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Potential for Coastal Wetland Blue Carbon Offset Projects in the Point Reyes Area

Abstract

Point Reyes is a 100-square mile peninsula located on the California coast about 30 miles north of San Francisco. The peninsula, surrounding bays, and neighboring coastal mainland are a unique biodiversity hotspot. The area underwent heavy human use, including ranching and logging, during the late 1800s and early 1900s. Conservation efforts beginning in the 1950s have resulted in most of the area remaining undeveloped as family-run ranches, rural villages, and State, County, and National Parks. However, many of the coastal wetlands are drained, impounded, or otherwise degraded.

This paper examines historical and current uses and management of the bays, estuaries, and lands of the Point Reyes peninsula and neighboring mainland and the ecological status of the area's coastal wetlands. It then explores potential economic support for restoration of degraded coastal wetlands through carbon offset projects, called "blue carbon" projects, and provides recommendations for the implementation of blue carbon projects there.

The area's patchy collection of small restoration sites and low prices for voluntary carbon offset credits challenge the viability of a blue carbon project, but this can be counteracted by developing a grouped project and combining funding sources. Development of a grouped blue carbon project for the area would generate supplemental funding for coastal wetland restoration, which supports the area's goals of ecosystem restoration, sustainable agriculture, and adaptation to sea level rise. Inclusion of blue carbon as an approved offset category in California's Cap-and-

Trade program would support these goals and statewide greenhouse gas reduction goals more than voluntary carbon offset credits.

Introduction

Coastal wetlands[1] are important ecosystems around the world as a habitat for wildlife and for the ecosystem services they provide, including filtration of water pollutants, reduction of flood risks, and carbon sequestration. Despite their ecological value, wetlands are the most rapidly degrading ecosystem on the planet (Millennium Ecosystem Assessment 2005).

California has lost more than 95 percent of its coastal wetlands due to human impacts, amounting to hundreds, possibly thousands, of acres (Pawley and Lay 2013). Those that remain have been identified as vulnerable to sea level rise and intense storms resulting from climate change. Their erosion and inundation is projected to lead to a reduction in wildlife habitat and recreational opportunities, and to destroy essential infrastructure (C-SMART 2016).

An emerging source of funding for coastal wetland restoration is the sale of carbon offset credits. To date, most ecosystem-based projects[2] to generate carbon offset credits have focused on avoiding deforestation or improving forestry practices. Such projects can be verified and registered to sell offset credits for use in regulatory emissions trading systems (ETSs) or as voluntary offsets, creating an income stream for forest restoration and conservation. Healthy coastal wetlands sequester carbon at a higher rate than forests, but measurement is more difficult because most of the carbon is stored in the soil, rather than in aboveground vegetation as is the case for forests (Chmura et al. 2003).

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[1] A catch-all term meant to encompass tidal wetlands and saline or brackish marshes

[2] As opposed to projects that change industrial or agricultural practices

Currently, carbon offset credits for coastal wetland restoration are not accepted in regulatory ETSs, but they are a source of voluntary offset credits. Voluntary offsets are purchased by concerned individuals, corporations, and states to lower their carbon footprint beyond what they can accomplish by reducing their own emissions (Hamrick and Gallant 2017). Voluntary offsets are typically sold at a lower price than regulatory offsets, but can still provide economic support for ecosystem restoration projects.

The goals of this study are to explore how carbon sequestration in California's coastal wetlands can be quantified to generate offset credits, whether the money generated from carbon offset credits can support restoration efforts, what social impacts such a program would have, and whether such projects would be successful.

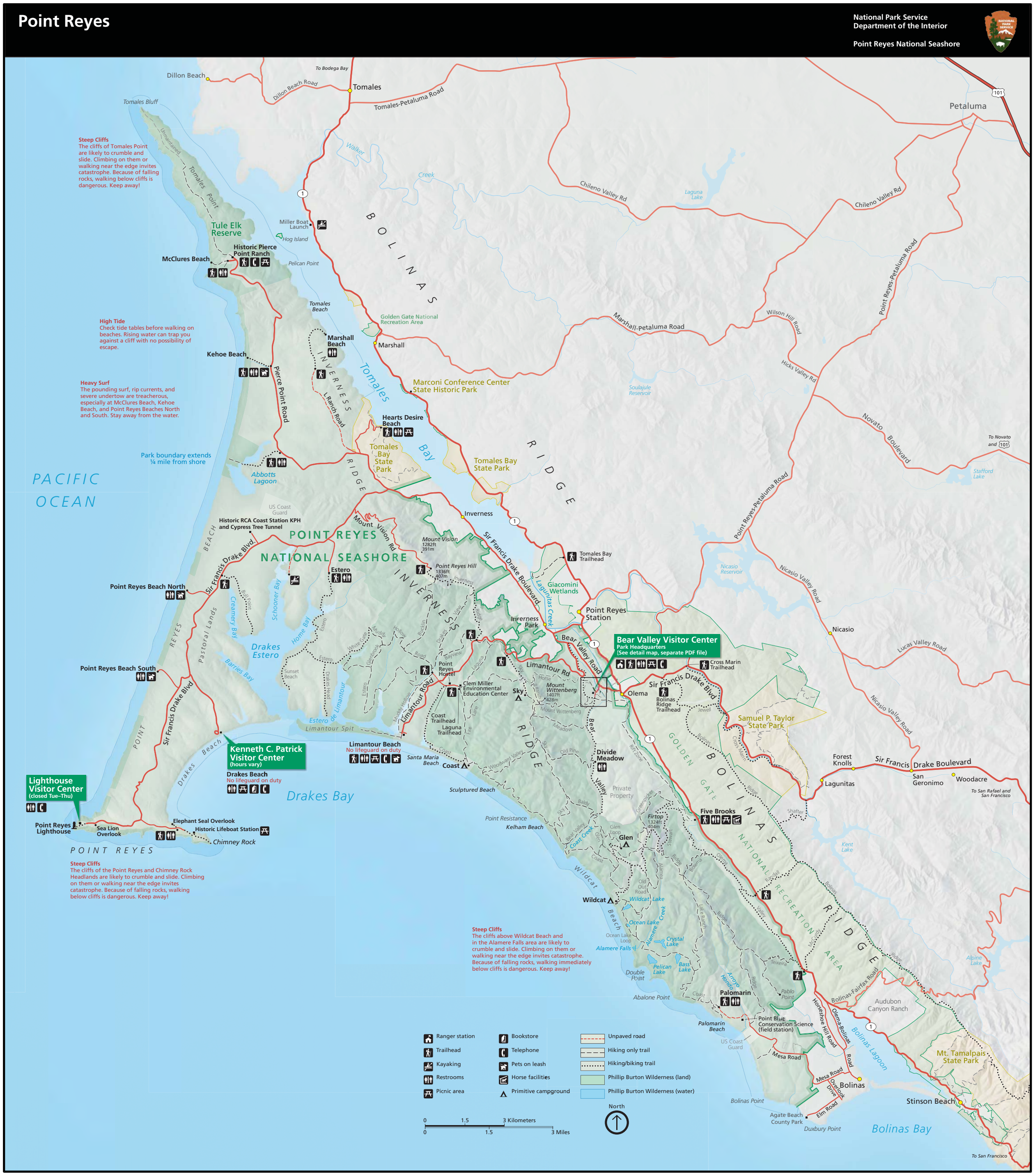
Study Location and Characteristics

This study applies the above questions to the coastal wetlands of Point Reyes and its neighboring bays and mainland (hereafter, "the Point Reyes Area"). Point Reyes is a 100-square mile triangular peninsula located on the California coast about 30 miles north of San Francisco. It lies on the west side of the San Andreas Fault and is part of the Pacific Tectonic Plate, rather than the North American Plate on which most of California lies, which results in unique geography with approximately 80 miles of shoreline (USGS 2018). Point Reyes' eastern side parallels the California mainland for roughly 29 miles. The northern half of the eastern side is separated from the mainland by 1.5-mile-wide, 15-mile-long Tomales Bay. South of Tomales Bay, Point Reyes is connected to the mainland for 13 miles by Olema Valley, at the southern end of which it separates again from the mainland to form Bolinas Lagoon, a triangular 1,000-acre estuary. The northwestern shore of Point Reyes is approximately 18 miles long and is mostly comprised of beaches, with 250-acre Abbotts Lagoon forming an inlet near the midpoint. The southwestern shore of Point Reyes is approximately 20 miles long, lined with beaches backed by tall cliffs, and somewhat hook-shaped to form Drakes Bay. There is a large multi-branched estuary named Drakes Estero that occupies approximately 2,500 acres near the center of the peninsula, and an adjacent 300-acre estuary, Estero de Limantour. Both connect with the Pacific Ocean through a short channel from Drakes Bay (see Figure 1) (Evens 2008; USGS 2018).

A large block of granite overlaid by a variety of soils, Point Reyes' rocks and soils differ from those of the mainland, creating unique ecosystems (Evens 2008, 35-60). Point Reyes has three major landscape areas: the 37,000-acre forested Inverness Ridge, which reaches an elevation of 1,300 feet at its highest point; a mid-elevation mix of Coastal Scrub and Coastal Prairie grasslands below 1,000 feet on the western slopes; and coastal areas that include beaches, cliffs, and wetlands (Evens 2008). There are no large rivers on Point Reyes or the adjacent coastal mainland, rather a network of creeks. Most creeks flow to the cliffs and beaches of the southwestern shore and to Drakes Estero and Estero de Limantour. Two creeks drain into Abbotts Lagoon and Kehoe Beach (Marin Watershed Program 2018).

The Point Reyes Area has a mild Mediterranean climate. Precipitation is rare from May to October (Meteoblue 2017), but frequent summer fog provides moisture to trees (Forrestel et al. 2011). The El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) climate modes cause multi-year periods of droughty and rainy conditions (Evens 2008; Perry et al. 2008, 29).

Figure 1: National Park Service map of PRNS, GGNRA-ND and surrounding parks, private properties, and towns. (Higher resolution version available from NPS at: https://www.nps.gov/pore/planyourvisit/upload/map_park.pdf) (Source: NPS 2018b)



Current Uses, Management, and Ecological Status of Coastal Wetlands

The Point Reyes Area is recognized as ecologically significant at the global, regional, and landscape scales. High biodiversity results from the convergence of two marine ecological provinces[3], unique geology, and a diverse coastline that creates essential habitats for migrating and nesting bird species, shorebirds, commercially important fish species, and marine mammals, some of which are federally threatened (Pawley and Lay 2013, 96-97). Wetlands in the area's estuaries, bays, and lagoons provide rich habitats supporting diverse wildlife (Pawley and Lay 2013, xliii). The loss of wetland habitats elsewhere in California elevates the importance of the coastal wetlands that remain and those that can be restored in the Point Reyes Area. Tomales Bay and Bolinas Lagoon are designated Ramsar Convention Wetlands of International Importance (USFWS 2015).

The National Park Service (NPS) manages Point Reyes National Seashore (PRNS) and the north district of the Golden Gate National Recreation Area (GGNRA-ND) – which consists of lands bordering PRNS to the east and a few pieces of land along on the east shore of Tomales Bay – as one 71,046-acre unit under PRNS management (see Figure 1) (Pawley and Lay 2013). When land was being acquired for PRNS during the 1960s and early 1970s, the federal government bought the ranchland on the peninsula (NPS 2015; Watt 2017, 89), and the ranching families, most of whom had been in operation for several generations with some dating back to the 1850s, entered into lease agreements with the NPS for periods of 20-25 years (Rilla and Bush 2009), as did the operators of one oyster farm in Drakes Estero (Brennan 2015). Today, about 28,000 acres of these lands are used for family beef and dairy ranches (see Figure 2) under 24

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[3] Northern Oregonian and southern Californian marine ecological provinces

special use permits that allow 6,000 cattle year-round (PRNS 2017). 33,373 acres of PRNS are designated wilderness, including Drakes Estero and Estero de Limantour (Brennan 2015).

