Scoping Assessment for Pacific Northwest Blue Carbon Finance Projects

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TABLES

FIGURES

ACRONYMS / ABBREVIATIONS

Acronym	Signification
ACR	American Carbon Registry
AGB	Aboveground Biomass
ARB	Air Resources Board
BC	Blue Carbon
BGB	Belowground biomass
C	Carbon
CAR	Climate Action Reserve
CH_4	Methane
cm	Centimeter
CO_2e	Carbon Dioxide Equivalent
CORSIA	Carbon Offset and Reduction Scheme for International Aviation
CPI	Consumer Price Index
CSR	Corporate Social Responsibility
ER	Emission Reductions
GHG	Greenhouse Gas(es)
ha	Hectare
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
m	Meter
MOU	Memorandum of Understanding
NERRS	National Estuarine Research Reserve System
N_2O	Nitrous Oxide
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
ODS	Ozone Depleting Substances
OWEB	Oregon Water Enhancement Board
PNW	Pacific Northwest
PSU	Practical Salinity Unit
RCO	Recreation and Conservation Office
RGGI	Regional Greenhouse Gas Initiative

t	Metric ton
UN	United Nations
U.S.	United States
VCS	Verified Carbon Standard

GLOSSARY

Allochthonous carbon—Carbon produced in one location and deposited in another. In the context of a carbon finance project, carbon produced outside of the project area cannot be included within the crediting process.

Blue carbon—the stocks and fluxes of organic carbon and greenhouse gases in tidally influenced coastal ecosystems such as wetlands, mangroves, seagrasses, and other wetlands. Blue carbon stocks include carbon stored within the soil, living biomass above- and belowground, and non-living biomass (litter and dead wood).

Freshwater tidal wetland—tidal wetland with salinities ranging from 0 to 0.5 PSU.

Mesohaline tidal wetland—tidal wetland with salinities ranging from 5 to 18 PSU

Oligohaline tidal wetland—tidal wetland with salinities ranging from 0.5 to 5 PSU.

Polyhaline tidal wetland—tidal wetland with salinities ranging from 18 to 30 PSU.

1 Executive Summary

This Scoping Assessment for Pacific Northwest (PNW) Blue Carbon Finance Projects (Assessment), funded by the National Estuarine Research Reserve System (NERRS) Science Collaborative and the Wildlife Forever Fund: (1) provides an initial assessment of the opportunity and key considerations of connecting carbon finance to tidal wetland restoration projects in the PNW; and (2) identifies remaining PNW blue carbon data gaps that need to be addressed before developing project-level carbon finance feasibility assessments in the region. Accordingly, this Assessment evaluates the potential viability of using income from carbon markets to augment tidal wetland restoration in three PNW estuaries using a range of illustrative scenarios representing characteristics typical of existing or potential restoration initiatives within those estuaries. The three estuaries considered within this Assessment are: Skagit Delta, WA, Snohomish Estuary, WA, and Coos Estuary, OR.

One of the principle conclusions of this Assessment is that the potential for carbon finance is highest in scenarios where biomass and soil carbon sequestration exceeds soil methane (CH_4) emissions in restored tidal wetlands. Projects occurring in more polyhaline (18.0-30.0 PSU) tidal wetland restoration areas are likely to generate low CH_4 emissions while those occurring in lower salinity areas may generate higher CH_4 emissions. This Assessment identifies a promising potential tidal wetland carbon finance opportunity in the Snohomish Estuary, WA where the reestablishment of Sitka spruce along with herbaceous vegetation is estimated to generate significant carbon offsets and revenues over 40 years in a project area as small as 500 hectares (ha), given the proper location and wetland elevations. This Assessment does not find a positive result for the application of carbon finance to support conversion of wet pastureland to emergent wetland in mesohaline and oligohaline river-estuary conditions, although more research is needed on low salinity tidal wetlands in the PNW.

This Assessment applies the rigorous framework of the Verified Carbon Standard (VCS) established by Verra, a not-for-profit that establishes standards, approves methodologies, and issues offsets to carbon projects in the voluntary carbon market. The Assessment provides first-order estimates of carbon offsets and associated financial benefits from predicted changes in greenhouse gas (GHG) emissions between “baseline” (no, or impaired, tidal connection) and “with project” (tidal restoration) scenarios, or project scenarios.

Within each estuary, estimates of soil and plant carbon GHG removals and GHG emissions, specifically CH_4 and nitrous oxide (N_2O), are compiled. Additionally, the amount of allochthonous carbon[1] is estimated for each scenario. No planned restoration projects are specified in this Assessment but rather a range of illustrative scenarios are explored for each estuary (Table E1). Baseline scenarios include former agricultural and pasturelands that are seasonally wet with freshwater and contain

[1] Allochthonous carbon is carbon imported from outside an ecosystem rather than created within by plant production.

grasses and forbs, including reed canarygrass, a non-native invasive grass species that, once established, forms dense monospecific stands that are a threat to natural wetlands[2]. Project scenarios include tidal wetland restoration to mesohaline (5.0-18.0 PSU), oligohaline (0.5-5.0 PSU), and freshwater conditions. In the Snohomish estuary, Sitka spruce tidal freshwater wetland restoration scenarios are presented; this ecosystem once dominated the oligohaline and freshwater portions of PNW estuaries.

Table E1. Illustrative examples examined for baseline and project scenarios in the Pacific Northwest Blue Carbon Finance Feasibility Assessment.

Scenario	Phase	Scenario Conditions	Assumptions
1	Baseline	Former agriculture	Seasonally wet, fresh, low herbaceous biomass
	Project	Mesohaline tidal wetland	Herbaceous cover by common three square and bulrush, low CH_4 emissions
2	Baseline	Former agriculture	Seasonally wet, fresh, low herbaceous biomass
	Project	Oligohaline tidal wetland	Herbaceous cover by Lyngbye's sedge, moderate CH_4 emissions
3	Baseline	Former pasture	Seasonally wet, fresh, dominated by invasive reed canarygrass
	Project	Oligohaline tidal wetland	Herbaceous cover by Lyngbye's sedge, moderate CH_4 emissions
4	Baseline	Former pasture	Seasonally wet, fresh, dominated by invasive reed canarygrass
	Project	Freshwater tidal wetland	Herbaceous cover by Lyngbye's sedge[3], moderate CH_4 emissions
5	Baseline	Former pasture	Seasonally wet, fresh, dominated by invasive reed canarygrass
	Project	Freshwater tidal, mix of herbaceous & forested	Assuming two scenarios with different coverage of Sitka spruce (1/3 and 2/3), with the remainder as Lyngbye's sedge[2], moderate CH_4 emissions

The financial feasibility of developing a tidal restoration carbon project is analyzed by calculating the cash flows and net present value (NPV) of cash flows over the first 40 years for each illustrative project.

[2] https://www.nwcb.wa.gov/weeds/reed-canarygrass, accessed October 2019

[3] While using *C. lyngbyei* as the dominant colonizing species for mesohaline and oligohaline wetlands within PNW estuaries is appropriate, its use as the dominant colonizing species for freshwater wetlands is undertaken provisionally due to the lack of local or regional biomass data for *Carex obnupta*, *Scirpus microcarpus*, and *Juncus effusus*, the three dominant native freshwater wetland species.

For calculating the NPV of cash flows, the discount rate, which represents the required rate of return on capital invested to develop the carbon project, is assumed to be 4.0%. The NPV analyses are based on the best estimates of emission reductions for each illustrative restoration scenario, carbon offset prices, and carbon project costs. Prices for tidal wetland restoration offset are likely to be at the high end of the range for land-based offsets (assumed to be $10 per ton of CO_2) given the scarcity of projects and high interest from traditional voluntary buyers.

Due to several uncertainties in the available GHG emissions data, results are presented for each scenario using varying baseline and project assumptions, specifically soil carbon accumulation in the baseline scenario and CH_4 emissions in the project scenario, to identify conditions that would likely lead to carbon offset generation. For these analyses, the assumptions on soil carbon sequestration in the baseline scenario vary between 0 and 1.5 t C ha^{-1} yr^{-1} and soil CH_4 emissions in the project scenario vary between 0.10 and 0.40 t C ha^{-1} yr^{-1}. A NPV sensitivity analysis is also developed to better understand changes in the NPV of cash flows due to changes to carbon offset prices (annual increases from 0% to +10.0% per year) and changes in project area (from 100 to 2,500 ha).

Managed lowlands with impaired hydrologic connection are the common land use condition prior to full tidal restoration in this Assessment, and common restoration practice would be to restore full tidal connectivity. These lowlands may or may not be partially connected to tidal flow (through partial flooding typically caused by leaking tide gates), which influences baseline GHG fluxes, and are often colonized by reed canarygrass. Additionally, the majority of the potential restoration sites in the three estuaries are in low salinity areas and thus have the potential to emit more CH_4, once tidally reconnected, than they currently do prior to restoration.

The largest data gap revealed in the Assessment is the dearth of trace GHG emission measurements from PNW tidal wetlands, particularly those with salinities below 18 PSU[4]. Only one study presented CH_4 and N_2O emissions data within degraded, restored and natural tidal wetlands in two Oregon estuaries (Schultz 2019). Methane emissions within a project scenario can negate any carbon sequestered within the soil or vegetation, and it is imperative to assess the range and magnitude of emissions across seasons, salinities, estuaries and site conditions to be incorporated into future blue carbon finance feasibility assessments.

