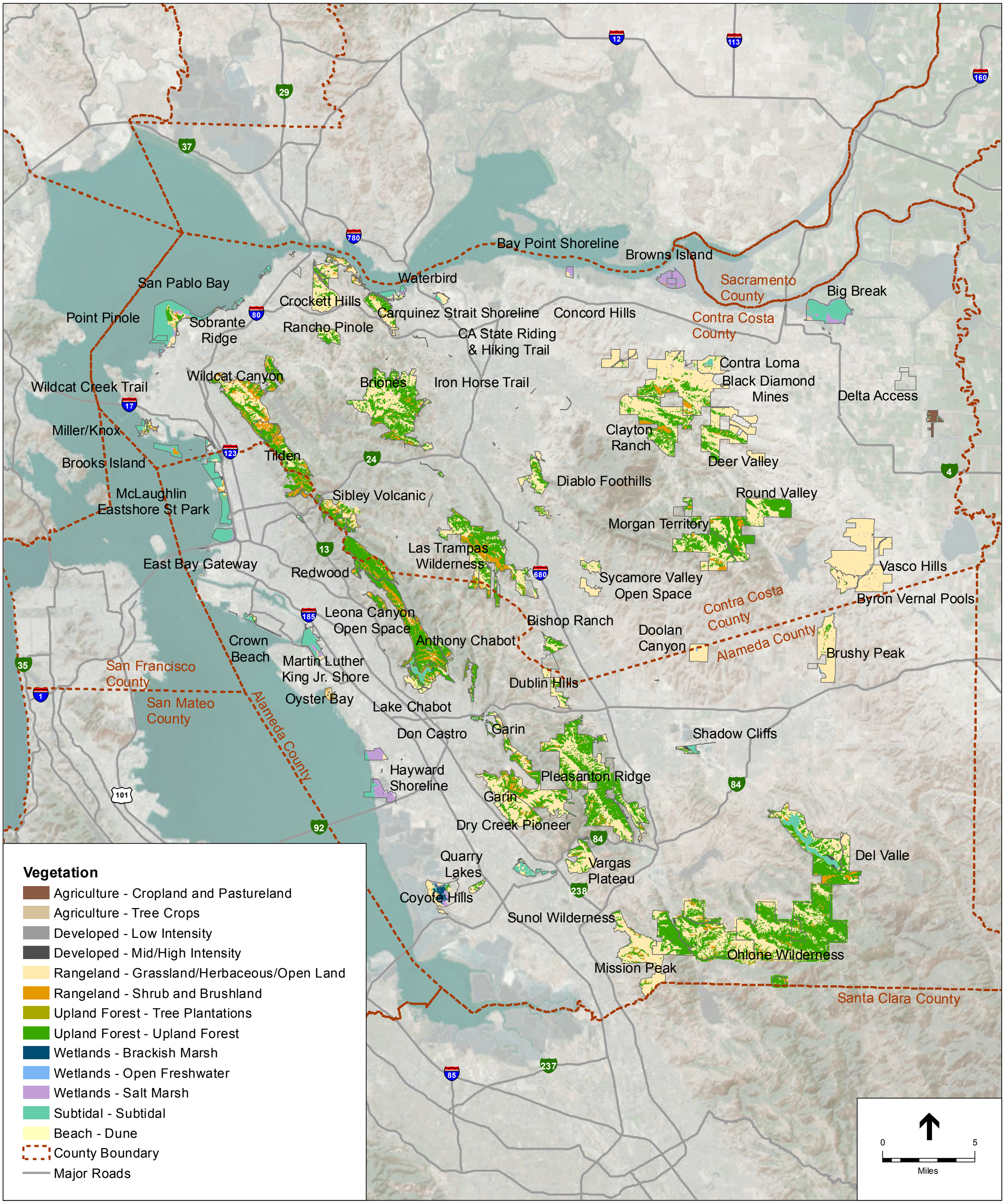
Dates of District Data	Acreage	Carbon Stock in Aboveground Biomass (tonnes CO_2e)	Biomass Carbon Sequestration (tonnes CO_2e/yr)	Soil Carbon Sequestration (tonnes CO_2e/yr)	Methane Emissions (tonnes CO_2e/yr)	Net Annual GHG Flux (tonnes CO_2e/yr)
All data	119,485	52,024,300	267,400	8,600	1,580	274,400
Data through July 2008	42,832	21,612,800	107,900	1,600	1,440	108,100
Data after July 2008	76,649	30,412,300	159,400	7,010	140	166,300

NOTE: Values are rounded.