Tomales Bay and Bolinas Lagoon have watersheds with multiple landowners and are not managed primarily by the NPS. Marin County manages Bolinas Lagoon in coordination with the Greater Farallones National Marine Sanctuary (GFNMS) and NPS (through PRNS/GGNRA-ND management), with input from the Bolinas Lagoon Advisory Council, which also includes representation from private landowners, local conservation organizations, and community members and organizations. Management of Tomales Bay and its watershed are coordinated by the Tomales Bay Watershed Council (TBWC), a group of landowners including the NPS, State and County Parks, and private landowners, and other stakeholders (Pileggi et al. 2012).

<u>Ranching in PRNS and West Marin</u>

Dairy and beef ranching is an important part of the culture, history, and economy of the Point Reyes Area and all western Marin County. Zoning laws have preserved ranchlands since the 1970s, with urban development limited to the eastern part of the county, centered on US Highway 101. More than two-thirds of the county's 520 square miles, including lands to the east of PRNS and GGNRA-ND, is designated as the Inland Rural Area and Coastal Corridor, where zoning laws restrict development to preserve family-operated ranches, rural villages, and protected areas (Dyble 2007), and is commonly referred to as "West Marin."

In West Marin, 100,000 acres of private lands are family farmland, mostly beef and dairy ranches (see Figure 3) (MALT 2018). This is approximately one-third of Marin County's 332,800 acres. Within PRNS and GGNRA-ND's 71,046 acres, beef and dairy ranches occupy 28,000 acres (PRNS 2017), approximately 39 percent (see Figure 2). Milk production is the largest sector of Marin County's agricultural economy at 39 percent of all agricultural production, while beef cattle production comprises 12 percent[4] (County of Marin 2017). According to a 2009 study, ranching in PRNS and GGNRA-ND amounts to 17 percent of Marin County's overall agricultural production and is considered key to maintaining the agricultural character of West Marin (Rilla and Bush 2009).

In 1980, the Marin Agricultural Land Trust (MALT) was established by members of two ranching families to help farmers keep their land and stay in operation through the purchase of agricultural easements on willing farmers' properties. MALT is supported by grants from private philanthropists and the California State Coastal Conservancy and currently holds easements on over 52,000 acres of farmland, just over half of the private farmland in Marin County[5] (MALT 2018). In addition to its core mission, MALT organizes outreach events that are targeted to urban Marin County residents, to maintain the cultural connection with local agriculture that has characterized Marin County since the mid-1800s (Hart 1991).

[4] Total agricultural production: $87,198,000. Milk (organic and conventional): $34,153,000. Cattle: $10,784,000 (County of Marin 2017).
[5] Excluding ranches on NPS lands (in PRNS and GGNRA-ND), which are not privately held.

Figure 2: Map of lands within PRNS and GGNRA-ND with ranching leases. (Source: PRNS 2017)

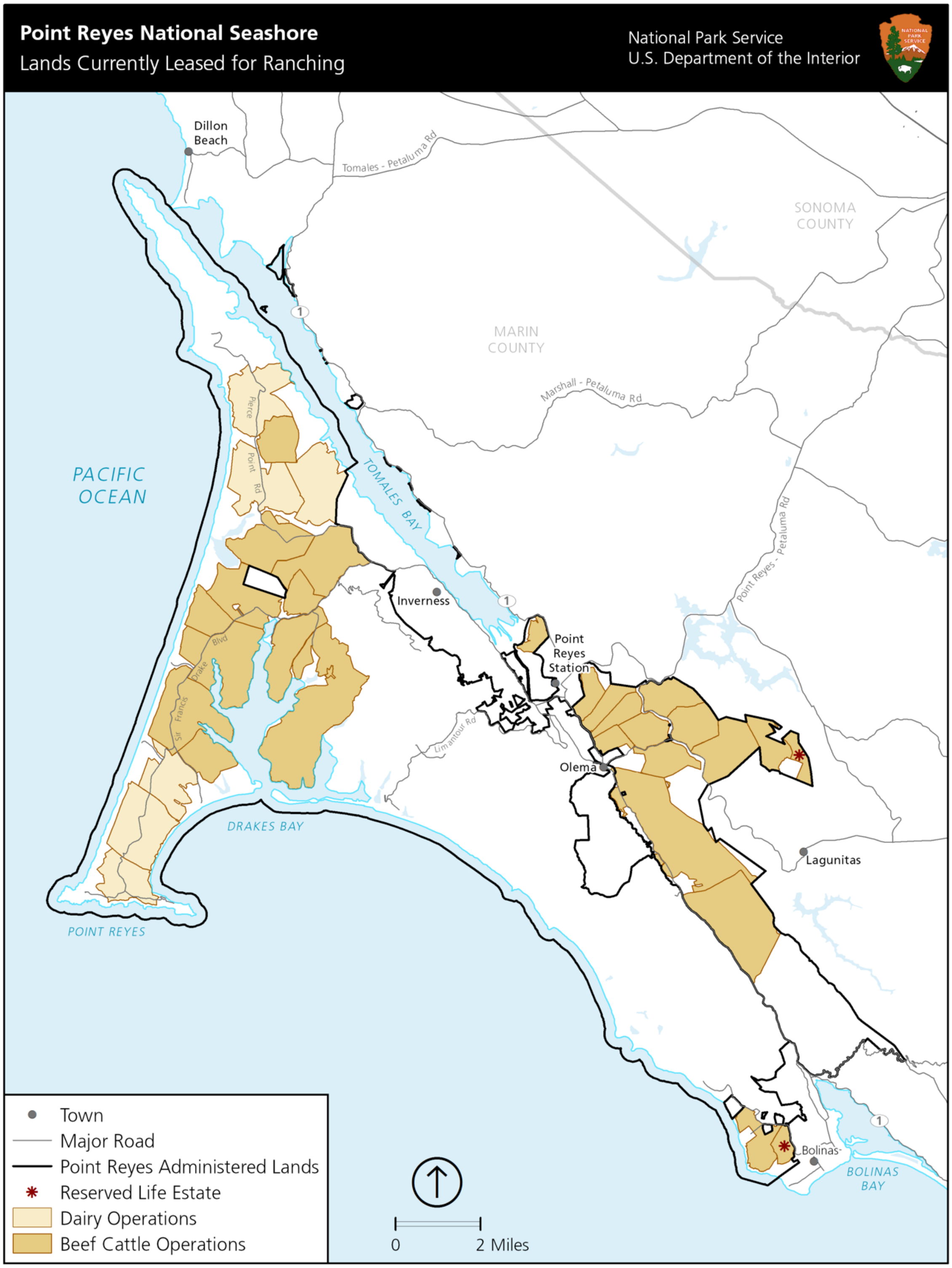
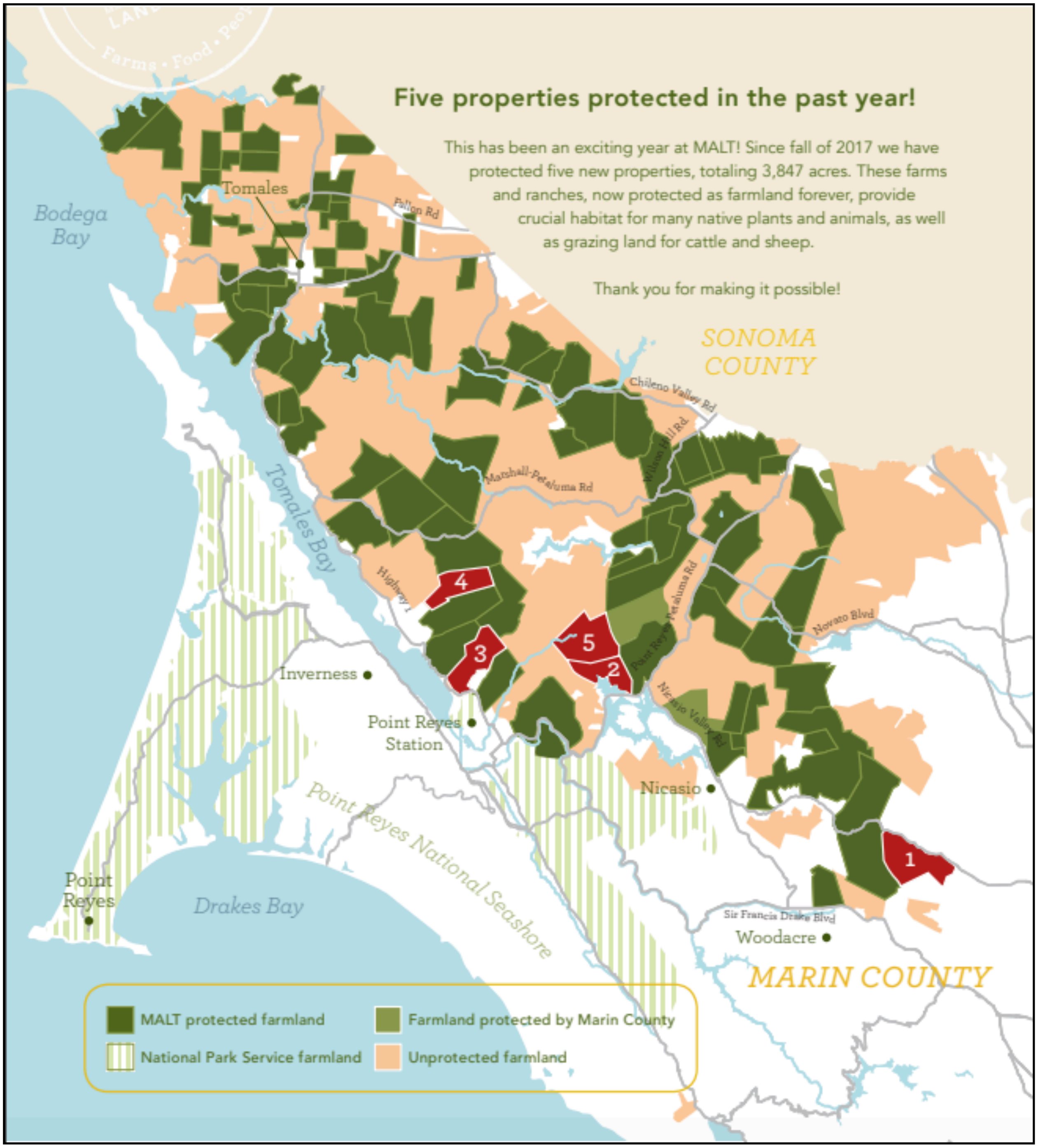


Figure 3: Map of privately-held family ranches and farms with MALT easements (dark green and red) and without MALT easements (tan). (Source: MALT 2018)



Tension Between Ranchers and PRNS Management

The coexistence of ranch land use with recreational uses and conserved wilderness areas within PRNS and GGNRA-ND causes an inherent tension between the economic interests of the ranchers and the conservation and historic preservation missions of the NPS, which has played out over the years in PRNS management decisions that have at times frustrated the ranchers, local community, and regional stakeholders (Watt 2017).