Regionally specific **research needs** include:

1) Quantification of carbon sequestration rates and CH_4 emissions on managed and unmanaged diked lands and least-disturbed tidal wetlands with salinities less than 18 PSU.
2) Understanding the fate of carbon produced in tidal wetland and exported to the nearshore ocean. Some proportion of this will be buried in marine sediments contributing to carbon

[4] Below this salinity, default values for methane emissions cannot be used and local or regional field data are required.

sequestration. Understanding the deposition of transported carbon is a growing field of interest, bringing in other coastal ecosystems such as kelp forests, but currently not recognized in carbon budgets for climate mitigation.

3) Understanding the changing CH_4 budget on coastal lands as sea levels and ground waters rise. At some point in the future, gravity drains will no longer be functional to drain lowland lands that were formerly tidal, driving up water tables and CH_4 emissions. Under such conditions, restoration to full tidal connection may not have a substantial increase in CH_4 emissions compared to baseline conditions.
4) Long-term carbon storage benefits of wetland grassland (including of reed canarygrass) should be explored. Questions remain as to the rate and duration of carbon sequestration in such wetlands.
5) Approaches and design guidance for restoring forested tidal wetlands.

Opportunities for carbon management for further consideration beyond this Assessment include:

1) Modified agricultural practices for soil carbon management;
2) Agricultural land conversion to pasture and/or wet grassland;
3) Agricultural land conversion to wetlands (including an option of grassland creation as an interim phase prior to full wetland restoration);
4) Restoration of tidal wetlands in polyhaline conditions (not identified in current project settings).
5) Tying forest carbon projects with collocated tidal wetland restoration carbon projects;
6) Tidal Sitka spruce swamp and forested floodplain restoration (identified as having high potential in this study).
7) Reconnection of saline flows to fresh or oligohaline waters impounded behind barriers.

Overall, the results of this Assessment highlight the value of accounting for emissions and emission removals across entire landscapes. Ecological co-benefits, such as increased salmonid habitat and overall climate change resilience can be derived from restoring a connected mosaic of habitats from the marine, estuarine and terrestrial environments. Over the long term (100+ years), all tidal coastal wetlands are projected to be net sinks of GHGs but soil carbon accumulation rates across shorter time frames are reduced or eliminated by soil CH_4 emissions in low salinity systems. Climate mitigation strategies are currently focused on the near-term needs but they should not overlook the recognized and significant carbon accumulation over longer timeframes and potential effects of sea level rise.

2 Introduction

Coastal wetlands, including tidal wetlands, seagrass beds and mangroves, are some of the most economically important yet most vulnerable ecosystems globally. They act as nurseries for many aquatic and terrestrial species, dampen storm surges, sequester significant amounts of carbon, and transform nutrients, among many other ecosystem services (Barbier et al. 2011, IPCC 2019). Due to their coastal location, they are intrinsically linked with sea levels and are the first to be affected by increasing rates of sea level rise (Kirwan and Megonigal 2013). Additionally, up to 50% of coastal wetlands globally already have been lost due to human-induced conversion to other land uses (Pendleton et al. 2012). Within the estuaries along the western United States, approximately 85% of vegetated tidal wetlands have been lost (Brophy et al. 2019). Over recent decades, tidal wetland restoration has increasingly garnered attention and significance, resulting in more widespread and larger projects globally. Tidal wetland restoration projects tend to be costly, on the order of $68,000 USD per hectare (ha) in developed countries (Bayraktarov et al. 2016) and are often limited in funding. Therefore, more creative sources of funding are needed for tidal wetland restoration. The formation of the voluntary carbon market and development of rigorous methodologies for incorporating tidal wetlands in it has created an opportunity for novel financing of both restoration and conservation projects (Emmer et al. 2015). Few tidal wetland restoration projects, however, have received carbon credits and associated funding, yet there is increasing interest in adopting this financing mechanism to offset high restoration costs. This Scoping Assessment for Pacific Northwest (PNW) Blue Carbon Finance Projects (Assessment), funded by the National Estuarine Research Reserve System (NERRS) Science Collaborative and the Wildlife Forever Fund, identifies: (1) provides an initial assessment of the opportunity and key considerations of connecting carbon finance to tidal wetland restoration projects in the PNW; and (2) identifies remaining PNW blue carbon data gaps that need to be addressed before developing project-level carbon finance feasibility assessments in the region.

2.1 Project Setting

This Assessment builds on several recent and ongoing advances in blue carbon (BC) research:

(1) new valuation methods for coastal wetland carbon under the Verified Carbon Standard (VCS; Emmer et al. 2015, Needelman et al. 2018);

(2) findings from the PNW BC stock assessment and database project (also NERRS Science Collaborative-funded); and

(3) BC feasibility assessments from the Snohomish Estuary (Crooks et al. 2014) and other U.S. and international projects.

This work was conducted in the Snohomish, Skagit and Coos estuaries, the latter two sites closely linked to the Padilla Bay and South Slough National Estuarine Research Reserves (NERR).

2.2 Project Objectives

The objectives of this project include: (1) perform scoping assessments for the three project estuaries to identify opportunities and key considerations of connecting to carbon finance; (2) develop preliminary assessments of projects' economic viability; (3) gain greater understanding of known, and identify, emerging information gaps and approaches for filling those gaps; and (4) engage coastal communities in blue carbon project development. While no specific restoration sites or plans are included in this analysis, the Assessment highlights where viable carbon finance projects could occur.

2.3 Project Partners

Silvestrum Climate Associates and TerraCarbon led the technical aspects of the project. Silvestrum collated the GHG emissions and removals data and TerraCarbon conducted the carbon finance feasibility analyses. End user engagement and workshop logistics and facilitation were conducted by Strategic Collaborations, LLC and the Institute for Applied Ecology.

2.4 What Is Blue Carbon?

Over the past 15 years, the crucial worldwide role of coastal ecosystems (i.e., mangroves, tidal wetlands, and seagrass beds) in sequestering significant amounts of carbon has been clearly demonstrated (Twilley et al. 1992, Duarte et al. 2005, Donato et al. 2011, McLeod et al. 2011, Sifleet et al. 2011, Fourqurean et al. 2012, Pendleton et al. 2012, Holmquist et al. 2018, Sanderman et al. 2018, Windham-Myers et al. 2018, Rogers et al. 2019). This "blue carbon" storage, so named because of its association with marine and coastal habitats, is largely the result of the extremely slow decomposition and mineralization rates of wetland plant-generated organic matter in saturated, anoxic soils. When wetland soils are dried and exposed to oxygen, typically through land conversion practices such as wetland diking and draining, oxidation occurs quickly. The stored carbon is released rapidly into the atmosphere as carbon dioxide (CO_2) when organic matter in dried wetland soils decomposes (Drexler et al. 2009, Lovelock et al. 2011, Spivak et al. 2019). This effect is particularly notable in mangroves that have been converted to shrimp ponds or cattle pastures (Kauffman et al. 2017) and with conversion to agriculture in the Sacramento-San Joaquin River Delta in California (Deverel and Leighton 2010).

2.5 End User Engagement

This Assessment is conducted in close association with another PNW blue carbon project, the PNW Carbon Stocks and Database Project[5], also supported by the NERRS Science Collaborative. Both projects are undertaken by members of the PNW Blue Carbon Working Group[6], a collaborative group of scientists, carbon finance experts, restoration practitioners, conservation leaders, land managers, policy makers, and representatives from carbon registries, funding programs and key government agencies. The working group was formed in 2014 to develop coastal blue carbon as a conservation and management tool to help mitigate climate-related changes using carbon credits, markets and other innovative strategies.

Members of the working group provide end user guidance to the projects through direct participation in remotely convened and in-person meetings designed to both inform and solicit feedback from end user teams associated with each project. Many end users are providing guidance to both projects.

2.5.1 Meetings

The Assessment project team (Crooks, Beers, Settelmyer, Swails, Emmett-Mattox, Cornu) convened the following meetings with local site teams (including prospective blue carbon project proponents and additional end users from the local area), and project end users (18 working group members):

- Sept 2018: In person meeting with the Snohomish Basin Salmon Recovery Technical Committee
  Steve Emmett-Mattox presented information on the Assessment project in person and received initial feedback on the project.
- Sept-Oct 2018: Three remotely convened project introduction meetings
  Participants included the Assessment project team and site teams. Meeting goals: (1) introduce project team to site teams (including prospective blue carbon project proponents and local end users); (2) introduce the project goals and timeline to the site team; (3) discuss local site attributes; and (4) discuss local participation at the project kick-off workshops for each site.
- Jan-Feb 2019: Three in-person project kick-off workshops

  Participants included the Assessment project team, local site teams and project end users. Workshop goals: (1) explain context and purpose of the Assessment for the local estuary; (2) describe proposed content and approaches to assess carbon project feasibility; and (3) engage site teams and project end-users in Assessment planning and provide opportunity for input into the project design. Workshop summaries are provided in Appendix A.

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[5] https://www.pnwbluecarbon.org/projects; accessed September 2019

[6] https://www.pnwbluecarbon.org/; accessed September 2019

- March 2019: Follow-up meeting to workshops
  Participants included the Assessment project team and project end users, including end users who were unable to participate in the project kick-off workshops. Meeting goals: (1) summarize for end users the proceedings of the three blue carbon workshops convened in Snohomish, Skagit and Coos estuaries; (2) discuss the Assessment team's preliminary perspectives on the opportunities and constraints for blue carbon project development at each of the project sites— including a review of preliminary carbon emissions and storage calculations for sites in each estuary; and (3) review with end users the feasibility assessment process, timeline and next steps and any early recommendations from the Assessment team.
- October 2019: Joint blue carbon projects results-sharing workshops
  Results and next-step discussions for both working group projects were combined into two workshops, one in Everett, WA and the other in Coos Bay, OR. A smaller results-sharing workshop was organized for the Skagit assessment site focused solely on Assessment results at the request of local end users in response to local political sensitivities. Workshop goals were to: (1) share and discuss the results of the draft Assessment for each project estuary, results of the PNW carbon stocks research, and associated blue carbon database development, and (2) identify and discuss remaining blue carbon information gaps for the PNW and come to consensus on next steps for PNW blue carbon research and proposal development opportunities.

