Coastal Blue Carbon Opportunity Assessment for the Snohomish Estuary

The Climate Benefits of Estuary Restoration

Restore America's Estuaries

ESA

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Cover Photo Caption and Credit

Photo of Quilceda marsh, currently owned by The Tulalip Tribes, looking southwest down Steamboat Slough of the Snohomish River toward Port Gardner, Washington, USA. Photo by K. O'Connell (2013).

EXECUTIVE SUMMARY

Background

Blue carbon is a term that recognizes the role of coastal wetlands in the global carbon cycle. Tidal marshes, tidal forested wetlands, and seagrasses sequester carbon dioxide from the atmosphere continuously over thousands of years, building stocks of carbon in organic-rich soils. When coastal wetlands are drained and converted to terrestrial land uses, carbon is rapidly released back to the atmosphere in the form of carbon dioxide. Restoring coastal wetlands stops the drainage-induced releases of carbon and reactivates carbon sequestration.

Coastal wetlands are one of the world's most rapidly disappearing ecosystems due to human impact (Pendleton et al., 2012). At current rates, within less than 100 years most of the world's coastal wetlands will be lost. Though wetlands are protected by law in the United States, losses continue. Restoration of coastal ecosystems brings benefits that support the livelihoods of local communities, improve water quality, reduce risk of flooding, facilitate future adaptation to climate change, and not only reduce greenhouse gas (GHG) emissions from converted wetlands but reverse emissions from that land.

The need for improved management of coastal wetlands for climate change mitigation benefits is recognized and advanced by a number of important recent actions:

- In November 2012 the **Verified Carbon Standard** recognized *Wetland Restoration and Conservation* as an eligible project activity for carbon finance[1]. In December 2013 the first global *Methodology for Tidal Wetlands and Seagrass Restoration* was submitted to the Verified Carbon Standard for review[2]. Once approved, there will be mechanisms for coastal wetlands restoration projects in the U.S. and internationally to apply for carbon financing.

- In October 2013, **the Intergovernmental Panel on Climate Change (IPCC)** adopted the *2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement)*[3]. This document fills a gap in the 2006 Agriculture, Forestry and other Land Use (AFOLU) GHG guidelines to cover wetlands and organic soils. In November 2013, at the Conference of Parties in Warsaw (COP 19), the Subsidiary Body for Scientific and Technological Advice (SBSTA) invited Parties (Nations) to apply the Wetlands Supplement in developing national GHG inventories and report back to the SBSTA in 2017 on their experiences in application[4].

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[1] http://www.v-c-s.org/wetlands_restoration_conservation

[2] https://www.estuaries.org/draft-greenhouse-gas-methodology-for-wetland-restoration.html

[3] http://www.ipcc-nggip.iges.or.jp/home/wetlands.html

[4] http://unfccc.int/resource/docs/2013/sbsta/eng/l29.pdf

- In the **United States**, federal agencies have established an interagency team to support blue carbon efforts. These include integrating blue carbon science and policy into the National Ocean Policy and activities to develop tools and methodologies for blue carbon management. *The National Assessment of Ecosystem Carbon Sequestration and Greenhouse Gas Fluxes* recognizes that national estimates of GHG fluxes are lacking and that filling this data gap is a priority[5].

Purpose of the Report

The purpose of this report is to support the above actions by providing information to: (1) inform policy makers of the scale of GHG emissions and removals associated with management of coastal lowlands under conditions of climate change; and (2) identify information needs for future scientific investigation to improve quantification of GHG fluxes with coastal wetlands management.

The Snohomish Estuary was selected as a system representative of the wider Puget Sound and Pacific Northwest Region in terms of geomorphology, land use, and management issues. The historic estuary, the second largest in Puget Sound, consisted of a suite of forested wetlands, scrub-shrub wetlands, and emergent tidal wetlands. Clearing and draining the wetlands resulted in subsidence of organic soils. Today the subsided lands include agriculture (lowered water table), anthropogenic Palustrine wetlands (high water table), and a small area of planted forest. Soils are a mix of organic and mineral materials. The estuary hosts remnant emergent and forested wetlands; an example of a large-scale regenerating wetland, North Ebey Island, breached in the 1960s; and drained wetland soils under various forms of management.

We hypothesize that because of geomorphic form, sediment delivery, and the composition of emergent wetland communities, estuaries in the Pacific Northwest offer locations where restoring wetlands would be of relatively high resilience to sea level rise and act as effective sinks for carbon sequestration. The Snohomish Estuary has benefited from a number of scientific and engineering investigations to support coastal management planning and restoration activities.

Approach and Methods

This study provides a first assessment of carbon fluxes over multiple decades for historic drained and future restoring wetlands.

Soil carbon stocks were determined from cores collected at 12 sites across the Snohomish Estuary, representing emergent tidal wetland, forested wetland, a regenerating emergent wetland, and drained wetlands. Soil and carbon accumulation rates were determined by ^{210}Pb (lead) radiometric dating at five natural and restoring wetlands sites. Changes in living forest biomass, a significant component of the historic landscape, were derived from a prior regional assessment. In the absence of field data on

[5] http://www.usgs.gov/climate_landuse/land_carbon/default.asp

methane (CH_4) fluxes from wetland and drained soils, IPCC Tier 1 default values from the Wetlands Supplement were used.

The historic carbon emissions of drained wetlands were calculated from soil carbon density values obtained from field samples, combined with the volume of soil subsidence resulting from wetland drainage (derived from publically available digital elevation data). The total carbon sequestration potential for restored estuarine wetlands was calculated from changes in carbon stock when wetland soils rebuild up to elevations at which vegetation can colonize. Rebuilding of wetlands to typical elevations at Mean Higher High Water was assumed. A future condition was based upon a 1 m sea level rise.