The two recent controversies are over free-ranging Tule elk, a native ungulate, and the closure of an oyster farm. In 1998, PRNS staff relocated 45 Tule elk to Limantour Spit in the wilderness area, across Estero de Limantour from several ranches. The ranchers' understanding was that PRNS staff would relocate or destroy any elk found wandering outside of their designated range (Watt 2015). Within a few years several elk established a new herd near the ranches. Ranchers reported that elk were eating their cattle's forage, killing their cows, and damaging fences and irrigation systems. But, PRNS management has done little to address the situation, which continues today (Watt 2017).

In addition to the immediate economic impacts, dairy ranchers claimed that elk activity risks their organic certification because of limits on how much supplemental feed can be fed to a dairy's cows under organic certification rules (Kimmey 2014; Watt 2015). Loss of organic certification would be a major blow to the dairies' business (Watt 2015). This conflict has given rise to a regional organization, including members who are ranchers located outside of NPS lands, calling for elk fences to be installed to confine the herd to the wilderness areas (Seashore Ranch Support 2014).

The oyster farm's lease had expired in 2012 at the end of the 40-year lease term to which the original owners agreed when land was acquired by the federal government for inclusion in

PRNS. The oyster farm owners resisted closure and sued the government to remain in operation (Watt 2017). The controversy played out over several years and resulted in conflict within the community as residents took sides on the question of whether it should be allowed to stay (Brennan 2015). Ultimately, Secretary of the Interior Salazar decided to not extend the lease and directed PRNS to convert the area to protected wilderness (Salazar 2012), paving the way for the restoration activities that were completed in 2017 (NPS 2018a). But, he also directed the NPS to support agricultural activity and establish new 20-year leases for the PRNS ranchers, replacing the 5-year lease terms that have been standard since the expiration of the initial leases that were signed when the Seashore was established (Salazar 2012).

Both the Tule elk issue and the lease issue are at the heart of a proposed General Management Plan Amendment, for which the public process began in 2017. The amendment process is the result of legislation brought against the NPS by the Center for Biological Diversity and other environmental groups to force the NPS to consider eliminating all ranching in PRNS. Through the General Management Plan Amendment process, the NPS is considering a range of management options, including no ranching with little Tule elk herd management, reduced ranching with management of the herd, continued ranching with management of the herd, and continued ranching with elimination of the herd (PRNS 2017). Some ranchers oppose the General Management Plan Amendment process, claiming PRNS management has been neglectful of ranchers, while others support the process (Guth 2018).

<u>Environmental Impacts of Ranching and Other Uses</u>

Historical and current cattle ranching is the greatest land management challenge and the leading cause of environmental degradation in the area’s coastal wetlands. The peninsula’s marshes used to be characterized by a continuum of salt-brackish-freshwater marsh as one moves from the shore to the source of freshwater inputs. Starting in the mid-1800s, ranchers constructed levees to separate freshwater and saltwater areas, creating freshwater habitats where brackish marshes used to exist. Many wetlands have been grazed, converted into stock ponds, leveled, or drained to improve pasture conditions, leading to a significant reduction in coastal wetland acreage and water quality degradation (Pawley and Lay 2013, xliii, 100-115).

Examples of the degradation that has occurred include high levels of fecal coliform and extremely low levels of dissolved oxygen (DO) in Tomales Bay, Drakes Estero, and Abbotts Lagoon. These water quality impairments have been attributed to agricultural sources, which are predominantly beef and dairy ranches (Pawley and Lay 2013, xlii, 115-116, 142-155, 166). Additionally, excessive sediment inputs have been documented at Bolinas Lagoon (Pawley and Lay 2013, 25) and Chicken Ranch Beach on the shore of Tomales Bay has the highest number of exceedances of water quality standards for bacterial indicators due to sewer discharges, agricultural runoff, and other unknown causes (Pawley and Lay 2013, 166).

Other historical uses that have legacy impacts on terrestrial and aquatic ecosystems in the area are logging, military installations, fishing, shellfish aquaculture, dredging, mining, and maritime shipping (Pawley and Lay 2013, xxvi). Erosion from logging caused water quality declines and altered hydrologic functions. Restoration projects and protective measures have increased coastal wetland acreage in the past few decades, but coastal wetlands continue to be impacted by excess nutrients (Pawley and Lay 2013).

<u>Coastal Wetland Restoration Projects</u>

Since the 1990s, several restoration projects have been undertaken at Bolinas Lagoon to manage invasive plants, restore natural hydrology, and prepare for climate change, particularly relevant due to the location of State Highway 1 on the eastern shore (MCOSD 2006; Marin

County Parks 2018). Planning is currently underway for a wetland restoration and sea level rise adaptation project at the north end of Bolinas Lagoon (MCPOSD 2017). Additionally, options are being considered for addressing erosion on the western shore (Baye 2017).

The NPS acquired a 563-acre pastureland on the former Giacomini Ranch at the south end of Tomales Bay, and removed levees to restore natural flows in 2008. Post-restoration monitoring has shown a transition from pasture to a salt marsh with native vegetation and invertebrates, an increase in the population of wintering shorebirds in southern Tomales Bay[6], as well as increased numbers of marsh birds and wintering ducks. The restored wetlands have also improved the quality of water entering Tomales Bay, reviving subtidal meadows of eelgrass that play a key ecological role for native fishes and harbor seals (Kelly and Evens 2015).

The NPS also undertook restoration activities in Drakes Estero following the closure of the oyster farm in 2014. The NPS's goals included eliminating disturbances to harbor seals caused by oyster farm operations, opening more area for eelgrass colonization, and controlling an invasive sea squirt, *Didemnum vexillum* (Brennan 2015; NPS 2018a). Restoration included removing five miles of oyster racks and several acres of plastic, metal, cement, and shell debris on which the sea squirt was thriving. These activities were completed in 2017 and the NPS plans to monitor the site long-term for ecological health and water quality (NPS 2018a).

At Estero de Limantour, the NPS restored tidal connection to 15 acres of coastal wetlands on the east shore in 2008 by removing two earthen dams that were constructed prior to establishment of PRNS. The site provides habitat for smolting steelhead trout and federally threatened California red-legged frogs, as well as native wetland plants (Williams 2009).

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6 In contrast, populations in northern Tomales Bay did not increase during the same period (Kelley and Evens 2015).

Efforts to improve the water quality and ecological health of Tomales Bay and its watershed are coordinated by the Tomales Bay Watershed Council (TBWC) (Pileggi et al. 2012). The group has been successful in reducing inputs of excess nutrients into the bay from agricultural runoff, improving water quality to the point that exceedances are generally episodic rather than chronic (Hameed et al. 2013). TBWC has prioritized an impounded tidal wetland at Chicken Ranch Beach for restoration, but has not yet been successful in gaining funding for the project (TBWC 2017a).

Local Environmental Organizations

Environmental organizations in Marin are well-supported and influential. For example, Marin Conservation League (MCL) was established in 1934 with a mission "to preserve, protect, and enhance the natural assets of Marin County for the public" through advocacy and land acquisition (MCL 2018). In 2017, MCL received over $166,000[7] in charitable contributions and $81,000 from its endowment (MCL 2017). In the 1960s, demand for suburban development of the remaining rural areas of Marin County galvanized local environmentalists and farmers, including MCL, to form a coalition to fight suburban sprawl in West Marin and tipped the political balance toward very low density zoning in West Marin (Griffin 1998). Audubon Canyon Ranch is an environmental conservation and education organization founded in 1962 that owns a 1,000-acre preserve on the east shore of Bolinas Lagoon and 500 acres along the shore of Tomales Bay (ACR 2018a; ACR 2018b) and receives over $1 million in contributions and grants annually, and over $2 million in endowment income (ACR 2016). The 47-year-old Environmental Action Committee of West Marin (EAC) is dedicated to preserving rural communities and ecosystems of West Marin (EAC 2018). These are representative examples of

[7] All dollars ($) cited in this paper are U.S. dollars.

the many local and regional environmental organizations that are involved in planning and conservation in the Point Reyes Area.

Regional and Global Drivers of Ecological Degradation

In addition to local causes of ecological degradation, the Point Reyes Area is subject to degradation drivers on a regional and global scale.

Population Growth

Given its proximity to the San Francisco Bay Area, the Point Reyes Area is impacted by high visitation, population growth, and associated effects. The Bay Area has a population of approximately 7.2 million people and is projected to have a population of 9.5 million by 2040 (ABAG 2016). As population levels increase, land use change and increased use of recreation resources result. Adjacent development and increased park visitation can lead to soil compaction and erosion, disturbances to wildlife, road wear and tear, and introduction of non-native species. Sensitive ecosystems including wetlands are especially vulnerable to these impacts (Pawley and Lay 2013, 32-35).

The Bay Area suffers from a long-term housing shortage that has become acute in recent years (ABAG 2018), increasing demands on Marin County to allow more housing development (Marzorati 2017). Although no policy changes have occurred, housing development in the Inland Rural Area or Coastal Corridor would bring an increase in impervious surfaces and increased car traffic, leading to erosion, pollutant runoff, and declines in air quality.

Climate Change

Point Reyes' location, surrounded by ocean and undeveloped land, buffers it from temperature extremes due to climate change. Temperature and wildfire risk are rising more quickly inland and to the south. Nonetheless, the average annual temperature is projected to increase by 3-5°F by the end of the century, and the upward climb has already begun (Cal-Adapt 2017). Reduced precipitation and less frequent summertime fog are predicted to impact Point Reyes due to climate change, which will stress forests and reduce freshwater flows into coastal wetlands (Hameed et al. 2013). Other predicted effects of global warming are a 10-25 percent increase of wildfire risk (Cal-Adapt 2017), ocean acidification that threatens the viability of aquaculture operations (Barton et al. 2015; Hameed et al. 2013, 103), and sea level rise.

Climate Change Adaptation and Mitigation: Sea Level Rise and Carbon Sequestration Benefits of Coastal Wetlands

Wetland restoration in the Point Reyes Area has been shown to benefit wildlife, improve water quality, and mitigate flood risk (C-SMART 2016, 192; Kelly and Evens 2015). Considering the anticipated effects of climate change, two additional ecosystem services of coastal wetlands have come to the fore: serving as sea level rise transition areas and providing mitigation for greenhouse gas (GHG) emissions through carbon sequestration.

<u>Sea Level Rise</u>

Sea level rise projections for the region are 1.6-11.8 inches (4-30 cm) by 2030, 4.7-24 inches (12-61 cm) by 2050, and 16.6-65.8 inches (42-167 cm) by 2100 (C-SMART 2016, ix). Paleontological evidence shows that coastal wetlands have migrated upland with past sea level rise, but the pace of anthropogenic sea level rise due to climate change may outpace the accretion rates of sediment in coastal wetlands, leading to wetland submergence, which causes marsh vegetation die-off and loss of coastal wetland ecological character and environmental functions. Coastal wetlands can also migrate inland horizontally into adjacent low uplands where topography and land use make it feasible, thus preserving coastal wetland ecosystem acreage and ecosystem services. However, migration is prevented where hard human infrastructure has been built adjacent to coastal wetlands (Flitcroft et al. 2018; Thorne et al. 2018). Moreover, California has relatively small coastal wetlands compared to other regions of the globe, and they are often backed by steep mountains or sheer cliffs that prevent upland migration (Thorne et al. 2018).