3 Assessment Components

Below, key project requirements, GHG emissions, sources and assumptions, and carbon market, financial, and legal assessments are discussed. The VCS's methodology for restoring tidal wetlands and seagrass, VM0033, is the guiding document for this Assessment (Emmer et al. 2015).

3.1 Baseline and Project Scenarios

3.1.1 Baseline Scenario

The baseline scenario refers to the site conditions that would occur without the planned restoration (business as usual). This could include degraded wetlands, mudflats, or agricultural land or pastureland where natural tidal wetland or seagrass reestablishment is not likely to happen without intervention. Greenhouse gas emissions and removals from soils, vegetation, and non-CO_2 gasses need to be accounted for during the entire proposed timeframe for the project.

3.1.2 Project Scenario

The project scenario represents the planned GHG emissions reductions through restoration activities. These activities include increasing GHG removals and reductions through augmenting autochthonous soil carbon (carbon produced within the system rather than imported from another) and plant biomass, reducing CH_4 and N_2O emissions and reducing CO_2 emissions through oxidation of organic soils. There must be a net emissions reduction (or removal) when comparing GHG emissions in the project scenario to those in the baseline scenario for a carbon project to be viable.

3.2 Applicability Conditions

Certain conditions must apply to use the VCS methodology for restoring tidal wetlands and seagrass (Emmer et al. 2015). Project activities to restore a tidal wetland could include creating, restoring, and/or managing hydrological conditions, improving water quality, changing sediment supply or salinity, restoring native vegetation, and/or management activities that improve the project, such as preventing grazing or eradicating invasive species. The project activity must not displace productive activities in the project area that could results in leakage or emissions if these activities shift to a new area. One way to demonstrate that no productive activities are displaced is to establish that the project area has been abandoned or has not been profitable for at least two years so that no productive activity in the baseline scenario is displaced through project activities. The project activity also cannot disrupt, degrade or increase GHG emissions in adjacent lands.

3.3 Geographic Boundaries

The geographic boundary of the project site needs to be identified at the start of the project. A project can contain a single site or multiple sites. Sites are georeferenced and mapped with the full project area calculated, and the land rights holder and user rights identified. If needed, a project can be organized by strata (different project elements) reflecting different site conditions, including soil types, vegetation types and cover, salinity, and non-tidal bodies of water. Boundaries should reflect titled property rights in accordance with state laws on submerged lands.

3.3.1 Sea Level Rise

Projects need to incorporate projected relative sea level rise impacts. This can include inundation of additional stretches of land in the future, in both the baseline and project scenarios, and any areas that do not generate a significant carbon benefit over 100 years need to be excluded from the project area. Furthermore, related changes in water tables, vegetation composition and associated GHG emissions should also be considered in establishing baseline emissions. For example, under some scenarios, gravity drains may no longer be functional to drain diked coastal lowlands. This will drive up water tables and result in increased CH_4 emissions for some baseline scenarios. Under such conditions, reconnection to full tidal connection may not have a substantial increase in water levels or CH_4 emissions as compared to baseline conditions.

3.4 Greenhouse Gas Removals and Emissions

Both GHG removals and emissions need to be quantified in the baseline and project scenarios for a carbon finance project, specifically with respect to soil carbon, aboveground herbaceous and total tree/shrub plant carbon, and CH_4 and N_2O emissions. These values can be measured directly at the site, modeled, or drawn from the literature as regional or Tier 1[7] default estimates.

3.4.1 Soil Carbon Stocks

The largest carbon stocks in blue carbon ecosystems occur within the soil (Chmura et al. 2003, Donato et al. 2011, Fourqurean et al. 2012, Sanderman et al. 2018, Rogers et al. 2019). This carbon pool takes hundreds to thousands of years to develop, reaching depths of over 10 m in some regions, and is the most vulnerable to disturbance. Once drained and exposed to oxygen, oxidation can occur rapidly, resulting in high CO_2 emissions and land subsidence (Drexler et al. 2009). Soil carbon accumulation rates (t C ha^{-1} yr^{-1}) are needed in both the baseline and project scenarios to account for carbon changes over time.

Some wetland soils have a higher mineral content than others, depending on location and proximity to sediment sources. Not all the carbon sequestered in tidal wetland soil originates from processes occurring within the wetland (autochthonous C). Carbon created in other ecosystems can bind to sediment that is transported into wetlands by the tides and can be buried in the soil. This allochthonous carbon cannot be counted towards the carbon stock for the purposes of carbon offset accounting unless it can be demonstrated that the project causes storage of C that otherwise would be returned to the atmosphere. In lieu of site-specific data, an equation was used to estimate the proportion of allochthonous carbon based on percent soil organic matter developed by Needelman et al. (2018).

3.4.2 Plant Carbon Stocks

While not as extensive as soil carbon stocks, plant carbon stocks are key components to the total ecosystem carbon stocks. These stocks are the sum of above- and belowground biomass of trees and/or shrubs and aboveground biomass for herbaceous plants. Since the biomass of herbaceous plants is considered to be in a steady state once maximum site coverage has been obtained (assuming no net change in biomass across years with yearly growth and senescence of plant material), the amount of carbon that can be credited is limited to a maximum total value equal to 100% coverage, or on a 1:1 ratio until this is met (Emmer et al. 2015). When trees and/or shrubs are present, net

[7] Tier 1 values refer to emission factors that are readily available at national or international scales such as those provided by the IPCC and therefore are quantifiable for all countries.

annual stock change must be included, meaning annual above- and belowground growth[8]. Most studies report biomass in dry mass per unit area, and these values need to be converted to percent carbon.

3.4.3 Methane Emissions

Methane emissions within coastal ecosystems occur naturally and vary based on salinity. Wetlands that experience salinity greater than 18 PSU are very likely to have insignificant CH_4 emissions (Poffenbarger et al. 2011); however, emissions cannot be considered negligible according to the VCS unless field data are collected that demonstrate otherwise (Needelman et al. 2018). In absence of local data, the default value for tidal systems with salinities greater than 19 PSU of 0.0056 t CH_4 ha^{-1} yr^{-1} or 0.14 t CO_2e ha^{-1} yr^{-1} can be used (Emmer et al. 2015, Needelman et al. 2018). For tidal systems with salinities lower than 18 PSU, a default value cannot be used due to the large variance in emissions and therefore field-based measurements are needed (Needelman et al. 2018).

A global warming potential of 25 is used to convert CH_4 to CO_2 equivalent (CO_2e), which is the conversion used in the IPCC Fourth Assessment that is currently adopted within the VCS. There are a variety of new methods for calculating global warming potential that take into consideration the residency time of GHG in the atmosphere (Neubauer and Megonigal 2015); however, they are not currently adopted under the VCS. These advancing approaches emphasize the role of CH_4 in near term GHG management and that over the long-term wetlands tend towards net GHG sinks.

3.4.4 Nitrous Oxide Emissions

Nitrous oxide (N_2O) is a naturally occurring GHG that has a significantly greater contribution to atmospheric warming than CO_2 on the order of 298 times greater using the IPCC Fourth Assessment global warming potential. As with CH_4, N_2O can vary seasonally but is also influenced regionally by human activity via fertilizer runoff from agriculture and sewage. Emissions tend to be low within natural wetlands and are more prevalent on land, where water levels are drawn down.

3.5 Carbon Market Assessment

Carbon offsets can be transacted on voluntary or compliance carbon markets. In voluntary carbon markets, buyers are typically motivated by corporate social responsibility – they are concerned about climate change and have set a target to reduce their emissions, outside of or ahead of regulation. In compliance carbon markets, buyers are motivated to purchase offsets when they offer a more cost-

[8] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v4.1.pdf; accessed July 2019

effective way to meet their requirements to cut emissions under the law – for instance, if the price of offsets falls below the cost of allowances or the carbon tax (Goldstein 2016).

Currently, voluntary market buyers represent the main source of demand for carbon offsets from tidal restoration projects, as there are no compliance markets that currently accept offsets from these types of projects. The buyers of voluntary carbon offsets are located mainly in North America and Europe. Most buyers are multinational companies in consumer-facing industries, with companies in the energy, financial services, consumer goods, events, and transportation industries topping the list.

Voluntary carbon offsets are issued to eligible projects using approved methodologies by voluntary standards such as the VCS, American Carbon Registry (ACR), and the Climate Action Reserve (CAR). Eligible projects include a wide range of activities including wind energy production, energy efficiency improvements, reductions in landfill and livestock CH_4, and land use activities such as reforestation, improved forest management, avoiding deforestation, and tidal wetland restoration. Currently, only the VCS has an approved methodology covering the restoration of tidal wetlands that is applicable globally, including projects in the States of Washington and Oregon. The VCS is the dominant voluntary standard in the carbon market, representing about 50% of all newly issued credits (Hamrick and Gallant 2017a).