SOURCE: EBRPD 2016, ESRI

Figure 1
Field Data Collection Dates
East Bay Regional Park District



SOURCE: EBRPD 2016, ESRI

East Bay Regional Parks District Carbon Sequestration . 150894

Figure 2

Land Cover Types

East Bay Regional Park District

References

ARB 2007. California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit, California Air Resources Board, Planning and Technical Support Division.

ARB 2014a. Technical Support Document for California's 2000-2012 Greenhouse Gas Emission Inventory and 1990 Emissions Level, California Air Resources Board, Air Quality Planning and Science Division.

ARB 2014b. 2014 Edition. California Greenhouse Gas Emission Inventory: 2000-2012**.** California Air Resources Board, Air Quality Planning and Science Division. Available at http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-12_report.pdf

ARB 2016. 2016 Edition. California GHG Emission Inventory. 0F1FCalifornia Greenhouse Gas Emissions for 2000 to 2014. Trends of Emissions and Other Indicators Available at http://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2014/ghg_inventory_trends_00-14_20160617.pdf

Battles, J.J., P. Gonzalez, T. Robards, B.M. Collins, D.S. Saah 2014. California Forest and Rangeland Greenhouse Gas Inventory Development. Final Report. Prepared for the California Air Resources Board. Available at http://www.arb.ca.gov/cc/inventory/pubs/battles%20final%20report%2030jan14.pdf

California Energy Commission. 2004. Baseline Greenhouse Gas Emission for Forest, Range, and Agricultural Lands in California. Prepared by Winrock International. March 2004.

ESA 2016. Potential for Producing Carbon Offsets on East Bay Regional Park District Land**.** Technical Memorandum.

ICF 2008. Carbon Sequestration Study for East Bay Regional Park District. Available at http://www.ebparks.org/Assets/files/ebrpd_carbon_seq_study_2008.pdf

International Panel on Climate Change (IPCC) 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Penman J., Kruger D., Galbally I., Hiraishi T., Nyenzi B., Emmanuel S., Buendia L., Hoppaus R., Martinsen T., Meijer J., Miwa K., and Tanabe K. (Eds. IPCC/OECD/IEA/IGES, Japan).

IPCC 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds., IGES, Japan).

IPCC 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K.B., Tignor M., and Miller H.L. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Chapter 2, Table 2.14.

IPCC. 2013a. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

IPCC. 2013b. Working Group I Contribution to the IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis. Final Draft Underlying Scientific Technical Assessment. September 2013.

Kroodsma, D.S. and C.B. Field. 2006. Carbon Sequestration in California Agriculture, 1980-2000. Ecological Applications, 16 (5): 1975-1985.

Poffenbarger, H., B. Needelman, and P. Megonigal. 2011. Salinity Influence on Methane Emissions from Tidal Marshes. Society of Wetland Scientists. 31:831-842.

U.S. EPA 2008. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006. (April 2008) EPA 430-R-08-005. Available at https://www3.epa.gov/climatechange/Downloads/ghgemissions/08_CR.pdf

U.S. EPA 2013. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011. Available at http://www.epa.gov/climatechange/emissions/usinventoryreport.html

U.S..EPA 2014. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, United States Environmental Protection Agency, # EPA 430-R-14-003.

US.EPA 2015. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013, United States Environmental Protection Agency, # EPA 430-R-15-004.

APPENDIX A
Summary of Steps in Carbon Offset Project

Development and Implementation

TABLE A-1.
OVERVIEW OF STEPS TO DEVELOPING A CARBON OFFSET PROJECT

Project Idea and Preliminary Assessment
Project Design and Planning
Develop a Preliminary Project Design Document
Review Project Activities and Develop Project Implementation Strategy
Finalizing Financing and Investment Arrangements
Approvals, Validation and Registration
Implementation and Monitoring
Third Party Verification and Issuance