Enabling upland migration where possible and ensuring appropriate sediment accumulation are key to maintaining California's limited coastal wetland acreage. California has been predicted to lose 99 percent (496 ha, or 1,225 ac) of coastal wetlands, but can lower that percentage to 59 percent (292 ha, or 721 ac) by facilitating upland migration, including creating space for wetland expansion through land reallocation (Thorne et al. 2018). Due to species lifecycles and upland area soils, species that are adapted to the tidal influences and soils of a specific location may not be able to migrate quickly enough to survive anthropogenic sea level rise (Hameed et al. 2013). Land managers can facilitate this transition through planting and seeding plants and relocating animals when appropriate as wetlands migrate.

Sea level rise has been a consideration in planning regional coastal wetland restoration projects since at least 2007, when it was a component of both the Giacomini Wetlands restoration project (NPS 2007) and a multi-agency analysis of restoration needs at Bolinas Lagoon (GFNMS 2008). Planning for sea level rise became a key initiative of Marin County government in 2014, with the release of a vulnerability assessment for the west coast of the county in 2016 (C-SMART 2016).

<u>Carbon Sequestration</u>

Saline wetlands are carbon sequestration hotspots, with a higher carbon burial rate per unit area than freshwater wetlands and forests (Chmura et al. 2003; Theuerkauf et al. 2015). Freshwater wetlands are often a significant source of emissions of methane (CH_4) [8], which is a short-lived climate pollutant (SLCP) with 30 times the global warming potential of carbon dioxide (CO_2) (Holm et al. 2016). In contrast, saline wetlands typically emit only minor amounts of CH_4 (Holm et al. 2016; Kroeger et al. 2017).

When diked and drained for agriculture or development, or otherwise degraded, saline wetlands lose their function as carbon sinks and contribute to anthropogenic GHG emissions by releasing substantial amounts of carbon, primarily as CO_2, on a continuous basis (Kroeger et al. 2017; Wylie et al. 2016). For example, wetland soils that were drained in the San Francisco Bay and Sacramento-San Joaquin Delta during the mid to late 19th century are estimated to currently emit 6.6 to 8.6 $tCO_2e\ ac^{-1}\ yr^{-1}$ (ACR 2017). When saline wetlands are impounded and converted to a freshwater wetland, significant CH_4 emissions result (Macreadie et al. 2017). Kroeger et al. (2017) found that 20 years of CH_4 emissions from one hectare (2.47 ac) of impounded wetland are equivalent to the radiative forcing produced by 20 years of continuous tailpipe emissions of 1.7 to 6.3 automobiles. Saline wetland restoration eliminates CO_2 and CH_4 emissions and sequesters additional carbon by accumulation of sediment.

However, excessive nutrient inputs and erosion from the watershed have been shown to reduce the carbon sequestration rate of intact and restored coastal wetlands (Macreadie et al. 2017). Evidence of these impacts to coastal wetlands in the Point Reyes Area already exists in water quality data and is largely attributed to agricultural activities, primarily cattle grazing, as described in the section "Current Uses, Management, and Ecological Status of Coastal

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8 The IPCC Tier 1 default value for CH_4 emissions from non-saline tidal wetlands is 1.8 t C $ha^{-1}\ yr^{-1}$ equivalent (Crooks et al. 2014).

Wetlands," above. Thus, in addition to the ecological impacts, ranching may be causing a reduction in the carbon sequestration performance of the area's coastal wetlands.

Current Coastal Wetland Restoration Needs in the Point Reyes Area

This section provides an inventory of current coastal wetland restoration needs in the Point Reyes Area, as identified by County government, NPS, other government agencies, private landowners, and independent researchers and consultants. Estimated total acreage of potential coastal wetland restoration is 266.5-458.5 acres, with 112-185 acres within PRNS; outside PRNS acreage is 154.5-273.5 acres. Approximate acreages of the restoration opportunities, the jurisdiction that each site falls under, and the potential for upland migration of the wetlands are given in Table 1 at the end of this section. The following paragraphs briefly describe each site.

Bolinas Lagoon has been the subject of the most extensive studies and restoration planning of any coastal wetland in West Marin. Currently, preliminary planning is underway to restore 19 to 23 acres of historic floodplains and tidal wetlands as part of the North End Project, which aims to expand habitat, reconnect tidal influences on tributary creeks, improve safety by reconfiguring roadways that encircle the lagoon, and allow for future expansion of Bolinas Lagoon to accommodate sea level rise (MCPOSD 2017).

Additional areas of Bolinas Lagoon that are proposed for restoration include: The Letter Parcel on the west shore, where restoration of a tidal gradient is being considered to solve erosion problems caused by invasive plants and unstable riprap preventing upland migration of a narrow tidal marsh (Baye 2017); the Pine Gulch Creek floodplain, south of the Letter Parcel, where landowners are considering floodplain restoration to reduce excessive sediment inputs into Bolinas Lagoon, reestablish tidal influences on the creek, and allow for sea level rise migration (GFNMS 2008); several small floodplains at the mouths of creeks on the east shore of the lagoon that were impounded by the construction of Highway 1 and have become freshwater (C-SMART 2016; GFNMS 2008); and Kent Island, a formerly mobile tidal island that has lost mobility due to exotic plant invasion (GFNMS 2008).

On Tomales Bay, a proposed restoration project at Chicken Ranch Beach will restore approximately 1.5 acres of tidal marsh and create approximately 2.0 acres of new brackish marsh with goals to improve water quality and increase ecological value (KHE 2013). Other areas of potential coastal wetland restoration include salt marshes on the east shore, where a series of creeks enter the bay but are impounded by Highway 1, like on the east shore of Bolinas Lagoon. These include tidal reconnections at Millerton Gulch, Marshall, and other points along the route of Highway 1 (C-SMART 2016; MCCDA 2018; TBWC 2007).

At PRNS, the largest coastal wetlands with potential for restoration are along the shores of Drakes Estero and Estero de Limantour. Restoration activities have already been completed in Schooner Bay, the central arm of Drakes Estero, following closure of an oyster farm, as described earlier in this paper. On the other arms of Drakes Estero – Barries Bay, Creamery Bay, and Home Bay – potential areas of restoration exist where wetland impoundments for ranch operations are in place, in addition to an impounded wetland on the east shore of the main arm along Sunshine Beach Trail. Similarly, at Estero de Limantour, several impoundments could be removed for tidal wetland restoration and to facilitate migration of tidal marshes in response to sea level rise (Hameed et al. 2013).

West of Drakes Estero, a parking lot occupies the former site of tidal connection for a former coastal lagoon and marsh area on the shore of Drakes Bay (Pawley and Lay 2013, 38), presenting another restoration opportunity. Impoundments on both arms of Abbotts Lagoon could also be removed to increase wetland acreage and facilitate migration.

Table 1: Approximate acreages, jurisdiction, and upland migration potential of coastal wetland restoration opportunities in the Point Reyes Area.

Estuary/Lagoon	Site	Acres (source)	Upland Migration Possible?	Total Acreage by Estuary/Lagoon
Bolinas Lagoon (Jurisdiction: County of Marin, in cooperation with NPS, GRNMS, and private landowners)	North End	19-23 (1)	Yes, with planned alteration of highway routes and/or replacement of culverts with bridges	143-252
	Letter Parcel	8-10 (2)	Yes, with restoration	
	Pine Gulch Creek	40-125 (3)	"	
	East Shore	76-94 (4)	"	
Tomales Bay (Jurisdiction: Mix of State, NPS, and private lands)	Chicken Ranch Beach	1.5-3.5 (5)	Yes	11.5-21.5
	East Shore	10-18 (6)	Yes, with tidal reconnection	
Total acreage outside PRNS:				**154.5-273.5**
Drakes Estero (PRNS)	Barries Bay	0-20 (7)	Yes, with removal of impoundments	10-50
	Creamery Bay	0-10 (7)	"	
	Home Bay	0-6 (7)	"	
	Central Arm	10-14 (7)	"	
Estero de Limantour (PRNS)	--	35-40 (7)	"	35-40
Drakes Beach (PRNS)	Parking Lot Lagoon	60-65 (8)	"	60-65
Abbotts Lagoon (PRNS)	North Branch	0-10 (9)	"	7-30
	South Branch	7-20 (9)	"	
Total acreage within PRNS:				**112-185**
TOTAL:				**266.5-458.5**

Sources: (1) MCPOSD (2017); (2) Author estimate based on Baye (2017) imagery and measurements using USGS National Map Viewer (NMV); (3) Author estimate based on GFNMS (2008) description, measurements using USGS NMV, and accounting for various possible scenarios; (4) Author estimate based on C-SMART (2016), GFNMS (2008), and measurements using USGS NMV; (5) KHE 2013; (6) Author estimate based on C-SMART (2016), MCCDA (2018), TBWC (2007) and measurements using USGS NMV; (7) Author estimate based on Hameed et al. (2013) and measurements using USGS NMV; (8) Author estimate based on Pawley and Lay (2013) and measurements using USGS NMV; (9) Author estimate based on measurements using USGS NMV.

"Blue Carbon": Carbon Offsets for Coastal Wetland Carbon Sequestration

Coastal wetland carbon sequestration has recently garnered interest as a way to reduce and mitigate anthropogenic GHG emissions. Termed "blue carbon," conservation and restoration of mangrove forests, seagrass meadows, and tidal marshes with a goal of storing carbon was identified by the United Nations (UN) in 2010 as a means for countries to mitigate their GHG emissions (Thomas 2014). The UN Framework Convention on Climate Change (UNFCCC) has adopted policies that permit countries to account for changes in carbon emissions through land use change, including by creating mechanisms to fund and implement conservation projects (Wylie et al. 2016). One such mechanism could be as a component of an emissions trading system (ETS), which is a regulation that puts a cap on total jurisdictional GHG emissions and allows emitters to trade pollution permits and to offset a portion of their emissions by purchasing carbon offset credits. California's Cap-and-Trade system is an ETS in which emitters may offset up to 8 percent of emissions by purchasing carbon offset credits. Under Cap-and-Trade, only certain categories of carbon offset credits are permitted to be used, and projects must follow specific procedures (a "protocol") and be verified by a third party before offset credits are issued (CARB 2018a; CARB 2018b).

Currently, carbon offset credits for coastal wetland restoration and conservation are not accepted by any regulatory ETS, including Cap-and-Trade, but they are emerging as a source of voluntary offset credits, which are purchased by individuals and organizations to lower their carbon footprint. One offset credit represents one metric ton (or "tonne") of carbon dioxide equivalent (tCO2e) that either has not been emitted into the atmosphere or has been sequestered – i.e., stored – in trees, other plants, or soil, due to an offset project (Hamrick and Gallant 2017).

There are several components to confirming the legitimacy of carbon offset credits: First, a baseline is quantified from total carbon that would be sequestered under business as usual, which is then compared to carbon sequestered with the offset project to determine the number of offset credits to be issued (New Forests 2014). Second, methods of measuring the change being credited must be consistent across all sources and projects and be verified by a trusted organization. Voluntary offsets are calculated, measured, and verified by a third party according to a set of rules established by a voluntary standard body (Hamrick and Gallant 2017). On the regulatory side, the Regional Greenhouse Gas Initiative (RGGI) and California's Cap-and-Trade program designate independent third-party verifiers to monitor and verify emissions quantities and offset credits (Anderson et al. 2017; CARB 2017b; Newell et al. 2012). This consistency supports the tradability of permits and credits as equal entities worth an equal amount of emissions or emissions reductions. Third, there must be a mechanism to ensure that the change being credited would not have taken place in the absence of the program, which is termed "additionality" (Newell et al. 2012; Tietenberg n.d.).