Tidal wetland restoration projects are well positioned to sell offsets to voluntary buyers as they are likely to generate several co-benefits, including increased resilience to sea level rise and improved and more nursery grounds for fish and birds. Corporate buyers with operations in the Pacific Northwest are expected to have the strongest interest in tidal restoration projects that are implemented in Oregon or Washington since these co-benefits will be most appreciated by their stakeholders.

Carbon offset prices across all project types average about \$2-\$3 per ton $CO2_e$; however, prices for offsets from land use projects trade at about \$4-\$10 per ton (Hamrick and Gallant 2017a). Prices for tidal wetland restoration offset are likely to be at the high end of the range for land-based offsets (\$10-\$20 per ton) given the scarcity of projects and high interest from traditional voluntary buyers.

Looking forward, a significant new source of demand for voluntary offsets could come from the airline sector. Because international aviation is excluded from the UN's Paris Agreement on climate change, the airline sector has committed to carbon neutral growth in international aviation beginning in 2021. These commitments will be implemented through the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) that will allow airlines to use carbon offsets to meet these GHG commitments. The ultimate impact on voluntary offset demand and prices, and the opportunity for tidal restoration projects, will be better understood after offset eligibility rules are finalized.

There are two compliance markets that currently operate in the United States - the California cap-and-trade program and the Regional Greenhouse Gas Initiative's (RGGI) cap-and-trade program in nine northeastern states. Both programs allow regulated companies to use offsets (or allowances) for compliance, and allow offsets from forest projects; however, they do not currently allow for offsets from tidal restoration projects. The California program has established a process for approving new protocols and offset prices are relatively attractive ($12 per ton), providing a potential opportunity for tidal restoration projects in the future; however; it is likely that pilot projects will need to first be developed as "proof of concept". The RGGI program appears to provide less opportunity in the medium term given low offset prices ($5 per ton), and requirements for host state to sign an MOU with the participating RGGI state.

New compliance market opportunities may emerge in the future at the state or federal level that could provide additional demand for offsets from tidal wetland projects. Whether designed as cap-and-trade or carbon fee/tax, these programs could also create additional demand for offsets from tidal wetland restoration.

3.6 Carbon Project Legal Assessment

The VCS requires project proponents to provide evidence of establishing project ownership. The VCS defines a project proponent as the individual or organization that has overall control and responsibility for the project. For land use projects, project ownership can arise "by virtue of a statutory, property or contractual right in the land, vegetation or conservational or management process that generates GHG emission reductions and/or removals", or it can arise from an enforceable and irrevocable agreement with the holder of such rights that transfers these rights to the project proponent (VCS Standard, version 3.7).

In practice, this means that the owner of the land that will be restored will own the carbon rights, unless those rights are transferred by an agreement to another party (e.g., organization developing and registering the carbon project). In any event, the land title for the land that will be restored will need to be provided as part of the evidence to demonstrate project ownership respecting the boundaries established by state laws with respect to state rights of submerged lands.

In Oregon and Washington, tidal wetlands that could be restored may be owned by private, public, and tribal landowners. In the case of public lands, it will be necessary to review the administrative rules of the agency that manages the land to ensure that any necessary approvals are secured, that the sale of carbon offsets and subsequent use of revenues follows all applicable rules. In the case of federal lands, there are precedent carbon offset projects that have occurred on US Fish and Wildlife Service lands[9]. In the case of state lands, while no precedent carbon offset projects have been identified in Oregon or Washington, carbon offsets projects have occurred on state lands in Louisiana, Tennessee,

[9] https://www.fws.gov/refuges/vision/pdfs/BiologicalCarbonSequestrationAccomplishmentsReport2009_2013.pdf; accessed July 2019

and Arkansas. In the case of county lands, a new forest carbon program in King County[10] has been implemented that will aggregate county owned and privately-owned lands within a single “grouped” project that is being developed under the VCS.

In the Pacific Northwest, many tidal restoration projects receive grant funding from various sources, including state agencies such as the Washington State Recreation and Conservation Office (RCO) and the Oregon Water Enhancement Board (OWEB). In many cases, grant funding carries certain restrictions that that should be considered if developing a carbon project.

The Washington State RCO provides grant funding to support Washington State’s habitat, outdoor recreation, and salmon habitat resources. The RCO grants can be used for land acquisition and restoration except in cases where the funding is used to comply with mitigation requirements, unless they arise from an RCO grant-assisted project.

Carbon offset projects differ from mitigation projects in important ways. Mitigation is a legal requirement to preserve, enhance, restore, or create wetlands, streams, or habitat areas to compensate for expected adverse impacts to similar nearby ecosystems. Mitigation requirements generally arise from development activities. Carbon offsetting is not a legal requirement; in compliance programs, it may be one of many options available to the regulated party to reduce emissions; in voluntary programs, the decision to reduce emissions and the decision to purchase offsets is completely discretionary and can be changed at any time.

Deeds of rights are required for each RCO grant. These deeds limit the use of grant-assisted project sites to those uses that have no overall impairment to the habitat conservation, outdoor recreation, or salmon habitat resource funded by RCO. Uses of grant-assisted project sites must be either: (1) identified in the project agreement; (2) allowed by RCO policy; or (3) approved by RCO or the funding board.

Development of a carbon project would not change the use of the project site or result in impairment to the habitat conservation, outdoor recreation, or salmon habitat resource. Rather, it would provide a source of supplemental funding that is consistent and supports the overall objectives of the grant funding.

Lastly, RCO requires that any income generated on grant-assisted projects (1) is “compatible with the funding source and the agreement”, (2) is used as matching funds or to cover project costs, including ongoing maintenance and monitoring, and (3) is consistent with the value of the service furnished[11].

[10] https://kingcounty.gov/services/environment/water-and-land/land-conservation/forest-carbon.aspx; accessed July 2019

[11] https://rco.wa.gov/documents/manuals&forms/Manual_7.pdf; accessed September 2019

Each of the requirements can be satisfied if the revenues from the sale of carbon offsets are used to supplement funding for ongoing maintenance and monitoring of the project and if the sales are conducted at prevailing market prices.

The Oregon Water Enhancement Board (OWEB) is a state agency that provides grants to help Oregonians take care of local streams, rivers, wetlands, and natural areas. OWEB grant programs include restoration and land acquisition programs. Like RCO, OWEB does not provide restoration grant funding to projects constructed solely to comply with a state or federal agency enforcement order, legal judgment or mitigation requirement. OWEB restoration grant agreements include access, monitoring and reporting requirements, but do not prohibit or limit the use of the restored area in any way[12]. OWEB land acquisition grants also include access requirements, as well as requirements that subsequent conveyances be made subject to OWEB approval and shall not result in a profit[13]. The sale of carbon offsets from a restoration project that occurs on land acquired with OWEB grant funding does not result in a conveyance of the land or easement acquired, and therefore appears to be consistent with the terms of the OWEB grant guidelines.

In both the case of OWEB and RCO grant funded restoration where a carbon project may also be developed, the potential to generate carbon finance funding should be identified and integrated into these grant agreements to provide clarity on ownership of carbon rights and uses of carbon revenues. In some cases, the potential for carbon financing may be important to include in grant proposals and may strengthen the competitiveness of the proposal.

3.7 Carbon Project Financial Assessment

The financial feasibility of developing a tidal restoration carbon project was analyzed by calculating the cash flows and net present value (NPV) of cash flows expected over the first 40 years for each illustrative project. As discussed below, illustrative projects assessed include: (1) restoring pasture/agricultural land to tidal freshwater wetland, (2) restoring pasture/agricultural land to tidal mesohaline wetland, (3) restoring pasture/agricultural land to tidal oligohaline wetland, and (4) restoring pasture/agricultural land to tidal freshwater wetland forested with Sitka spruce. The NPV analysis is based on the best estimates of emission reductions for each illustrative restoration scenario (as detailed in section 4), carbon offset prices, as well as carbon project costs.

The key assumptions used in the analysis are described below.

[12] https://secure.sos.state.or.us/oard/displayChapterRules.action?selectedChapter=167; accessed September 2019

[13] https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=3244; accessed September 2019

Baseline emissions/removals

- **Baseline soil emissions/removals** are the soil carbon, soil CH_4, and soil N_2O emissions/removals in the baseline (pasture) land use scenario.
- **Baseline biomass emissions/removals** is the change in carbon stocks in aboveground herbaceous and above- and belowground woody biomass in the baseline land use scenario. For this analysis, vegetation in the pasture is assumed to be 100% grass at the start and end of the baseline period, and therefore changes in biomass carbon stocks in the baseline are estimated at zero.

Project emissions/removals

- **Project carbon soil emissions/removals** are the soil carbon, soil CH_4, and soil N_2O emissions/removals in the project (restored) land use scenario. Negative values refer to removals and positive values refer to emissions. For these emission reduction calculations, it is assumed that restoration occurs over five years.
- **Project biomass emissions/removals** are the change in carbon stocks from herbaceous and woody biomass in the project land use scenario. For this analysis, low biomass pasture grass is assumed to be replaced with higher biomass wetland sedges when restored to tidal fresh, oligohaline and mesohaline wetlands, and with higher biomass wetland sedges and Sitka spruce when restored to tidal forested wetland.

Gross reductions

- **Gross emission reductions** are the difference between emissions from soil and biomass in the baseline scenario and in the project scenarios (before any applicable deductions for uncertainty, leakage, or non-permanence).