TABLE A-2.
ROLES AND RESPONSIBILITIES IN CARBON OFFSET PROJECT DEVELOPMENT AND IMPLEMENTATION

General • Overall project lead and coordinator • Owner of carbon, empowered to enter into agreement for sale or transfer • Owner of the land/wetlands
Technical • Providers of existing data regarding land use, carbon stocks, growth rates, drivers and agents of degradation/deforestation • Producers of additional data to quantify emissions reductions or removals (e.g., field data collection, biomass inventories, land-use change mapping, property boundaries) • Provider of technical support for project design, drafting of Project Design Document (PDD) and preparation of project documents for validation (by registry) and verification (by auditor) • Assessors of biodiversity impacts
Business and Legal • Developer of legal agreements, or Provider of documents that evidence land/wetland ownership, protected status and management commitments by land manager • Negotiator with potential offset buyers/investors • Broker, intermediary or buyer • Provider of funding for project development phase • Provider of funding for upfront investment into implementation; insurance and guarantees, if needed • Administrator of project development funds and carbon revenues
Stakeholder Relations • Community liaison • Government liaison • Coordinator of reporting (to donors, investors, regulators)
Project Implementation • Coordinator of forest and land management activities (useful to break this down into detailed components and phases of project execution) • Executors or service providers for land/wetland management • Provider of technical assistance for land/wetland management
Monitoring • Coordinator/Implementer of monitoring efforts and data storage and management • Coordinator of validation process and liaison with external auditor • Coordinator of verification process and liaison with external auditor
Third-Party Auditor • External Third Party auditor performs verification of Project by reviewing all back-up data and PDD along with adherence to the appropriate Project Protocol.

APPENDIX B

Land Use/Cover and Vegetation Type Crosswalk

%	Parks Subcategory	GHG Category
Cropland	Cropland	Agriculture - Cropland and Pastureland
Cropland	Cultivated field	Agriculture - Cropland and Pastureland
Cropland		Agriculture - Cropland and Pastureland
Developed	Bare gravel	Developed - Mid/High Intensity
Developed	Building	Developed - Mid/High Intensity
Developed	Children's play area	Developed - Mid/High Intensity
Developed	Coast Live Oak - California Bay - Blue Gum Eucalyptus	Agriculture - Tree Crops
Developed	Cult. trees	Agriculture - Tree Crops
Developed	Cultivar	Agriculture - Cropland and Pastureland
Developed	Cultivated	Agriculture - Cropland and Pastureland
Developed	Developed	Developed - Mid/High Intensity
Developed	Developed - Franklin Ridge Staging Area	Developed - Mid/High Intensity
Developed	Developed - Ranch	Rangeland - Grassland/Herbaceous/Open Land
Developed	Developed/Landscaped	Developed - Mid/High Intensity
Developed	Environmental Education Center / Little Farm: Structures, irrigated park turf, bare dirt	Developed - Mid/High Intensity
Developed	Eucalyptus	Agriculture - Tree Crops
Developed	Eucalyptus - Cultivated Pine	Agriculture - Tree Crops
Developed	Golf Course: Developed	Developed - Low Intensity
Developed	Golf Course: Water	Wetlands - Open Freshwater
Developed	Gravel road	Developed - Mid/High Intensity
Developed	Irrigated Park Turf	Rangeland - Grassland/Herbaceous/Open Land
Developed	Lake Anza parking lot - irrigated park turf - structures - beach - landscape trees	Developed - Mid/High Intensity
Developed	Lake Chabot Marina - Developed	Developed - Mid/High Intensity
Developed	Landscaped Parking Lot	Developed - Mid/High Intensity
Developed	Model airplane field	Rangeland - Grassland/Herbaceous/Open Land
Developed	Park office and Parking Lot	Developed - Mid/High Intensity
Developed	Parking lot	Developed - Mid/High Intensity
Developed	Peruvian Peppertree	Agriculture - Tree Crops
Developed	Ranch Buildings	Developed - Mid/High Intensity
Developed	Ranch buildings	Developed - Mid/High Intensity
Developed	Ranch house	Developed - Mid/High Intensity