Funding for coastal wetland restoration is currently insufficient because the ecosystem services of coastal wetlands are undervalued by economic incentives, despite their many social and environmental benefits (SSJDC 2017; Thomas 2014; Wylie et al. 2016), due to their nature as a non-excludable[9] public good[10]. Coastal wetland restoration often produces no direct economic benefit to a landowner (ASWM 2018), and removes the site from more profitable uses such as livestock grazing or urban development. The negative impacts of coastal wetland

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[9] Non-excludability: No individual or group can be excluded from enjoying the benefits conferred by the resource, whether they contributed to its provision or not (Tietenberg and Lewis 2016).

[10] Public good: A resource characterized by non-excludability and indivisibility. Indivisibility: One person's use of a good does not diminish the amount available for others (e.g., GHG reduction benefits received by one person do not reduce the benefits others receive) (Tietenberg and Lewis 2016).

degradation are not borne exclusively by the landowner, rather they are paid by downstream users impacted by water pollution, neighbors whose property floods, by those who value the area lost for recreation or wildlife habitat, and globally through GHG emissions. The landowner does not pay a price for these negative externalities[11].

The sale of offset credits has potential to counteract the economic incentives that lead to degradation by producing income from restoration activities. However, early blue carbon projects have revealed some challenges when put into practice.

Lessons Learned from Early Blue Carbon Projects

Most blue carbon projects that have been undertaken or planned thus far aim to conserve mangrove forests in developing countries. These projects have been, or are intended to be, financed through UNFCCC market mechanisms REDD+ and CDM, and the sale of voluntary offsets verified by the Verra Verified Carbon Standard Program and Plan Vivo (Wylie et al. 2016, Table S1). REDD+ (Reducing Deforestation and Forest Degradation) is a UN program launched in 2005 to provide offset credits for a global carbon market, which has not yet come to be (Turnhout et al. 2017). Pilot REDD+ projects have been designed to conserve mangrove forests, but have been limited to demonstration projects (GRID-Arendal 2018; REDD Desk 2018; Wylie et al. 2016, Table S1). Because REDD+ is designed to value carbon stored in trees, it does not apply to tidal marshes and seagrass meadows. CDM (Clean Development Mechanism) is a UN program that allows projects in developing countries to earn offset credits that can be purchased by industrialized countries to a meet a portion of their emission reduction targets (UNFCCC 2018). Projects in industrialized countries cannot earn CDM credits.

[11] Negative externality: Costs of a land use accrue to people other than the landowner (Tietenberg and Lewis 2016,240).

The academic literature on blue carbon projects is limited and heavily focused on mangrove projects in developing countries. Wylie et al. (2016) collected information on all extant blue carbon projects[12] and researched four of these projects – located in Kenya, India, Vietnam, and Madagascar – in depth. They found common challenges faced by these projects: (1) for small projects, the voluntary market is more accessible because the transaction costs[13] are lower than compliance markets such as CDM, which require more stringent monitoring, reporting, and verification; (2) economic and livelihood considerations of communities dependent on use of the mangrove must be taken into consideration to determine whether income generated from a blue carbon project would enable sustainable management or alternative livelihoods; and (3) long-term success of blue carbon projects requires planning for sea level rise and effects of climate change (Wylie et al. 2016). In a feasibility study of a potential blue carbon project in the Philippines, Thompson et al. (2014) found similar challenges, in addition to finding that the opportunity cost[14] of mangrove restoration could likely only be compensated by the prices that offset credits earn in regulatory compliance markets, which are generally two to three times higher than voluntary market prices (Hamrick and Gallant 2017; Mack et al. 2014; Thompson et al. 2014). Additionally, Thomas (2014) found that due to high transaction costs, blue carbon projects are not typically economically viable when sales of blue carbon offset credits are the only source of funding, but that offset credit sales can supplement other sources of funding for coastal wetland restoration projects, for example public grants and private funding

[12] All projects were for mangrove ecosystems.

[13] Transaction costs: Costs incurred in attempting to complete a transaction (e.g., overhead costs for administration, paperwork, negotiations, and related activities) (Tietenberg and Lewis 2016).

[14] Opportunity cost: The net benefit (i.e., profit) forgone because the resource can no longer be used in its next-most-beneficial use (in this case, the use that results in mangrove destruction) (Tietenberg and Lewis 2016).

targeting environmental co-benefits such as flood protection, pollution filtration, and sea level rise adaptation.

Market Uncertainty

The creation of a blue carbon project is no guarantee that the project will find buyers for the voluntary carbon offset credits that it generates. The offset credits may not sell for years after they are issued. In an offsets marketplace, there is also a need for long-term confidence in demand and prices. Creation of an offset project is not worth the investment if the project operator cannot be assured of selling credits generated and receiving a minimum price for the credits it sells.

Historically, supply of voluntary offset credits (measured by credits issued) has exceeded demand (measured by credits retired, i.e. used), although this is at least partly due to a time lag between the two actions. Ecosystem Marketplace's annual report on the voluntary carbon market characterized it as "a buyers' market—almost as many offsets remain unsold as sold" (Hamrick and Gallant 2017). Both supply and demand dipped in 2016: issuances fell from 47.1 million metric tons of CO2e (MtCO2e) in 2015 to 36.7 MtCO2e in 2016, and retirements fell from 40.7 MtCO2e in 2015 to 32.7 MtCO2e in 2016. But, 2017 saw a dramatic uptick and record volumes of 62.7 MtCO2e issued and 42.8 MtCO2e retired (Hamrick and Gallant 2018). It is worth noting that the increase in credits issued was 2.5 times greater than the increase in credits retired, creating even more of a buyers' market.

One potential way to get around the demand uncertainty problem is to sell credits upfront to companies and other organizations as an investment in getting the project done. However, such a scheme might require offering price discounts for the risk (of project failure or delays, voluntary carbon market depression, and so forth) that investors take on when purchasing credits that have not yet been issued (Emmer et al. 2015, 66), exacerbating the problem of low prices.

<u>First Blue Carbon Project in the United States</u>

In the United States, the most fully developed blue carbon project is the Luling Oxidation Pond Wetlands Assimilation System in Luling, Louisiana. This pilot project is billed as the first of its kind in the United States, and is a partnership between Entergy Corporation, St. Charles Parish, and Tierra Resources, LLC. Municipal wastewater is directed into an adjacent 1,200-acre area that was formerly a coastal cypress forest wetland, restoring hydrology and revitalizing native wetland plants and soils. The project is set up to earn voluntary offset credits verified by the American Carbon Registry, although none have been issued yet, and it is expected to sequester a net total of 10,000 tCO_2e per year (Tierra Resources 2018). A study by Tierra Resources and The Climate Trust found that wetland restoration in the coastal areas of the Mississippi River Delta has the potential to generate $540 million to almost $1.6 billion in carbon credits over the course of 50 years, depending on the price paid for the carbon credit (Mack et al. 2014). More information on carbon credit methodologies is provided in the following section.

<u>Methodologies for Blue Carbon Offset Credits in the United States</u>

Carbon offset methodologies specify procedures for quantifying GHG benefits of a project and provide guidance to help project developers quantify GHG emissions reduced or removed. Verra Verified Carbon Standard (VCS) and American Carbon Registry (ACR) are offset verification standard bodies that verify and issue voluntary offsets, as well as verifying offsets for regulatory markets, including CDM credits, REDD+ credits, and offset credits for California's Cap-and-Trade program.

VCS and ACR currently have three methodologies for issuing voluntary offset credits for coastal wetland restoration and conservation that could potentially be used in the Point Reyes Area. The *VCS Methodology for Coastal Wetland Creation (VM0024)* was approved by VCS in 2014. It applies to projects that restore wetlands by establishing substrate and/or vegetation in places that are currently open water on the site of degraded former wetlands (Verra 2014).

In 2016, VCS followed up with the *VCS Methodology for Tidal Wetland and Seagrass Restoration (VM0033)*, which applies to projects carried out at degraded tidal wetlands, mud flats, or shallow water that include activities to enhance, create, or manage hydrological conditions (e.g., tidal reconnection), sediment supply, water quality, native plant communities, and/or improve management practices including reduced grazing (Verra 2016). VM0033 includes several provisions to simplify carbon accounting. First, it allows projects to assume baseline (i.e., without-project) emissions of carbon to be zero, and provides default values for calculating with-project GHG emissions and sequestration that can be used if a project does not have field measurements, published data, or quantification methods applicable to the site location. It also exempts wetlands with salinity >18ppt from reporting CH_4 emissions. This makes VM0033 an option for project proponents who are developing a project in a location where scientific studies of wetland carbon sequestration have not been completed, and allows projects with sufficiently saline wetlands to skip expensive field measurements of CH_4 emissions, thereby improving feasibility of smaller projects (Verra 2016). VM0033 further simplifies project accounting by deeming “all new tidal wetland restoration in the U.S. that is not otherwise required by law or regulation to be additional,” because “the opportunity and need for restoration in the U.S. is so much greater than the nation’s ability to fund it, and it is occurring at very low levels compared to restoration goals, that the addition of carbon finance to the funding mix can catalyze new restoration and improve the quantity and quality of restoration" (Emmer et al. 2015, 46). This automatic additionality removes the burden on project proponents to prove that the carbon benefit would not accrue in the absence of the project. Additionally, VM0033 requires projects to report projected sea level rise and gives projects the option of including anticipated areas of wetland migration, so that these areas can be included in GHG reduction calculations later in the project term[15], potentially increasing the number of credits earned for carbon sequestration, or at least making up for some of those lost to sea level rise (VCS 2015).

In 2017, ACR approved its *Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals from the Restoration of California Deltaic and Coastal Wetlands* (hereafter, ACR Methodology) (ACR 2017). The methodology was developed in partnership with the Sacramento-San Joaquin Delta Conservancy (SSJDC), a State agency, with a goal to provide a new funding stream for restoration of subsided former wetlands in the Sacramento-San Joaquin Delta (hereafter, "the Delta") and the San Francisco Bay Estuary (hereafter, "the Bay" or "San Francisco Bay") (SSJDC 2017). The ACR Methodology is applicable to projects within California that restore agricultural lands or seasonal wetlands to managed non-tidal wetlands, tidal wetlands, or rice cultivation, and to projects that restore areas of open water to tidal wetlands (ACR 2017). The ACR Methodology provides default values and exemptions for specific project scenarios in the Delta and the Bay, based on the extensive research and monitoring that has occurred there, but does not provide any default values for coastal areas such as Point Reyes (ACR 2017).

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15 Similarly, wetlands that convert to open water may emit GHGs, which must also be accounted for in calculating net GHG reduction for a project (VCS 2015). The minimum project term for VM0033 projects is 30 years (VCS 2015).

Potential for Blue Carbon Projects in the Point Reyes Area

There are many potential ways to create blue carbon projects at Point Reyes. The first and most obvious way is to restore coastal wetlands' hydrology through tidal reconnection, which in most cases would result in restoration of historical salinity. In addition to hydrological restoration, land managers could plant wetland species to jumpstart the vegetative community and increase carbon sequestration capacity in both restored and existing wetlands by reducing upland erosion and pollution inputs by installing vegetative buffers, reducing pollution runoff from ranches, and reducing grazing. These activities qualify for blue carbon offset credits under VM0033 (Emmer et al. 2015).