Deductions

- **Uncertainty** is the deduction for uncertainty in estimating baseline and carbon stocks and is required only if the precision of the emission reduction estimates exceed 20% at the 90% confidence level or 30% at the 95% confidence level. Assumptions are made that the precision would fall below this level, and that the deduction for uncertainty would be zero.
- **Leakage** is the deduction for offsite emissions resulting from the project activity. As per the methodology applicability conditions, no productive activities are assumed to be displaced by the restoration projects (meaning, pastures that are restored have been abandoned).
- **Non-permanence buffer** represents the contribution that the project must make to the non-permanence buffer pool to protect against potential future reversals (e.g., project activity fails and CO_2 that has been credited is released back into the atmosphere). It is expressed as a percentage of the gross emission reductions related to the project's net CO_2 benefits minus uncertainty. Net CH_4 and N_2O benefits are not subject to the buffer as these avoided emissions cannot be reversed. The buffer is established at the time that the project is initially registered and must be updated at each verification event. A 15% non-permanence buffer is assumed for the projects, which is line with other U.S. land-based carbon projects.

Carbon Offsets

- **Carbon offsets** are calculated as the gross emission reductions less any deductions for uncertainty, leakage or non-permanence and represent the amount of carbon credits that can be issued and sold.

Carbon Revenues and Costs

- **Carbon prices** are assumed to be $10 per ton initially. The initial price represents a premium to average carbon offset prices observed in the voluntary market recognizing the strong co-benefits and scarcity of blue carbon offset projects. For reference, the average voluntary carbon price in 2016 received by project developers across all project types was $3 per ton, while prices for forest/land use projects ranged from $4.20 per ton (avoided deforestation) to $9.50 per ton (improved forest management) (Hamrick and Gallant 2017b).
- **Carbon revenues** are derived by multiplying the carbon offsets by the applicable carbon price over the 40-year projection period.
- **Carbon development and validation costs** are assumed to be $150,000 and relate to the third-party fees and travel expenses of preparing ($100,000) and validating ($50,000) the Project Description to be registered with the VCS. This estimate is based on experience for similar land use projects. These are one-time expenses that are incurred at the inception of the project.
- **Carbon monitoring and verification costs** are assumed to be $75,000 per monitoring event assuming 5-year monitoring intervals (maximum elapsed time between verifications before VCS buffer credits are put on hold). The estimated costs include the costs to collect soil and biomass carbon data ($25-$35,000 per event) and preparing and verifying the VCS monitoring report ($40,000-$50,000 per event).
- **Carbon price increases** are assumed to be 0-10.0% per year; using initial carbon prices of $10.00 per ton, and 10.0% per annum increase, carbon prices are estimated at approximately $25, $70, and $175 per ton in 2030, 2040, and 2050, respectively. For reference, the World Bank estimates the low/high price of carbon needed to achieve GHG reductions to keep warming at or below 2°C at $50-$100 per ton in 2030, $63-$125 per ton in 2040, and $78-$156 per ton in 2050 (World Bank 2017).
- **Carbon expense increases** are assumed to be 2.5% per year to reflect general price inflation.

Net Cash Flows and Present Value

- **Net cash flows** are carbon revenues less carbon costs over the 40-year projection period.
- **Net present value (NPV)** of net cash flows are the discounted value of future net cash flows and represent the value of future cash flows in today's dollars.
- **Discount rate** for calculating the NPV of cash flows is assumed to be 4.0%. The discount rate represents the required rate of return on capital invested to develop the carbon project and may differ by organization or project proponent.

Due to several uncertainties in the data available, results are presented across a range of GHG and financial assumptions and to identify the conditions that would likely lead to carbon offset generation in each restoration scenario. Assumptions on soil carbon sequestration in the baseline scenario vary between 0 and 1.5 t C ha^{-1} yr^{-1} and soil CH_4 emissions in the project scenario between 0.10 and 0.80 t C ha^{-1} yr^{-1} to reflect the potential site-specific variability in these emissions. Assumptions for carbon offset prices vary from 0% to +10.0% per year and for the project area from 100 to 2,500 ha.

4 Case Studies

The three estuaries in the PNW region considered to assess the feasibility of a blue carbon finance project are: Skagit Delta, WA, Snohomish Estuary, WA, and Coos Estuary, OR. All three are river dominated, meaning that these estuarine ecosystems are influenced more by freshwater inputs than by marine waters. All three estuaries also have been significantly altered by past human activities, providing ample opportunities for tidal wetland restoration.

4.1 Skagit Delta, Washington

4.1.1 Site Introduction

The Skagit delta is in the northeastern portion of the Puget Sound (Figure 1). The Skagit River is the largest river flowing into the Sound and is also its largest source of sediment (Czuba et al. 2011). Since the mid-1800s, roughly 80% of the tidal wetlands within the delta has been diked, drained and converted to agriculture and urban development (Collins et al. 2003, Brophy et al. 2019); the delta has served as the PNW's most productive agricultural land. Recently, and despite the high suspended sediment concentrations and loads in the delta, remaining un-diked tidal wetlands in the system have begun to erode due to increased wave activity, a process likely to increase with predicted sea level rise (Hood et al. 2016). Additionally, levees along the Skagit River could be increasing river current speeds, forcing sediment into the bay and away from the un-diked wetlands.

Source: ESRI, Digital Global, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1. Imagery of the Skagit Delta, WA.

4.1.2 Local Partners

The local project partners within the Skagit Delta that provided key information and data were Padilla Bay National Estuarine Research Reserve, Washington Department of Fish and Wildlife, Skagetonians to Preserve Farmland, and the National Oceanic and Atmospheric Administration (NOAA) Restoration Center. They facilitated tours of current and future restoration sites, proposed plans for future wetland restoration targets, and provided key insight into farming activities, traditions, and community perspectives.

4.1.3 Analytical Approach

a) Baseline Scenario

All baseline scenarios considered are former agricultural land that is seasonally wet during the winter and spring (Table 1). Although not explicitly measured, soil carbon accumulation rates assessed range from 0.5 to 1.5 t C ha^{-1} yr^{-1} (1.84 – 5.50 t CO_2e ha^{-1} yr^{-1}). The midpoint of 1 t C ha^{-1} yr^{-1} is based on soil C accumulation rates in abandoned farm fields across the United States (Koch et al. 2019) and a low proportion allochthonous carbon is assumed since the sites are not often breached during storms or flood events. Aboveground biomass is based on abandoned farm fields biomass (Steinshamn et al. 2018). Methane and N_2O emissions are based on measurements made in disturbed former tidal wetlands sites in coastal Oregon (Schultz 2019).

b) Project Scenario

Two project scenarios are considered based on potential restoration site characteristics: a tidal mesohaline wetland restoration and a tidal oligohaline wetland restoration (Table 1). Under both project scenarios, a soil carbon accumulation rate of 3.521 t C ha^{-1} yr^{-1} (12.910 t CO_2e ha^{-1} yr^{-1}) from North Ebey Island, an oligohaline restoration site in the Snohomish estuary, Washington, is used (Crooks et al. 2014) and full restoration (and carbon accumulation) is assumed to occur after five years. Due to the high suspended sediment concentrations from the Skagit River, the proportion of allochthonous carbon is greater than in the other estuaries. Under the mesohaline wetland scenario, the dominant herbaceous tidal wetland plant is assumed to be a mix of *Schoenoplectus americanus* and *Bolboschoenus maritimus* (Ewing 1986). The herbaceous plant C stock is calculated using an aboveground biomass value of 1.48 t C ha^{-1} (5.43 t CO_2e ha^{-1}; Ewing 1986) and percent C conversion of 0.45 (Emmer et al. 2015), which is all multiplied by 0.5 to account for seasonality in growth. In the oligohaline wetland restoration scenario, the dominant herbaceous tidal wetland plant is assumed to be *Carex lyngbyei*. Its biomass carbon stock is calculated assuming an aboveground biomass value of 5.3 t C ha^{-1} (19.43 t CO_2e ha^{-1}; Ewing 1986), the same percent C conversion (45%), and the same seasonality growth conditions (multiplied by 0.5) as described above. An illustrative project size of 100 ha is used, which is based on planned restoration site areas. Methane and N_2O emissions assumptions are derived from observations in meso and polyhaline tidal wetlands in coastal Oregon (Schultz 2019).

Table 1. Greenhouse gas flux data used in the analysis for carbon financing in the Skagit Delta, WA. Negative values denote to **GHG removals** and positive values denote **GHG emissions**.

Scenario #	Phase	Scenario Conditions	Soil C accumulation (t CO_2e ha^{-1} yr^{-1})	Proportion alloch. C	AGB C stock (t CO_2e ha^{-1})	CH_4 (g m^{-2} yr^{-1})	CH_4 (t CO_2e ha^{-1} yr^{-1}) [n]	N_2O (t ha^{-1} yr^{-1})	N_2O (t CO_2e ha^{-1} yr^{-1})
1	Baseline	Former ag., seasonally wet	-1.84 – -5.50	0.094	-1.62	1.39	0.35	0.0012	0.36
	Project	Mesohaline, herbaceous	-12.91	0.439	-5.43	10 - 40	2.50 – 10.00	0.0005	0.16
2	Baseline	Former ag., seasonally wet	-1.84 – -5.50	0.094	-1.62	1.39	0.35	0.0012	0.36
	Project	Oligohaline, herbaceous	-12.91	0.439	-9.72	10 - 40	2.50 – 10.00	0.0034	1.01

[n] The current VM0033 methodology uses a global warming potential of 25 for methane and 298 for nitrous oxide. Although there are updated values and calculations for global warming potential, the VM0033 methodology will be followed.