%	Parks Subcategory	GHG Category
Developed	Redwood Equestrian Arena	Rangeland - Grassland/Herbaceous/Open Land
Developed	Rifle Range: Structures + bare soil	Developed - Low Intensity
Developed	Road-Trail-Bare Dirt	Developed - Low Intensity
Developed	SFWD Water Treatment	Developed - Mid/High Intensity
Developed	Staging area	Developed - Mid/High Intensity
Developed	Staging Area: Developed	Developed - Mid/High Intensity
Developed	Storage yard	Developed - Mid/High Intensity
Developed	Storage Yard	Developed - Mid/High Intensity
Developed	Structures and Parking	Developed - Mid/High Intensity
Developed	Structures, gravel parking lot, corrals	Developed - Mid/High Intensity
Developed	Structures, Roads, Corral	Developed - Mid/High Intensity
Developed	Swimming pool	Developed - Mid/High Intensity
Developed	Tilden Botanic Garden: California Native Plant Collection	Developed - Mid/High Intensity
Developed	Tilden golf course: Structures and Parking lot	Developed - Mid/High Intensity
Developed	Tilden golf course: Structures, irrigated turf, and landscape shrubs/trees	Developed - Mid/High Intensity
Developed	Trails	Developed - Low Intensity
Developed	unlabeled	Developed - Mid/High Intensity
Developed	Urban / Developed	Developed - Mid/High Intensity
Developed	Valley Oak - Eucalyptus	Agriculture - Tree Crops
Developed	Walnut Orchard	Agriculture - Tree Crops
Developed	Wind turbine infrastructure	Developed - Mid/High Intensity
Grassland	"Unknown plant"	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Ann./ Per. Grassland + per. wildflowers	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Annual / Perennial Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Artichoke Thistle	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Bare gravel	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Bristly Ox-tongue - Deerweed	Rangeland - Grassland/Herbaceous/Open Land
Grassland	California Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Fennel	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Ground Clover	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Harding Grass	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Italian Thistle	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Mixed Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Mowed Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Mustard - Gum Plant - Sow Thistle	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Mustard - Gum Plant - Sow Thistle - Mixed Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	OAK WOODLAND	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Perennial Grassland + native wildflowers	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Perennial Peppergrass?	Rangeland - Grassland/Herbaceous/Open Land

%	Parks Subcategory	GHG Category
Grassland	Perennial Peppergrass? - Pickleweed - Dodder	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Perennial Peppergrass? - Salt Grass	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Poison Hemlock - Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Poison Hemlock - Artichoke Thistle	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Poison Hemlock / Black Mustard	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Purple Needle Grass	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Purple Needle Grass - Coyote Brush	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Rock	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Ruderal	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Rumex	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Sand	Beach - Dune
Grassland	Sow Thistle	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Tall Wheatgrass	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Teasel	Rangeland - Grassland/Herbaceous/Open Land
Grassland	unlabeled	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Wild Oats	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Wild Rye	Rangeland - Grassland/Herbaceous/Open Land
Grassland	Wild Rye - Coyote Brush - Wild Oats - Purple Needle Grass	Rangeland - Grassland/Herbaceous/Open Land
Rock	Rip-Rap	Developed - Mid/High Intensity
Rock	Rock Pile	Developed - Mid/High Intensity
Rock		Developed - Mid/High Intensity
Shrubland	Blackberry	Rangeland - Shrub and Brushland
Shrubland	Blue Elderberry	Rangeland - Shrub and Brushland
Shrubland	Broom	Rangeland - Shrub and Brushland
Shrubland	California Buckwheat - California Sagebrush	Rangeland - Shrub and Brushland
Shrubland	California Coffeeberry	Rangeland - Shrub and Brushland
Shrubland	California Sage - Annual Grassland - Coyote Brush	Rangeland - Shrub and Brushland
Shrubland	California Sagebrush	Rangeland - Shrub and Brushland
Shrubland	Chamise	Rangeland - Shrub and Brushland
Shrubland	Chamise - Black Sage	Rangeland - Shrub and Brushland
Shrubland	Coast Live Oak - California Bay	Upland Forest - Upland Forest
Shrubland	Coyote Brush	Rangeland - Shrub and Brushland
Shrubland	Eucalyptus sprouts - Coyote Brush	Rangeland - Shrub and Brushland
Shrubland	Fennel	Rangeland - Shrub and Brushland
Shrubland	French Broom	Rangeland - Shrub and Brushland
Shrubland	Gravel road	Developed - Low Intensity
Shrubland	Himalayan Blackberry	Rangeland - Shrub and Brushland
Shrubland	Italian Thistle - Coyote Brush - Mixed Annual Grassland	Rangeland - Shrub and Brushland
Shrubland	Manzanita	Rangeland - Shrub and Brushland
Shrubland	Moist North Coastal Scrub - Oak - Bay	Rangeland - Shrub and Brushland
Shrubland	Monkey Flower - Poison Oak	Rangeland - Shrub and Brushland