Of the blue carbon offset crediting methodologies currently available and described in the section above, the one with the best potential to generate offset credits in the Point Reyes Area is VM0033, VCS' *Methodology for Tidal Wetland and Seagrass Restoration.* This is due to three factors: (1) VM0033 allows for the greatest variety of baseline scenarios, including degraded tidal wetlands, mud flats, and shallow water, all of which are found at Point Reyes, whereas the VM0024 only allows a baseline of open water, and the ACR Methodology is specifically written for land uses and conditions in the Delta and the Bay, and does not include some of the land uses and conditions found at Point Reyes; (2) VM0033 has crediting mechanisms for the most granular of project activities, including improvements to water quality and natural hydrology in existing degraded wetlands, rather than wholesale conversion from one scenario to another, as is required by the other methodologies; and, (3) VM0033 provides a default value for quantifying carbon sequestration that can be used in the absence of region-specific data, models, or methods, which reduces the potential cost of complying with verification requirements and may make blue carbon projects in the Point Reyes Area more financially viable by reducing transaction costs.

Estimating Carbon Sequestration and the Number of Credits that Can Be Generated

By reviewing the literature and making inquiries with relevant agencies and experts, I found that carbon sequestration rates have not been published for coastal wetlands in the Point Reyes Area, which makes it difficult to estimate the number of offset credits that could be generated from blue carbon projects there. However, studies have been carried out in San Francisco Bay and the Delta, where degraded wetland soils are estimated to currently emit 6.6 to 8.6 $tCO_2e\ ac^{-1}\ yr^{-1}$ (ACR 2017) and are projected to sequester an additional 5 to 6 $tCO_2e\ ac^{-1}\ yr^{-1}$ after restoration (Weiser 2017). Taken together, these values yield a carbon benefit of 13.1 ± 1.5 $tCO_2e\ ac^{-1}\ yr^{-1}$ for wetland restoration projects in the Bay and the Delta. This is much more than the default value for with-project soil carbon sequestration that is permitted for use with the VM0033 methodology, 1.46 $t\ C\ ha^{-1}\ yr^{-1}$ (Emmer et al. 2015, 51; VCS 2015, 35), or 2.17 $tCO_2e\ ac^{-1}\ yr^{-1}$[16].

Until field measurements, published data, or quantification methods are available, the default value for with-project soil carbon sequestration could be used for projects in the Point Reyes Area[17]. Multiplying the default value of 2.17 $tCO_2e\ ac^{-1}\ yr^{-1}$ by the estimated total acreage of potential coastal wetland restoration sites in the Point Reyes Area (266.5-458.5 ac) produces an estimated total of 578.3-994.9 tCO_2e sequestered per year. Per methodology requirements, the total tCO2e sequestered would be discounted by approximately 18 percent to account for inputs of allochthonous carbon (estimated based on the organic content of area soils according to USDA-NCSS soil survey data accessed through UC Davis' SoilWeb (UC Davis 2018)). Additionally, up to 30 percent of earned credits would be placed in a buffer pool based on a risk

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[16] 1.46 $t\ C\ ha^{-1}\ yr^{-1}$ (44 tCO2e / 12 t C) = 5.353333 $tCO2e\ ha^{-1}\ yr^{-1}$;
5.353333 $tCO2e\ ha^{-1}\ yr^{-1}$ ÷ 2.47105 ac/ha = 2.17 $tCO2e\ ac^{-1}\ yr^{-1}$

[17] The default value may not be used if crown cover is <50%, and it may take a few years for a restored site to reach that level of crown cover and begin generating credits.

analysis. However, upon successful completion of the 30-year crediting period, the buffer pool credits would be returned to the project proponent (i.e., the landowner or coalition of landowners and investors that undertook the project) (Emmer et al. 2015, 57). Over the course of a 30-year crediting period and after the 18 percent deduction for allochthonous carbon inputs, the total tCO_2e sequestered based on this estimate would be approximately 14,226.2-24,474.5 tCO_2e and credits earned would be 14,226-24,474, depending on acreage of the project.

Assumptions and Uncertainties in this Estimate

This estimate does not include a credit for eliminating baseline carbon emissions because VM0033 does not allow such crediting for sites that have been drained for more than 20 years (Emmer et al. 2015, 51), which is the case with most, if not all, potential restoration sites in the Point Reyes Area. The estimate assumes that the potential restoration sites are not currently sites of net carbon sequestration, and are not expected to become so in the absence of restoration (this assumption is based on Crooks et al. (2014)). It does not include an estimate for emissions or emissions reductions of CH_4 on the assumption that the restored systems will have salinity >18ppt, in which case emissions need not be estimated (Howard et al. 2014, 118), and does not include an estimate of N_2O emissions because these need only be measured when the project results in a lowering of the water table (Emmer et al. 2015, 46), which is not expected for the potential restoration areas. If any of these assumptions is untrue, the total quantity of carbon sequestered and offset credits earned would be reduced accordingly.

This estimate also does not take account of projected sea level rise. Callaway et al. (2012) found that accretion rates in natural tidal wetlands in the San Francisco Bay are keeping pace with recent rates of sea level rise at 0.2–0.5 cm $year^{-1}$. If accretion rates in the Point Reyes Area are similar and keep pace with sea level rise, restored wetlands at sites where geomorphology allows for upland migration are not expected to be lost to open water. At such sites, tidal wetland acreage may increase over time, adding to the total number of carbon credits generated. However, there is a high level of uncertainty in predictions of the magnitude and timing of sea level rise, which translates into a high level of uncertainty about the persistence of any given coastal wetland (C-SMART 2016, ix).

Potential Income from Blue Carbon Projects

Prices for voluntary carbon offsets are highly variable by type and location, and the market is somewhat volatile and vulnerable to changes in national and international carbon market policies and commitments to GHG reduction. Ecosystem Marketplace has tracked the voluntary carbon market since 2007, when it published its first annual State of the Voluntary Carbon Markets report. Prices paid for offset credits in the past decade range widely, from under \$1.00 per tCO_2e to \$300 per tCO_2e (Hamilton et al. 2007; Hamilton et al. 2008; Hamilton et al. 2010; Hamilton et al. 2009; Hamrick and Gallant 2017; Hamrick and Gallant 2018; Hamrick and Goldstein 2015; Hamrick and Goldstein 2016; Peters-Stanley and Gonzalez 2014; Peters-Stanley and Hamilton 2012; Peters-Stanley et al. 2011; Peters-Stanley and Yin 2013), making use of the entire range nearly meaningless for this analysis. Instead, this analysis uses annual average prices paid to establish a range of potential values for blue carbon offset credits. Since 2007, the average price paid for a voluntary carbon offset has ranged from \$7.34 per tCO_2e in 2008 (Hamilton et al. 2007) to \$3.00 per tCO_2e in 2016 (Hamrick and Gallant 2017) and \$2.40 per tCO_2e for the first quarter of 2018 (Hamrick and Gallant 2018, 9). For offset projects involving land use, restoration, afforestation and avoided deforestation (collectively, “forestry and other land use” or “FOLU”), average offset prices have ranged from \$9.40 per tCO_2e in 2013 (Peters-Stanley and Gonzalez 2014) to \$1.00 per tCO_2e in 2010 (Peters-Stanley et al. 2011).

Using the estimate of total offset credits from the previous section (14,226 to 24,474 credits), and multiplying by the range of annual average prices paid for FOLU offsets in the past decade ($1.00 to $9.40 per tCO_2e), yields a potential income of $14,226 to $230,055 for all identified potential restoration sites in the Point Reyes Area over the course of a 30-year crediting period, or $1.78 to $16.73 ac^{-1} yr^{-1} [18] (at the current average price of $2.40 per tCO_2e, the potential income is $34,096 to $58,644). Using this range of prices ($1.00 to $9.40 per tCO_2e), the 563-acre Giacomini Wetland restoration project that was completed in 2008 could have earned between $30,000 and $282,500 over the course of a 30-year project term.

Regulatory compliance offset credits earn more than voluntary offset credits and prices are more stable. Emmer et al. (2015) cite a price of $11.00 per offset credit for carbon offset projects certified for compliance with California's Cap-and-Trade program, and the weighted average for offset transactions in 2016 was near that, at $10.86 (CARB 2017d). At $11.00 per offset credit, a blue carbon project would earn approximately $156,000 to $269,000 for all identified potential restoration sites in the Point Reyes Area over the course of a 30-year crediting period, or about $587.00 ac^{-1} ($19.56 ac^{-1} yr^{-1}). If offset credit prices were to rise in future years, earnings would be expected to increase accordingly.

Analysis

In the Point Reyes Area, coastal wetland restoration is at the crossroads of many social and environmental goals. It is a part of the County's plan for addressing sea level rise, it helps to reduce the negative impact of agricultural runoff on the water quality of estuaries and bays, and it provides habitat for rare and important plant and animal species. Yet there are many challenges

[18] 2.17 tCO_2e ac^{-1} yr^{-1} x 0.82 allocthonous carbon discount = 1.78 tCO_2e ac^{-1} yr^{-1};
high value: $9.40 x 1.78 tCO_2e ac^{-1} yr^{-1} = $16.73 ac^{-1} yr^{-1}; low value: $1.00 x 1.78 tCO_2e ac^{-1} yr^{-1} = $1.78 ac^{-1} yr^{-1}

for blue carbon projects in the Point Reyes Area, ranging from scientific limitations to the constraints of social issues and human systems. First, published data or quantification methods do not yet exist for the region (ACR 2017). Emmer et al. (2015) anticipate blue carbon projects nationwide to be hindered by the absence of regional quantification of baseline GHG fluxes on former coastal wetlands, and Point Reyes is no exception. Second, there is no single State or federal agency that would logically take the lead on such a regional quantification. Third, and specific to the Point Reyes Area and the outer coast[19] of California in general, the small acreage of potential coastal wetland restoration sites limits opportunities to reduce administrative costs through economies of scale[20]. In contrast, the large contiguous acreages of potential restoration areas in the San Francisco Bay and the Delta enable more economically feasible projects. Fourth, the patchwork of land ownership of the potential restoration sites makes central coordination of a blue carbon project challenging because of the large number of entities involved, from private landowners to the County of Marin and the NPS. Despite the challenges, in order to maintain biodiversity in the Point Reyes Area – and similar areas along California's coast – it is critically important to restore the patchwork of small coastal wetland habitats that are interspersed throughout the rich variety of terrestrial and aquatic habitats.

The structure of blue carbon offset programs incentivizes restoration of larger contiguous areas of coastal wetlands over small patches. These programs could end up neglecting highly variable landscapes like those at Point Reyes and lead to ecological homogenization at the

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19 The ocean coast of California that is characterized by cliffs, rocky shores, beaches, and small coastal wetlands, as opposed to deltas and estuaries like the Sacramento-San Joaquin Delta and the San Francisco Bay Estuary.

20 Economies of scale: Percentage increase in output (e.g., acres of wetland restoration) exceeds the percentage increase in all inputs (e.g., the cost of administering the program). Average cost falls as output expands (Tietenberg and Lewis 2016).

landscape scale. This is a perverse incentive[21], or an unintended negative outcome of the program that results from failure to sufficiently account for the ecological value of patchy wetland environments. It can be counteracted by compiling multiple restoration sites into one project, forming partnerships, and combining funding sources.

<u>Economic Feasibility</u>

Offset credits could help government agencies, private landowners, and stakeholder groups such as TBWC close the funding gap for planned coastal wetland restoration projects. For example, the Chicken Ranch Beach project has been in the planning stages since 2005 but has not yet been fully funded (TBWC 2017a). An additional funding stream from the sale of offset credits could complement existing funding sources such as government and non-profit grants, investment from NGOs, and private philanthropy.