4.1.4 GHG Reductions and Emissions Results

In these hypothetical examples of restoring abandoned agricultural fields in the Skagit Delta to either tidal mesohaline or oligohaline wetlands, changes in carbon emissions and removals occur (Table 1). For soil carbon accumulation rates, the amount of carbon amassed increases with restoration activity; 40% of this gain, however, is allochthonous material and thus does not count towards crediting. The increase in carbon accumulation is negated in part by corresponding increases in CH_4 emissions with restoration. Nitrous oxide emissions are projected to decrease under scenarios where sites are restored to mesohaline wetlands and increase when a site is restored to oligohaline wetlands. Restoration to either wetland type also results in a modest increase in herbaceous vegetation carbon storage.

Using the assumptions described above, carbon offsets are projected that would be generated by converting pasture to (1) tidal oligohaline wetland (Table 2) and (2) tidal mesohaline wetland (Table 3). Carbon offsets are projected over a 40-year period assuming a 100 ha (247 acre) project area. Positive values represent GHG removals (sequestration) or net emission reductions while negative amounts represent GHG emissions (all stated in tons of CO_2e). Detailed calculations for a scenario assuming low baseline soil carbon accumulation (0.50 t C ha^{-1} yr^{-1}) and project soil CH_4 emissions (0.10 t CH_4 ha^{-1} yr^{-1}) are provided in Appendix A (Table A-1).

Table 2. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal oligohaline wetland** in the Skagit Delta, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.25**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	10,049	49	-	-
	0.50	7,225	-	-	-
	0.75	4,401	-	-	-
	1.00	1,577	-	-	-
	1.50	-	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

Table 3. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal mesohaline wetland** in the Skagit Delta, WA.

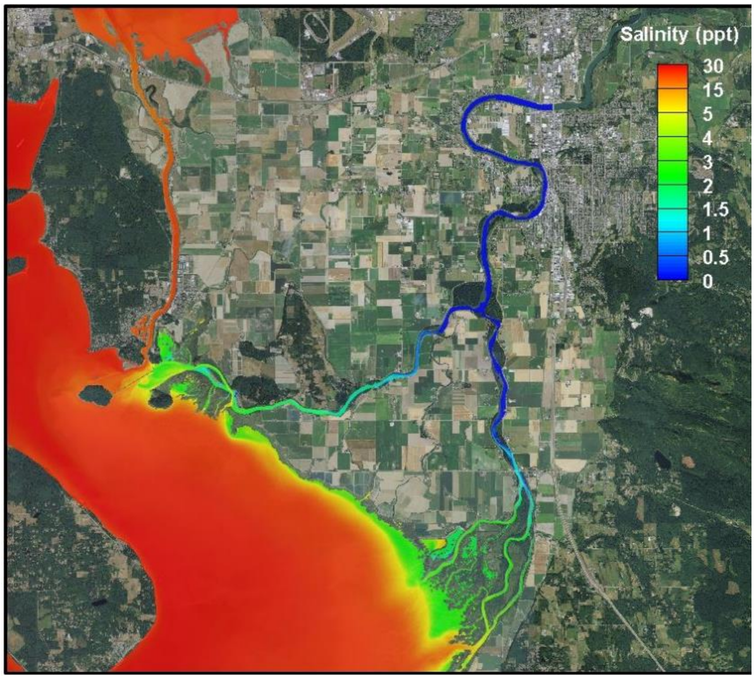
		Project soil CH_4 ($t\ CH_4\ ha^{-1}\ yr^{-1}$)			
		0.10	**0.22**	**0.25**	**0.40**
Baseline soil C accumulation rate ($t\ C\ ha^{-1}\ yr^{-1}$)	**0.25**	13,093	3,093	-	-
	0.50	10,269	269	-	-
	0.75	7,446	-	-	-
	1.00	4,622	-	-	-
	1.50	-	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

Differences in results between the two restoration scenarios reflect slight differences in assumptions on herbaceous biomass stocks and N_2O emissions in the project scenario.

4.1.5 Uncertainties

Soil carbon sequestration in the baseline scenario and soil CH_4 emissions in the project scenario are two key assumptions that can vary based on site-specific conditions including vegetation and salinity. Salinity within the estuary is variable (Figure 2); areas with salinity greater than 18 PSU, denoted in red, are likely to have low or negligible CH_4 emissions whereas CH_4 emissions are likely in all the other parts of the estuary with lower salinity. To date, no measurements of CH_4 have occurred within the Skagit Delta and uncertainty exists in the applicability of data used from sites in coastal Oregon. Additionally, data on soil carbon stocks and accumulation within active or abandoned agricultural lands is lacking within the Puget Sound region and this data input can significantly impact estimates of baseline conditions. The results above illustrate the impact of these assumptions and the potential conditions that would lead to carbon offset generation in each restoration scenario (Tables 2 and 3). As illustrated above, carbon offset generation is positive in all restoration scenarios when project soil CH_4 emissions are low (less than 0.10 $t\ CH_4\ ha^{-1}\ yr^{-1}$) and highest when baseline soil sequestration is low (less than 0.50 $t\ C\ ha^{-1}\ yr^{-1}$).



Source: Smith et al. 2017

Figure 2. Salinity ranges during low flow and high spring tide in the Skagit Delta, WA.

The lower the soil C accumulation rates in the baseline scenario and the lower the CH_4 emissions in the project scenario, the more likely a project is to generate carbon credits. However, the data are not available to identify where these conditions are met primarily due to the scarcity and variability of CH_4 measurements observed in low salinity systems in the PNW.

4.1.6 Carbon Finance Results

Based on the offset estimates presented above, the potential carbon revenues have been calculated for each restoration scenario (Tables 4 and 5). As illustrated below, potential revenues over 40 years are estimated at \$0.0-\$0.5 million for a 100-ha tidal wetland restoration depending on baseline soil carbon accumulation and project soil CH_4 emission rates.

Table 4. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal oligohaline wetland** at $10 per ton + 5.0% increase per year in the Skagit Delta, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$362,460	$3,415	$0	$0
	0.50	$263,977	$0	$0	$0
	0.75	$165,495	$0	$0	$0
	1.00	$65,977	$0	$0	$0
	1.50	$0	$0	$0	$0

Table 5. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal mesohaline wetland** at $10 per ton + 5.0% increase per year in the Skagit Delta, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$476,706	$126,499	$0	$0
	0.50	$378,224	$17,095	$0	$0
	0.75	$279,741	$0	$0	$0
	1.00	$180,497	$0	$0	$0
	1.50	$0	$0	$0	$0

Carbon costs, considering estimated upfront and ongoing monitoring costs, and general cost inflation, are estimated at $1.2 million over 40 years. This estimate is independent of project scale as these costs are largely fixed for most projects. Thus, carbon revenues for a 100-ha project under all baseline soil carbon and project soil CH_4 scenarios and using our price assumptions (per above) are not sufficient to cover all of these costs.

However, for projects with low baseline soil carbon and project soil CH_4emissions, larger project scales and/or higher carbon prices could generate carbon revenues that exceed carbon costs and provide additional net funding for the restoration project (Tables 6 and 7). For example, a 1,000-ha project to restore oligohaline tidal wetlands with low baseline soil carbon accumulation and project soil CH_4 emissions could generate $1.4 million in net cash flows over 40 years assuming a $10 per ton initial carbon price that increases at 5.0% per annum. Net cash flows over 40 years in this same scenario increase to $10 million if carbon prices increase 10.0% per annum.

Table 6. Summary of net cash flows over 40 years for 100 ha restoration of abandoned land to **tidal oligohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Skagit Delta, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,165,866)	($1,103,390)	($974,137)	($113,265)
	500	($876,873)	($564,494)	$81,772	$4,386,130
	1,000	($515,633)	$109,126	$1,401,659	$10,010,374
	2,500	$568,090	$2,129,986	$5,361,317	$26,883,107

Table 7. Summary of net cash flows over 40 years for 100 ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Skagit Delta, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,135,421)	($1,045,691)	($859,890)	$378,401
	500	($724,650)	($275,996)	$653,004	$6,884,461
	1,000	($211,186)	$686,121	$2,544,122	$14,927,036
	2,500	$1,329,207	$3,527,474	$8,217,476	$39,174,762

The net present value (NPV) of these cash flows in today's dollars have also been calculated for each restoration scenario (Tables 8 and 9). In the prior examples assuming 1,000 ha restoration of tidal oligohaline wetlands and assuming annual carbon price increases of 5.0% and 10.0% per annum, the net present values of the cash flows are equal to $0.3 million and $2.7 million respectively (Table 8).

Table 8. Summary of NPV over 40 years for 100 ha restoration of abandoned land to **tidal oligohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Skagit Delta, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($557,698)	($536,969)	($497,496)	($261,337)
	500	($433,614)	($329,971)	($132,604)	$1,048,191
	1,000	($278,508)	($71,223)	$323,512	$2,685,100
	2,500	$186,808	$705,022	$1,691,859	$7,595,829

Table 9. Summary of NPV over 40 years for 100 ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Skagit Delta, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($545,123)	($515,433)	($458,785)	($119,322)
	500	($370,738)	($222,289)	$60,951	$1,758,266
	1,000	($152,756)	$144,142	$710,621	$4,105,251
	2,500	$501,188	$1,243,432	$2,659,632	$11,146,206

4.1.7 Key Outcomes and Next Steps

The present-day landscape of the Skagit delta is vastly modified from the historic condition (Collins et al. 2003). Once a landscape of expansive estuarine emergent and forested wetlands, the delta is now given over to agriculture. The historic delta would have held very substantial stores of biomass and soil carbon that accumulated over thousands of years. The Delta would also have been a substantial source of carbon that flowed from the wetlands to support the Puget Sound's marine food chain.