%	Parks Subcategory	GHG Category
Shrubland	Oak Bay Woodland	Upland Forest - Upland Forest
Shrubland	Ocean Spray	Rangeland - Shrub and Brushland
Shrubland	Pampas Grass	Rangeland - Shrub and Brushland
Shrubland	Poison Hemlock - Broom - Coyote Brush	Rangeland - Shrub and Brushland
Shrubland	Poison Oak	Rangeland - Shrub and Brushland
Shrubland	Rubber Rabbitbrush	Rangeland - Shrub and Brushland
Shrubland	Salt Marsh Baccharis - Poison Oak	Rangeland - Shrub and Brushland
Shrubland	Scotch Broom - Coyote Brush	Rangeland - Shrub and Brushland
Shrubland	Scrub Oak	Rangeland - Shrub and Brushland
Shrubland	Sedge Boundary	Rangeland - Shrub and Brushland
Shrubland	Sierra Plum	Rangeland - Shrub and Brushland
Shrubland	Toyon	Rangeland - Shrub and Brushland
Shrubland	unlabeled	Rangeland - Shrub and Brushland
Shrubland	Utah Serviceberry	Rangeland - Shrub and Brushland
Shrubland	Utah Serviceberry - California Coffeeberry	Rangeland - Shrub and Brushland
Shrubland	Western Chokecherry	Rangeland - Shrub and Brushland
Water	Perennial Pond	Wetlands - Open Freshwater
Water	Pond (edged by cattails and tules)	Wetlands - Open Freshwater
Water	SF Bay	Subtidal - Subtidal
Water	unlabeled	Subtidal - Subtidal
Water	Water - Mudflats	Subtidal - Subtidal
Wetland	Alder	Upland Forest - Upland Forest
Wetland	Blue Oak - Valley Oak - Western Sycamore	Upland Forest - Upland Forest
Wetland	California Bay - Bigleaf Maple - California Buckeye	Upland Forest - Upland Forest
Wetland	California Buckeye - California Bay - Western Sycamore	Upland Forest - Upland Forest
Wetland	California Bulrush	Wetlands - Brackish Marsh
Wetland	California Bulrush - Willows	Wetlands - Brackish Marsh
Wetland	Cattail	Wetlands - Brackish Marsh
Wetland	Clotbur - mud	Wetlands - Mudflat
Wetland	Coast Live Oak - California Bay - Western Sycamore	Upland Forest - Upland Forest
Wetland	Cord Grass	Wetlands - Salt Marsh
Wetland	Frick Lake - seasonal	Wetlands - Open Freshwater
Wetland	Frogs Bit	Wetlands - Open Freshwater
Wetland	Gravel pit pond	Wetlands - Open Freshwater
Wetland	Gray Pine - California Bay - California Buckeye - Western Sycamore	Upland Forest - Upland Forest
Wetland	Marsh	Wetlands - Salt Marsh
Wetland	Perennial Peppergrass? - Pickleweed - Dodder	Wetlands - Salt Marsh
Wetland	Perennial stream	Wetlands - Open Freshwater
Wetland	Pickleweed	Wetlands - Salt Marsh
Wetland	Planted Willows	Upland Forest - Upland Forest
Wetland	Poison Hemlock	Upland Forest - Upland Forest