Voluntary Carbon Offset Credits

Given the amount of potential income from blue carbon projects estimated in the previous section, can the money generated from voluntary carbon offset credits support coastal wetland restoration efforts? In addition to the cost of restoration activities, the development of a blue carbon project – including a feasibility assessment, measurement and monitoring, validation, third-party verification to comply with VM0033, and marketing and administration of the carbon credits themselves – is estimated to cost between $100,000 and $300,000 (Emmer et al. 2015, 37). In the Point Reyes Area, sales of voluntary carbon credits will cover only approximately $14,226 to $230,055[22] of these costs, and only if all acres from all potential restoration sites identified in this paper are included. All potential restoration sites would need to

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[21] Perverse incentive: Economic incentives that prevent the efficient use of resources, often by under-valuing and/or externalizing the value of ecosystem services, biodiversity, conservation, and restoration (Tietenberg and Lewis 2016, 262-265).

[22] The high estimate is only likely if credits are sold for prices at the high end of the historic price range. Given the Q1 2018 average price of $2.40 per tCO_2e, a potential income closer to $34,096 to $58,644 seems more likely.

be pooled into one project, called a "grouped project," which will likely cost a bit more to administer than the above estimate because of the many small sites that would be included. Emmer et al. (2015) estimate a cost of approximately $20,000 to integrate a new project site into a grouped project.

At current prices, income from voluntary carbon offset credits is not likely to fund the tasks required to earn the credits themselves, much less the restoration actions undertaken. Thus, voluntary carbon offset credits alone would not provide enough economic support to make coastal wetland projects happen that would not otherwise. However, a pilot blue carbon project could advance the state of the science for blue carbon in the Point Reyes Area by producing published data on GHG emissions from degraded coastal wetlands and sequestration rates at restored wetlands. This data could be used for feasibility assessments and quantification for future blue carbon projects in similar systems in California. The promise of that benefit in addition to the environmental co-benefits may be enough to attract investors to provide financial support to enable the development of a blue carbon project and perhaps additional funds for the restoration activities themselves. The ongoing income from carbon credits could also be used to fund monitoring of the restoration site for decades[23], which is often not possible for ecological restoration projects due to lack of funding (ASWM 2018).

Regulatory Compliance Offset Credits

Regulatory compliance offset credits for coastal wetland restoration, if they were available under California's Cap-and-Trade program, could generate up to ten times as much income per acre as voluntary offset credits, and would provide a more reliable source of income. Project operating costs would likely increase due to more stringent monitoring and verification

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[23] Crediting periods for VM0033 are 30 years and projects may last a maximum of 100 years with multiple crediting periods.

requirements for compliance offset credits (Wylie et al. 2016), but it is doubtful that the overhead cost increase would be large enough to significantly reduce the large increase of income. Nonetheless, the income from the sale of offset credits at current prices will, at best, just barely cover project operating costs. But, the expectation of rising prices for carbon offsets in the coming two decades (CARB 2018b; CARB 2018c) may pay off for a 30- to 100-year project. Thus, the addition of a Cap-and-Trade offset protocol for blue carbon projects would provide a more certain return on investment.

Demand for compliance offset credits would also be more reliable than for voluntary offset credits, because regulated firms are compelled to purchase offsets for any emission reductions they cannot achieve more cheaply than the price of offsets. However, demand can be undermined by uncertainty caused by a lack of clear direction from the regulatory body or the threat of political change (Newell et al. 2012). For example, in late 2016 prices of permits in California's Cap-and-Trade program fell due to protracted lawmaker negotiations over the program's future and a lawsuit challenging the program's legality. Once these issues were resolved, the market price rose back to where it had been before confidence was undermined (Busch 2017). Because permit prices are typically higher than prices for offset credits, which are a cost-containment tool for the program (Tietenberg and Lewis 2016, 412), this dip in permit prices probably caused offset credit prices to dip as well.

Regulated firms are also less likely to invest in long-term carbon offset projects if they do not expect the regulation to last more than a few years. Assuming the regulation does last, these firms may eventually buy offset credits at the end of a compliance period[24] if their emissions

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[24] California's Cap-and-Trade program has compliance periods of 3 years.

reductions are insufficient. This pattern reduces the confidence of project operators that their investments will pay off.

Other Funding Sources

There are other sources of funding for coastal restoration in California. The California State Coastal Conservancy (CCC) provides grants for wetland restoration, streambank stabilization, conservation and agricultural easements, and more. CCC grants funded planning for the Bolinas Lagoon and Chicken Ranch Beach restoration projects, and many other projects in Marin and surrounding counties (CCC 2018). The California Climate Investments program (CCI) uses the money collected from the Cap-and-Trade program to fund projects that reduce GHG emissions from sources that are not covered by Cap-and-Trade, including transportation, clean energy, waste diversion, and natural resources including wetland restoration (CCI 2018). So far, the program has funded restoration or enhancement of 2,500 acres of coastal wetlands, mountain meadows, and Delta wetlands across 12 projects (CDFW 2018). Funding from these sources may be used in combination with a blue carbon project, thus enabling projects that would not be possible using a single source of funding.

Social Considerations and Human Systems

Blue carbon projects can provide an economic incentive to restore coastal wetlands, thereby reducing social and economic disincentives to coastal wetland restoration. Currently, if a rancher restores a coastal wetland on their ranch, or makes improvements to water quality downstream by reducing agricultural runoff, setting grazing lands back from the shore of estuaries, and planting a vegetative barrier, these actions represent a cost for which the rancher sees no economic return. The costs come from both the expense of the restoration activities themselves and the trade-off of losing those acres for pasture, which means their property will support fewer cattle. But, blue carbon offset credits can internalize the positive externality[25] of restoration actions by quantifying the impact of the resulting restored wetlands and water quality improvements on increases in carbon sequestration and paying the rancher.

Ongoing tension between area ranchers and the NPS pose challenge to collaboration for blue carbon projects. The PRNS General Management Plan Amendment holds promise for improved relations, but while the process is ongoing it is likely that conflict will continue between the NPS, ranchers, environmentalists, and other stakeholders. This tension and the labor required to support the General Management Plan Amendment process make the possibility of working on blue carbon projects in PRNS unlikely in the near term. However, projects could start outside of PRNS and PRNS lands could be added after ranch lease terms are settled.

Models of Collaboration

Despite the tensions between stakeholders, there are several regional organizations that have created successful collaborations among government, civil society, and private landowners for sustainability. These organizations can serve as models for organizing a regional blue carbon project in the Point Reyes Area.

The Marin Carbon Project is a consortium of the County of Marin, MALT, the Marin Resource Conservation District, University of California (UC) Cooperative Extension, UC Berkeley, the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS), Nicasio Native Grass Ranch, and other scientists and farmers, that is educating and assisting landowners with enhancing carbon sequestration in rangeland, agricultural, and forest soils (Marin Carbon Project 2018b). The first phase of the Marin Carbon Project was focused on scientific experiments coordinated with interested landowners to establish the scientific basis for

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[25] Positive externality: Beneficial ecosystem goods and services that do not accrue exclusively to the landowner and are therefore undervalued by the landowner (Tietenberg and Lewis 2016, 240).

carbon farming – i.e., farming practices that increase and retain soil carbon, thereby improving crop yields and soil health. This experimental phase was funded primarily by philanthropic foundations (Nancy Scolari, Marin Resource Conservation District, phone conversation with author, July 26, 2018). Once the science was established, the Marin Carbon Project worked with local farmers to develop and implement three pilot carbon farm plans. Today, there are 20 carbon farm plans in development or implemented in Marin County alone and the Marin Carbon Project is serving as a model for similar programs throughout the state (Calla Rose Ostrander, Marin Carbon Project, phone conversation with author, August 1, 2018). Funding sources include the USDA NRCS Environmental Quality Incentives Program (EQIP), the California Healthy Soils program which is funded by Cap-and-Trade proceeds (CDFA 2018), and grants from the Coastal Conservancy (Marin Carbon Project 2018a). The program is administered through the Marin Resource Conservation District (Nancy Scolari, Marin Resource Conservation District, phone conversation with author, July 26, 2018).

The Bolinas Lagoon Advisory Council (BLAC), established in 2012, is a partnership of the County of Marin with the Greater Farallones National Marine Sanctuary (GFNMS) and NPS to coordinate and implement restoration projects in Bolinas Lagoon. BLAC includes representatives from Marin County Parks, GFNMS, GGNRA, PRNS, Audubon Canyon Ranch, Bolinas Rod and Boat Club, College of Marin, Point Reyes Bird Observatory (a science non-profit located in the village of Bolinas), and community representatives from the neighboring villages of Bolinas, Seadrift, and Stinson Beach (MCBS 2012). While Marin County Parks is the lead agency for restoration projects, working with other agencies that have jurisdiction over the lagoon and its watershed, as well as with neighboring non-profits and communities, eases the process for planning, development, implementation, and success of restoration projects (Marin County Parks 2018).

The Tomales Bay Watershed Council (TBWC) formed in 2000 as a forum for the many landowners in the 220-square mile watershed to collaborate on improving water quality in Tomales Bay following contamination in 1998 that caused more than 170 people to become ill after eating oysters from Tomales Bay (Pileggi et al. 2012). Membership includes representatives from State, County, and local government agencies, the GFNMS, the Marin Resource Conservation District, UC Cooperative Extension, utility districts, agricultural landowners, and conservation and environmental organizations (TBWC 2017c). The council operates on consensus-based decision-making, and conducts water quality monitoring in cooperation with the County and PRNS (Pileggi et al. 2012). In 2007, TBWC completed an Integrated Coastal Watershed Management Plan to prioritize stewardship actions and assist landowners in meeting State-mandated water quality standards (TBWC 2017b). As stated earlier in this paper, TBWC efforts have improved water quality by reducing inputs of excess nutrients into Tomales Bay (Hameed et al. 2013).

The South Bay Salt Pond Restoration Project (SBSPRP) is a partnership of the U. S. Fish and Wildlife Service, the California Department of Fish and Wildlife, the Coastal Conservancy, the U.S. Geological Survey (USGS), the Santa Clara Valley Water District, and the Alameda County Flood Control and Water Conservation District for the restoration of approximately 15,000 acres of former salt ponds and other properties at the southern end of San Francisco Bay. The properties, located in Alameda, Santa Clara and San Mateo Counties, were acquired by the State of California and the United States from Cargill, Inc. The partners entered into a Memorandum of Understanding in 2009 that established the overall work plan for the project, the process by which adaptive management decisions would be made, and collaboration on development, funding, and implementation of the project (SBSPRP 2009). Based on a long-term work plan and 50-year implementation schedule, the project secured program-level regulatory approval covering the more than 50 individual tidal wetland restoration projects that make up the SBSPRP (Emmer et al. 2015, 74). Funding and in-kind services for the project have been provided by local governments, philanthropic foundations, corporations, and non-profit organizations (SBSPRP 2018).

These four examples illustrate that partnerships among agencies, non-governmental organizations, and private individuals can work together to overcome the challenges of geographic, jurisdictional, and social fragmentation to achieve a regional goal for improvement of ecosystems at the landscape scale.

<u>Future Considerations</u>

The long-term viability of blue carbon projects depends largely on: keeping transaction costs as low as possible by establishing region-specific data, models, or methods for quantifying carbon stocks and sequestration rates; a consistent demand for offset credits; and sufficient prices for offset credits. This section identifies recent developments and future considerations that may impact these issues.