Projections of wetland restoration in the estuary were based upon state plans for recovery of emergent wetlands. An assessment of restoration potential was based upon geomorphic metrics that determine the potential for diked and drained wetlands to rebuild once the dike is breached. These metrics were supported by observed wetland rebuilding at North Ebey Island, a restoration site in the Snohomish Estuary that has been breached for decades.

Findings

Carbon measurements in natural wetland areas support the hypothesis that this estuary is representative of typical West Coast estuaries. The Snohomish Estuary is an excellent case study for restoration of tidal wetlands and estimates of carbon storage along the northwest coast of the U.S. and southwest coast of Canada. This study found that restoring wetland sites show good potential for high rates of accretion and high rates of carbon storage.

Historic land use change resulted in estimated emissions of 4.5 million tons of carbon (MtC), of which 2.8 MtC was a result of clearing forested wetland (loss of living biomass) and 1.7 MtC from draining soils. Of the 4,749 ha of converted and drained wetlands, 1,353 ha are currently in planning or construction for restoration. These projects are anticipated to rebuild soil carbon stocks of 0.32 MtC as wetlands recover to former tidal elevations, and an additional 0.38 MtC with sea level rise of 1 m. Full estuary restoration would rebuild soil carbon stocks of 1.2 MtC as marshes build to emergent wetland tidal elevations, and a further 1.2 MtC as they accrete with sea level rise of 1 m. Any recovery of forest biomass would be additional to projected accumulation of soil carbon.

Rates of soil carbon accumulation in natural emergent and forested tidal wetlands in the Snohomish estuary are in balance with the rate of current rate of sea level rise. Carbon sequestration at two restoring sites ranged from 0.9 t C ha^{-1} yr^{-1} to 3.52 tC ha^{-1} yr^{-1}. These two restoration sites represent different ages of restoration; North Ebey Island has been breached for over 40 years, whereas Spencer Island has only been open for about 20 years. Spencer Island is lower than North Ebey Island by 30 cm. This difference in elevation is large in tidal wetland development. Spencer Island is at the low-end of plant colonization elevation, while North Ebey Island is at an excellent elevation for emergent plant colonization. As emergent plants colonize restoring tidal wetlands, soil accretion rates may increase as sediment becomes trapped by dense vegetation and rootmats. We anticipate that as restoring sites age in the Snohomish estuary they are likely to span these two values, with increasing soil carbon accumulation rates over time. The rate observed at North Ebey is likely more than sufficient to offset estimated CH_4 emissions. For example, using the IPCC Tier 1 default value for CH_4 emissions from non-saline tidal wetlands, 1.8 tC ha^{-1} yr^{-1} equivalent, the measured carbon accumulation of 3.5 tC ha^{-1} yr^{-1} suggests that this recovering system is a net GHG sink of 1.7 tC ha^{-1} yr^{-1}, in soils alone. Future restoration at other tidal wetland sites in the Snohomish estuary is expected to achieve similar climate change benefits.

This study did not evaluate the rates of carbon emissions from drained soils, CH_4 emissions from drainage ditches, or nitrous oxide (N_2O) emissions from drained soil surfaces as a result of organic decomposition or fertilizer application. As a consequence, the calculated net reduction in carbon emissions associated with restoration of wetlands underestimates the net benefit of halting ongoing emissions from drained soils, and as such is conservative.

In addition to this carbon storage potential, measurements at preserved, natural, undiked sites in the Snohomish Estuary show that the hydrology of the estuary is healthy and soils are building up (accreting) at rates equal to or exceeding rates of current estimated sea level rise. This healthy accretion rate means that this estuary has built-in resilience to sea level rise. Future tidal wetland habitat will be able to keep up with rising waters over the 100-year timeframe of this study, rather than changing to an inundated shallow bay.

Recommended Next Steps

1) Establish a regional blue carbon working group to build local capacity to deliver coordinated scientific findings, improve land management, and inform policy. Coastal lowlands of the Pacific Northwest offer the potential for coastal wetlands restoration with natural resilience to sea level rise and carbon sequestration benefits. A coordinated action is required to further explore this opportunity and test it through demonstration projects.

2) With a carbon finance methodology for tidal wetlands restoration submitted to the Verified Carbon Standard for review, the next step to delivering a carbon finance project is selection of a potential project site and detailed feasibility assessment. This report suggests estuaries similar to the Snohomish offer potential to host successful projects. Such projects could include elements of upper estuary forest and floodplain restoration as buffers to sea level rise and components of climate change adaptation, as well as emergent tidal wetland restoration.

3) Expand the geographical extent of this study, regionally and nationally. The approach developed in this study is readily transferable to other coastal lowland settings. There is a need for regional quantification of GHG emissions and reductions associated with coastal land use practice in this and other regions. This study provides a first step.

4) Conduct higher resolution research to quantify carbon emissions and removals associated with wetlands management to inform best management practices for state and national reporting. In particular, further work is required to: (1) determine CO_2, CH_4, and N_2O emissions from drained soils;

and (2) develop refined regional (IPCC Tier 2) default values for state and national GHG inventory efforts.

5) Develop regional landscape-level management plans that incorporate both climate change adaption and mitigation. Restoring tidal wetlands sooner rather than later will enable marsh building before sea level rises above the elevation at which emergent vegetation will colonize. Creating buffer zones into which marshes can migrate with sea level rise will support both sea level rise mitigation and adaptation. Coordinating climate change adaption and mitigation planning will improve project outcomes.