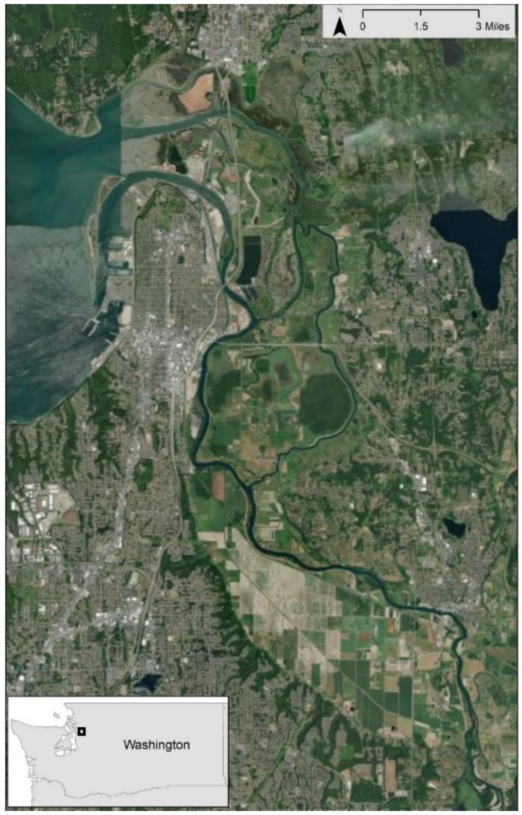
The present-day landscape, while providing substantial agricultural value, is largely depleted in biomass and soil carbon (discussions at first workshop did not identify remaining areas of peatland soils under agricultural use). Most of the Skagit delta has likely ceased to be a major source of carbon from soils since active tilling over the past century has depleted the once rich organic carbon stores.

The Skagit river remains a large source of freshwater to Puget Sound. Flows of water that once spread across the deltaic landscape are now confined to embanked channels with the effect of limiting saline incursion. Plans for large scale ecosystem restoration are not under consideration. Small scale restoration actions have been undertaken and are further planned along the riverbank margins. While providing many ecological benefits, wetland restorations in these settings may not provide substantial near-term (decadal scale) climate mitigation benefits (outside of countering land subsidence with agriculture) in cases where high rates of soil carbon sequestration may be tempered by increased soil CH_4 emissions.

4.2 Snohomish Estuary, Washington

4.2.1 Site Introduction

The Snohomish Estuary is located within a mosaic of diverse land uses: urban, tribal, least disturbed and restored tidal wetlands, crop and pastureland (Figure 3). The estuary once was comprised of tidal polyhaline, mesohaline and freshwater emergent wetlands, tidal scrub shrub wetlands, but mostly expansive tidal forested wetlands (Collins et al. 2011). Roughly 90% of the estuary was converted to other land uses, representing a 5,658-ha loss of vegetated tidal wetland (Brophy et al. 2019). This trend changed in the last decade when 1,300 ha of former tidal wetlands in the Snohomish estuary were committed to restoration and are now in various stages of planning or have been restored (Crooks et al. 2014, Rice et al. 2016). Due to its unique history and capacity for wetland restoration, an estuary-wide blue carbon assessment was conducted in 2013 to document soil carbon accumulation rates across a spectrum of historic, restored, and diked and drained wetlands, and to estimate the amount of carbon lost through wetland conversion and the potential carbon sequestration that could occur with restoration (Crooks et al. 2014). This study has served as the foundation for this Assessment.



Source: ESRI, Digital Global, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Figure 3. Imagery of the Snohomish Estuary, WA.

4.2.2 Local Partners

During workshops and site visits, the PNW Blue Carbon Finance Assessment team was supported in the Snohomish Estuary by contributions from representatives of the Tulalip Tribes, Western Washington University, Washington Department of Fish and Wildlife, Snohomish County, King County, Puget Sound Partnership, Washington Recreation and Conservation Office, National Fisheries Conservation Center and the Institute for Applied Ecology. These agencies provided logistical support and/or added key insights and data into the Assessment for the region.

4.2.3 Analytical Approach

a) Baseline Scenario

The baseline scenarios considered are on former pastureland (Table 10), whose plant community is comprised mostly of reed canarygrass, *Phalaris arundinacea*, a non-native tall bunchgrass that has aggressively invaded North American freshwater wetlands, outcompeting native vegetation and creating dense monospecific stands[15]. To date, no soil carbon accumulation data have been collected in reed canarygrass stands within the Snohomish estuary. In lieu of these data, a range of 0.25-1.50 t C ha^{-1} yr^{-1} (1.84-5.50 t CO_2e ha^{-1} yr^{-1}) is assessed, and a low but not negligible proportion of allochthonous carbon is used. Reed canarygrass biomass estimates are collated from a variety of sources and the average value is used (Sahramaa et al. 2003, Kandel et al. 2013) and the value is multiplied by 0.5 to account for seasonal variability (Emmer et al. 2015). Methane and N_2O emissions are based on measurements made in disturbed former wetlands sites in coastal Oregon (Schultz 2019).

b) Project Scenario

In the project scenario, a suite of predicted habitat types is incorporated (Table 10). Since none of the potential restoration sites within the estuary are former polyhaline wetlands, this scenario is not considered. Under all project scenarios, a soil carbon accumulation rate from North Ebey Island, an oligohaline restoration site in the Snohomish estuary, is used (Crooks et al. 2014) and full restoration (and carbon accumulation) is assumed to occur after five years. Under both, the freshwater and mesohaline tidal restoration conditions, the dominant herbaceous tidal wetland plant is assumed to be *Carex lyngbyei*[16]. The herbaceous plant C stock is calculated using an aboveground biomass value of 5.3 t C ha^{-1} (Ewing 1986), and percent C value of 45% (Emmer et al. 2015), which is multiplied by 0.5 to account for seasonality in growth. In two scenarios, Sitka spruce tree carbon stock data are incorporated: one assuming one third of the restoration site would be covered by Sitka spruce and the rest by *C. lyngbyei* and another where two thirds of the site is Sitka spruce and the rest is *C. lyngbyei*. This coverage is based on visual assessment of intact forested wetland sites in the estuary. Tree carbon stock data are estimated using a yield curve over a 40-year growth period (Smith et al. 2006). Methane and N_2O emissions assumptions are derived from coastal Oregon (Schultz 2019). An illustrative project size of 100-ha is used, which is based on planned restoration site areas.

[15] There is a native reed canarygrass in the United States; however, an ecotype from Eurasia was introduced and is either entirely responsible for the invasions or has hybridized with the native ecotype (Maurer et al. 2003).

[16] While using *C. lyngbyei* as the dominant colonizing species for mesohaline and oligohaline wetlands within PNW estuaries is appropriate, its use as the dominant colonizing species for freshwater wetlands is undertaken provisionally due to the lack of local or regional biomass data for *Carex obnupta, Scirpus microcarpus*, and *Juncus effusus*, the three dominant native freshwater wetland species.

Table 10. Greenhouse gas flux data used in the analysis for carbon financing in the Snohomish Estuary, WA. Negative values refer to **GHG removals** and positive values refer to **GHG emissions**. (RCG = reed canarygrass; biomass values for Sitka spruce include cumulative above- and belowground biomass per ha over 40 years)

Scenario #	Phase	Scenario conditions	Soil C accumulation (t CO_2e ha^{-1} yr^{-1})	Prop. alloch. C	Herbaceous AGB C stock (t CO_2e ha^{-1})	Sitka spruce C stock (t CO_2e ha^{-1})	CH_4 (g m^{-2} yr^{-1})	CH_4 (t CO_2e ha^{-1} yr^{-1})	N_2O (t ha^{-1} yr^{-1})	N_2O (t CO_2e ha^{-1} yr^{-1})
1	Baseline	Former pasture, RCG	-1.84 – -5.50	0.094	-8.75	-	2.44	0.61	0.0006	0.17
	Project	Freshwater, herbaceous	-12.91	0.372	-9.72	-	10 - 40	2.50 – 10.00	0.0034	1.01
2	Baseline	Former pasture, RCG	-1.84 – -5.50	0.094	-8.75	-	2.44	0.61	0.0006	0.17
	Project	Freshwater, 1/3 Sitka Spruce	-12.91	0.249	-6.48	-197.8	10 - 40	2.50 – 10.00	0.0034	1.01
3	Baseline	Former pasture, RCG	-1.84 – -5.50	0.094	-8.75	-	2.44	0.61	0.0006	0.17
	Project	Freshwater, 2/3 Sitka Spruce	-12.91	0.249	-3.24	-410.6	10 - 40	2.50 – 10.00	0.0034	1.01
4	Baseline	Former pasture, RCG	-1.84 – -5.50	0.094	-8.75	-	2.44	0.61	0.0006	0.17
	Project	Mesohaline, herbaceous	-12.91	0.372	-9.72	-	10 - 40	2.50 – 10.00	0.0005	0.16

4.2.4 GHG Reductions and Emissions Results

Unlike in the Skagit Delta, many opportunities for tidal wetland restoration in the Snohomish Estuary have been identified and many projects are in the planning stages or have been implemented. However, no specific sites are specified in this analysis. When restoring abandoned pastureland in the Snohomish Estuary to either tidal freshwater or mesohaline herbaceous wetlands or tidal forested freshwater wetlands, changes in carbon emissions and removals occur (Tables 11 through 14). For soil carbon accumulation rates, the amount of carbon accumulated increased with the restoration activity; approximately 25-40% of this gain, however, is allochthonous material and thus does not count towards crediting[17]. This increase in carbon accumulation is in part also negated by corresponding increases in CH_4 and N_2O emissions with restoration, particularly in the tidal freshwater wetland restoration scenario. Restoration to either herbaceous tidal wetland type results in a modest increase in vegetation carbon storage. However, restoring tidal forested freshwater wetlands significantly increases the potential to accumulate carbon in the woody material of the Sitka spruce.