%	Parks Subcategory	GHG Category
Wetland	Poison Hemlock - Elderberry - Live Oak - California Bay	Upland Forest - Upland Forest
Wetland	Poison Oak - Western Sycamore	Upland Forest - Upland Forest
Wetland	Pond	Wetlands - Open Freshwater
Wetland	Pond and Willows	Wetlands - Open Freshwater
Wetland	Riparian / Seasonal Wetland	Upland Forest - Upland Forest
Wetland	RIPARIAN WOODLAND	Upland Forest - Upland Forest
Wetland	Rush	Wetlands - Brackish Marsh
Wetland	Rush - Annual Grassland	Wetlands - Brackish Marsh
Wetland	Rush - Cattail - Blackberry	Wetlands - Brackish Marsh
Wetland	Rush (Juncus sp.)	Wetlands - Brackish Marsh
Wetland	Salt Grass	Wetlands - Salt Marsh
Wetland	Salt Grass-Velvet Grass-English Plantain-Peavine	Wetlands - Salt Marsh
Wetland	Sea Rocket	Beach - Dune
Wetland	Seasonal drainage	Wetlands - Open Freshwater
Wetland	Seasonal Pond	Wetlands - Open Freshwater
Wetland	Seasonal pond	Wetlands - Open Freshwater
Wetland	Seasonal wetland	Wetlands - Salt Marsh
Wetland	Seasonal Wetland (no Pickleweed)	Wetlands - Salt Marsh
Wetland	Seasonal Wetland (with Pickleweed)	Wetlands - Salt Marsh
Wetland	Sedge	Wetlands - Brackish Marsh
Wetland	Shoreline	Beach - Dune
Wetland	Spikerush - Pennyroyal	Wetlands - Brackish Marsh
Wetland	Spreading Rush	Wetlands - Brackish Marsh
Wetland	Tule	Wetlands - Brackish Marsh
Wetland	Tules (Bulrush)	Wetlands - Brackish Marsh
Wetland	unlabeled	Wetlands - Salt Marsh
Wetland	Water	Subtidal - Subtidal
Wetland	Water - Sand	Subtidal - Subtidal
Wetland	Water / Mud	Subtidal - Subtidal
Wetland	Western Sycamore	Upland Forest - Upland Forest
Wetland	Willow	Upland Forest - Upland Forest
Woodland	Acacia	Upland Forest - Upland Forest
Woodland	Acacia - Palm - Live Oak - California Bay	Upland Forest - Upland Forest
Woodland	Acacia - Purple Needle Grass	Upland Forest - Upland Forest
Woodland	Annual Grassland	Rangeland - Grassland/Herbaceous/Open Land
Woodland	Bigleaf Maple	Upland Forest - Upland Forest
Woodland	Bigleaf Maple - California Bay	Upland Forest - Upland Forest
Woodland	Bigleaf Maple - Common Snowberry	Upland Forest - Upland Forest
Woodland	Blue Gum Eucalyptus	Upland Forest - Upland Forest
Woodland	Blue Oak	Upland Forest - Upland Forest
Woodland	California Bay	Upland Forest - Upland Forest

%	Parks Subcategory	GHG Category
Woodland	California Black Oak	Upland Forest - Upland Forest
Woodland	California Buckeye	Upland Forest - Upland Forest
Woodland	California Coffeeberry - Oceanspray - Gray Pine	Upland Forest - Upland Forest
Woodland	California Sagebrush - Poison Oak - Blue Oak - Valley Oak	Rangeland - Shrub and Brushland
Woodland	Canyon Live Oak	Upland Forest - Upland Forest
Woodland	Coast Live Oak	Upland Forest - Upland Forest
Woodland	Coyote Brush - Gray Pine	Rangeland - Shrub and Brushland
Woodland	Coyote Brush - Poison Oak - California Sage	Rangeland - Shrub and Brushland
Woodland	Deciduous Oaks - California Bay	Upland Forest - Upland Forest
Woodland	Eucalyptus	Upland Forest - Upland Forest
Woodland	Fremont Cottonwood	Upland Forest - Upland Forest
Woodland	Gray Pine	Upland Forest - Upland Forest
Woodland	Live Oak - California Bay - Coyote Brush - Elderberry	Upland Forest - Upland Forest
Woodland	Mixed Conifer	Upland Forest - Upland Forest
Woodland	Monterey Cypress	Upland Forest - Upland Forest
Woodland	Monterey Pine	Upland Forest - Upland Forest
Woodland	Oak	Upland Forest - Upland Forest
Woodland	Pine	Upland Forest - Upland Forest
Woodland	Planted Cultivar Trees	Upland Forest - Tree Plantations
Woodland	Poison Oak - California Black Oak	Upland Forest - Upland Forest
Woodland	Redgum Eucalyptus	Upland Forest - Upland Forest
Woodland	Redwood	Upland Forest - Upland Forest
Woodland	Redwood - Live Oak - California Bay	Upland Forest - Upland Forest
Woodland	RIPARIAN WOODLAND	Upland Forest - Upland Forest
Woodland	Rotary Peace Grove : Giant Redwoods	Upland Forest - Upland Forest
Woodland	Scrub Oak - Poison Oak	Upland Forest - Upland Forest
Woodland	Thinned Bluegum Eucalyptus	Upland Forest - Upland Forest
Woodland	Toyon - California Bay	Upland Forest - Upland Forest
Woodland	Toyon - Coast Live Oak	Upland Forest - Upland Forest
Woodland	unlabeled	Upland Forest - Upland Forest
Woodland	Valley Oak	Upland Forest - Upland Forest
Woodland	Wild Rye - Blue Gum Eucalyptus	Upland Forest - Upland Forest
Woodland	Willow	Upland Forest - Upland Forest
Woodland	Willows	Upland Forest - Upland Forest