Regional Values for Carbon Stocks and Sequestration Rates

Holmquist et al. (2018) analyzed 1,959 soil cores from 49 different studies of tidal wetland soil carbon across the continental United States and found that carbon stocks in tidal wetlands varied much less than previously assumed. The authors propose that estimates of carbon stocks nationwide can best be quantified by applying a mean carbon density of 27.0 kg C m^{-3}, finding that this method performs better than using independently generated soil carbon maps that intersect with tidal wetlands and better than using models based on parameters associated with soil, vegetation, and salinity. This mean carbon density is within the confidence interval for IPCC global default values for salt marshes, and comparable to multiple previous syntheses in the United States, Australia, and Europe. This carbon stock value could be used as a standard for baseline carbon stocks for carbon accounting for blue carbon projects across the United States, including wetland conservation (i.e., avoided conversion) projects. Regional or default sequestration rates, such as the default provided in VM0033, would still be needed to quantify changes in carbon stocks over time.

Future Demand

Consistent demand for carbon offset credits can be provided by stable GHG emissions reduction policies and regulatory ETS programs. The voluntary market is unlikely to provide consistent demand due to its nature as voluntary. An August 2018 Ecosystem Marketplace survey found that while there is a generally favorable outlook, almost all market participants surveyed described the voluntary carbon market as uncertain (Hamrick and Gallant 2018, 13).

If a blue carbon offset protocol were included as part of California's Cap-and-Trade program, demand would likely be more consistent. But, there are uncertainties there as well. In 2017, legislation to extend Cap-and-Trade from 2021 to 2030 included a provision to reduce the percentage of a regulated entity's compliance obligation that can be met through the purchase and retirement of offsets from 8 percent, which was the limit from 2013 through 2020, to 4 percent from 2021 through 2025 and 6 percent from 2026 through 2030. There is also a new requirement that half of offsets used must have direct benefits for California (Pacific Forest Trust 2018). The impact these regulatory changes present for potential blue carbon projects in coastal California is mixed: overall demand for offsets may decline, while demand for offsets from projects within California may increase. But, the California Air Resources Board (CARB), which is the lead agency for implementing California's climate law and administers the Cap-and-Trade program, asserts that California's ambitious GHG emission reduction goals and regulated entities' need for lower-cost emissions reductions will continue to drive a consistent demand for offsets (CARB 2018c).

Future Prices

Prices for carbon offsets vary considerably on the voluntary market, while compliance market prices are relatively consistent. The average price in the first quarter of 2018 was $2.40 per tCO_2e (Hamrick and Gallant 2018, 8), lower than its peak of $7.30 per tCO_2e in 2008, and lower than its 2004-2014 average of $5.70 per tCO_2e (Ecosystem Marketplace 2015). Given the market's uncertainty, it is not clear whether prices will rise in the future.

Prices for Cap-and-Trade offsets tend to sell for about 15-20 percent below the program's auction reserve price[26] for emissions permits (CARB 2018c), and can be expected to rise with them. CARB estimates that the auction reserve price will be $72.90 in 2021, and $81.90 in 2030 (CARB 2017c). At 20 percent below these prices, offset prices would be approximately $58.32 per tCO_2e in 2021 and $65.52 per tCO_2e in 2030.

Recommendations

I recommend establishment of a central coordinating organization for blue carbon projects, development of a grouped project under VM0033 to incorporate the many small parcels of potential coastal wetland restoration in the Point Reyes Area, and collaboration with the Marin

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[26] "Auction reserve price" refers to the minimum prices set and published annually in accordance with Section 95911 of the California Cap-and-Trade Regulation (CARB 2017a). The auction reserve price serves as a price floor, preventing prices for emissions permits from dropping below that price and thereby reducing market volatility.

Carbon Project to leverage expertise and synergies between carbon farming and blue carbon projects.

<u>Coordinating Organization for Blue Carbon Projects</u>

The small size of potential restoration sites poses a special challenge for blue carbon projects in the Point Reyes Area and most of California's outer coast. Leveraging economies of scale through the development of grouped projects will be necessary to overcome this challenge. This will require coordinating many landowners and landowner types under the umbrella of a central administrative entity.

A logical choice for a central administrative entity would be the County of Marin. The County Community Development Department has divisions devoted to sustainability and sea level rise adaptation. A Blue Carbon Office within the Community Development Department could effectively provide administrative coordination for preparation of project documents and dispersal of funds, including serving as the grouped project aggregator. The office could also function as a clearinghouse for quantification methods and scientific information, and provide a mechanism for community engagement and input on blue carbon projects. Implementation and scientific expertise could be provided by a collaborative group of experts, similar to the partners and advisory panel of the Marin Carbon Project. Establishing a Blue Carbon Office would also enable landowners in Marin to quickly take advantage of blue carbon project financing as offset prices rise in the years to come.

The Blue Carbon Office and its scientific partners could use the North End Project at Bolinas Lagoon as a pilot project. This project is very likely to move forward due to infrastructure needs and strong community support (MCPOSD 2017). Field measurements of baseline carbon stock and with-project carbon sequestration and registration with VCS to potentially earn offset credits could be done if sufficient funding for this work were available. A conservation NGO, philanthropic foundation, or corporation seeking to offset emissions may be willing to fund these efforts to demonstrate their commitment to coastal wetland restoration in California.

The pilot project would generate data to establish baseline and with-project sequestration rates for the area, which would facilitate future projects in coastal Marin County and serve as a proof-of-concept for the economic viability of blue carbon projects or establish the price offsets must earn to be economically feasible. It is also possible that field measurements might show higher with-project sequestration rates than the default VM0033 value, which would result in projects earning more credits per acre. The pilot project would also provide valuable information on environmental and social outcomes to inform the consideration of a blue carbon offset protocol under California's Cap-and-Trade program.

Published data on carbon sequestration rates may also be useful for winning funding for coastal wetland restoration projects even if carbon offset credits are not pursued, by providing quantification of a climate co-benefit in addition to environmental and flood attenuation benefits. This information could be used in applications for grant funding from the Coastal Conservancy and the California Climate Investments program.

Structure of Grouped Project

As the aggregator of the grouped blue carbon project under VM0033, the Blue Carbon Office would establish Bolinas Lagoon North End as the first project site, or "project instance" in VM0033 terminology, and include all potential restoration sites in the Point Reyes Area as part of the project area in the master project plan. Project instances that are added later must have same baseline and use same methods and technologies for measurement as the initial project instance (Emmer et al. 2015, 69).

As the project aggregator, the Blue Carbon Office would be the primary institutional structure linking the project instances, deciding on whether a new project instance can be included, assessing compliance with the project description, and organizing the sale of carbon offsets and the distribution of carbon revenues, as recommended by Emmer et al. (2015, 71). Agricultural landowners could apply to the Blue Carbon Office to have a proposed coastal wetland restoration project added to the grouped project, and may want to form an organization through which they would collectively interact with the Blue Carbon Office (Emmer et al. 2015, 72). PRNS management could also collaborate with the Blue Carbon Office to include coastal wetland restoration sites in PRNS and GGNRA-ND in the grouped project, to leverage the administrative, scientific, and implementation coordination and transaction cost savings that inclusion in the grouped project would provide. For restoration sites within leased agricultural lands at PRNS, authorization could be provided to ranchers to work with the Blue Carbon Office to establish new project instances that comply with PRNS-approved practices.

Collaboration with Marin Carbon Project

Collaboration between the Blue Carbon Office and the Marin Carbon Project is logical because many agricultural landowners could benefit from both programs. Some actions for blue carbon are complementary to carbon farming actions, such as stream bank protection and riparian restoration that would improve water quality inputs into coastal wetlands downstream. By working with the Marin Carbon Project, the Blue Carbon Office could leverage the Marin Carbon Project's expertise, connections, and goodwill to extend landowners' carbon sequestration activities into coastal wetlands. Working together, these programs could build climate resilience on a landscape scale in West Marin.

It may seem more efficient to incorporate blue carbon projects into the Marin Carbon Project, but this is not likely to be a good fit because the Marin Carbon Project is administered by the Marin Resource Conservation District and the carbon sequestration quantification methods under the Marin Carbon Project are associated with USDA NRCS-approved conservation practices, and build on decades of expertise in conservation farming (Nancy Scolari, Marin Resource Conservation District, phone conversation with author, July 26, 2018). It would be an expansion of their repertoire and possibly outside the Marin Resource Conservation District's mandate to incorporate blue carbon into their carbon farming methods. Moreover, some blue carbon project sites are not in agricultural use, and therefore would not be logical candidates for the Marin Carbon Project but would still be viable blue carbon locations. By establishing a Blue Carbon Office independently of the Marin Carbon Project, the widest range of possible restoration sites can be included.

Social and Environmental Impacts

To be successful, blue carbon projects must account for community economic and livelihood issues. In the Point Reyes Area, potential blue carbon project sites that are not under State and federal ownership are on agricultural lands, and several with MALT easements. Farmers and ranchers in the region are concerned about the economic viability of their operations, and dairy ranchers are specifically concerned about maintaining a critical mass of dairy ranching to sustain regional agricultural suppliers and processors that are needed to maintain a dairy economy in the region (MALT 2017). Ranchers under PRNS jurisdiction have expressed interest in diversifying operations beyond dairy or beef ranching in order to increase income streams and provide more stability (Guthey et al. 2003; PRNS 2016).

A grouped blue carbon project in the Point Reyes Area could provide an additional income stream for agricultural landowners and PRNS ranchers through the sale of carbon offset credits. By creating a grouped project at the county level, costs would be reduced considerably for new project instances. Restoration activities could be funded, at least in part, by grants, reducing implementation costs and improving return on investment for ranchers.

Blue carbon has the potential to bolster many values that are regionally important: sustaining the agricultural economy and traditions of West Marin, improving ecological health and biodiversity, and supporting infrastructure projects needed to adapt to sea level rise. The resulting increases in coastal wetland and adjacent upland habitat acreage and improvements in water quality could, in turn, lead to reduced tension between ranchers and environmentalists and help ranchers comply with water quality standards. It would also help to restore the patchwork of habitat diversity that makes the Point Reyes Area a biodiversity hotspot.

Conclusion

Development of a grouped blue carbon project for the Point Reyes Area would generate supplemental funding for restoration and support the area's goals of ecosystem restoration, sustainable agriculture, and adaptation to sea level rise. Such small, patchy coastal wetland areas are vitally important to sustain biodiversity, even though their acreages are not ideal for leveraging economies of scale.

A grouped blue carbon a project would provide a proof-of-concept for blue carbon projects on the outer coast of California and would be well-positioned to benefit from rising prices for carbon offset credits in decades to come. Measurements of baseline carbon stocks and carbon sequestration on restored sites would establish regional values that can be used with blue carbon projects. This would boost the state of science for blue carbon and facilitate development of other grouped blue carbon projects in coastal counties to the north and south of Marin County. Funding support from State grant programs and private philanthropy is warranted to enable the project to overcome perverse incentives of blue carbon offset programs that disincentivize restoration of small, patchy coastal wetland areas.

Through coastal wetland restoration, California has an opportunity to mitigate GHG emissions while also preparing for sea level rise, restoring habitat for wildlife, improving water quality, and reducing flood risks. Coastal wetland restoration is a priority in the State's climate action plan (CARB 2017c, 87). A pilot blue carbon project in the Point Reyes Area could leverage restoration work that is already planned to jumpstart blue carbon financing for coastal wetland restoration up and down the outer coast of California, improving the state's climate resilience and contributing to California's GHG reduction goals.

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