Using the assumptions described above, carbon offsets are projected that would be generated by converting pasture to (1) tidal freshwater wetland (Table 11), tidal forested freshwater wetland with (2) one-third (Table 12) and (3) two-thirds Sitka spruce coverage (Table 13), and (4) tidal mesohaline wetland (Table 14). Carbon offsets are projected over a 40-year period assuming a 100-ha (247 acre) project area. Detailed calculations for a scenario assuming low baseline soil carbon accumulation (0.50 t C ha^{-1} yr^{-1}) and project soil CH_4 emissions (0.10 t CH_4 ha^{-1} yr^{-1}) are provided in Appendix A (Table A-2)

[17] Unless further analysis can demonstrate that allochthonous carbon buried in situ is mineralized if transported beyond the estuary.

Table 11. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal freshwater wetland** in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	12,475	2,475	-	-
	0.50	9,651	-	-	-
	0.75	6,828	-	-	-
	1.00	4,004	-	-	-
	1.50	-	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

Table 12. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering one third of the wetland** in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	35,161	25,161	15,161	5,161
	0.50	32,337	22,337	12,337	2,337
	0.75	29,513	19,513	9,513	-
	1.00	26,689	16,689	6,689	-
	1.50	21,042	11,042	1,042	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

Table 13. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering two thirds of the wetland** in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	53,249	43,429	33,249	23,249
	0.50	50,425	40,425	30,425	20,425
	0.75	47,602	37,602	27,602	17,602
	1.00	44,778	34,778	24,778	14,778
	1.50	39,131	29,131	19,131	9,131

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset

Table 14. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal mesohaline wetland** in the Snohomish Estuary, WA.

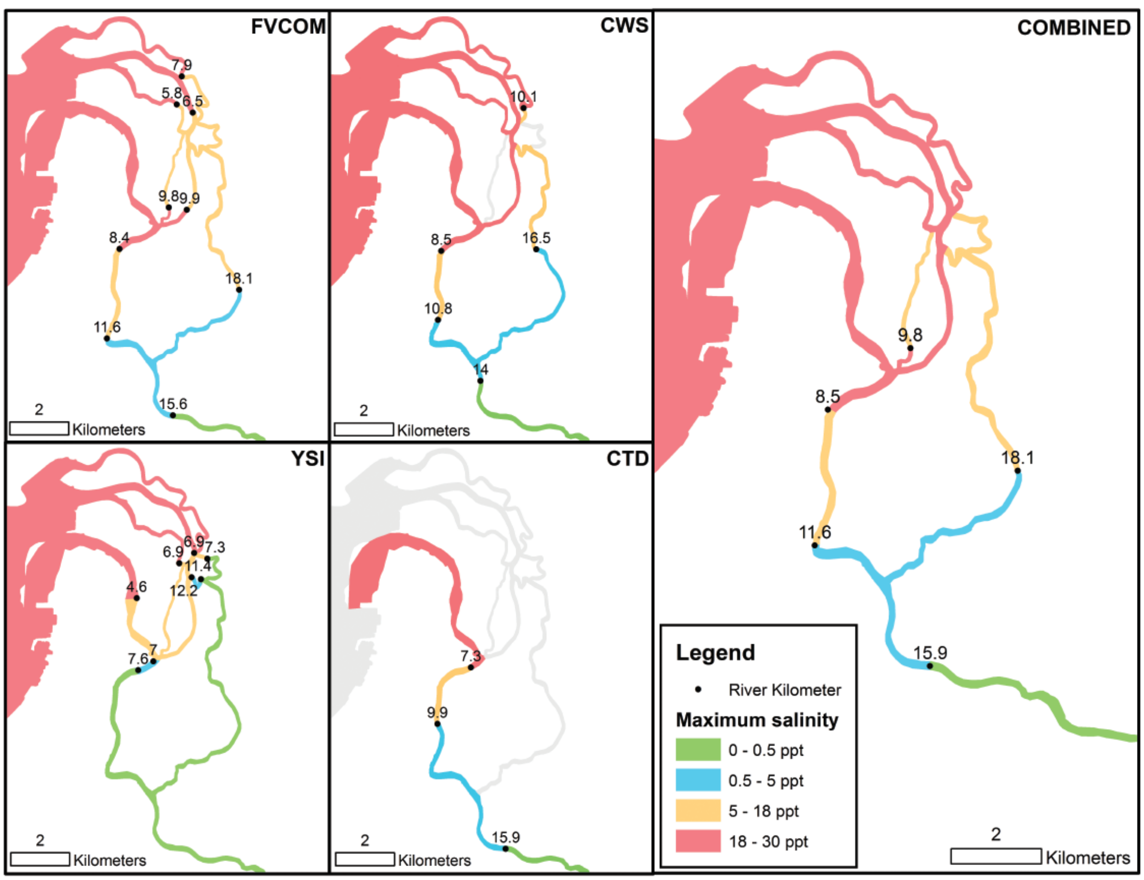
		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	15,884	5,884	-	-
	0.50	13,060	3,060	-	-
	0.75	10,237	237	-	-
	1.00	7,413	-	-	-
	1.50	1,766	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

As illustrated above (Tables 11 and 14), rewetting and restoring former pasture to native wetland sedges would generate carbon offsets only where project soil CH_4 emissions are very low (equal to or less than 0.10 tons CH_4 ha^{-1} yr^{-1}). In the case where Sitka spruce is also planted in the project area (Tables 12 and 13), the additional carbon sequestered by woody biomass yields a positive net GHG benefit over 40 years in cases where soil CH_4 emissions are higher (up to 0.30 t CH_4 ha^{-1} yr^{-1}).

4.2.5 Uncertainties

Soil carbon sequestration in the baseline scenario and soil CH_4 emissions in the project scenario are two key assumptions that can vary based on site-specific conditions including vegetation and salinity. Salinity within the estuary is variable (Figure 4); areas with salinities greater than 18 PSU (18-30 PSU), denoted in red, are likely to have low or negligible CH_4 emissions whereas CH_4 emissions are likely in all the other parts of the estuary with lower salinity. To date, no measurements of CH_4 have occurred within the Snohomish Estuary and uncertainty exists in the applicability of data used from sites in coastal Oregon. Additionally, although soil carbon accumulation rates have been documented within local pastureland and degraded wetlands, uncertainty exists as to how long sites dominated by reed canarygrass will continue to accumulate carbon and if this phenomenon is consistent across sites in the estuary. The results above illustrate the impact of these assumptions and the potential conditions that would lead to carbon offset generation in each restoration scenario (Tables 11 to 14). As illustrated above, carbon offset generation is positive in all restoration scenarios when baseline soil carbon sequestration is low (less than 1.0 C ha^{-1} yr^{-1}) and when project soil CH_4 emissions are low (less than 0.10 CH_4 ha^{-1} yr^{-1}).



Source: Hall et al 2018

Figure 4. Map of maximum salinities within the Snohomish Estuary, WA.

The lower CH_4 emissions in the project scenario, and the lower soil C accumulation rates in the baseline scenario, the more likely a project is to generate carbon credits. However, the data are not available to identify where these conditions are met primarily due to the scarcity and variability of methane measurements observed in low salinity systems in the PNW. Restoration projects that incorporate Sitka spruce are far more likely to have significant emissions reductions that those that only support herbaceous plants.

4.2.6 Carbon Finance Results

Based on the above offset estimates, the potential carbon revenues have been calculated for each restoration scenario (Tables 15 through 18). As illustrated below, potential revenues over 40 years are estimated at \$0.0-\$0.6 million for a 100-ha project restore tidal wetlands and \$0.0-\$2.2 million for a project to restore tidal forested wetlands depending on baseline soil carbon accumulation and project soil methane emission rates.

Table 15. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland** at \$10 per ton + 5.0% increase per year in the Snohomish Estuary, WA.

		Project soil CH_4 ($t\ CH_4\ ha^{-1}\ yr^{-1}$)			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate ($t\ C\ ha^{-1}\ yr^{-1}$)	**0.25**	\$463,709	\$110,452	\$0	\$0
	0.50	\$365,226	\$0	\$0	\$0
	0.75	\$265,760	\$0	\$0	\$0
	1.00	\$166,033	\$0	\$0	\$0
	1.50	\$0	\$0	\$0	\$0

Table 16. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering one third of the wetland** at $10 per ton + 5.0% increase per year in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$1,396,318	$1,047,547	$694,047	$294,397
	0.50	$1,297,835	$948,485	$587,578	$151,322
	0.75	$1,199,353	$848,758	$478,592	$0
	1.00	$1,100,870	$749,031	$361,928	$0
	1.50	$902,755	$537,603	$73,361	$0

Table 17. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering two thirds of the wetland** at $10 per ton + 5.0% increase per year in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$2,166,726	$1,817,955	$1,467,646	$1,104,103
	0.50	$2,068,244	$1,719,472	$1,367,919	$955,117
	0.75	$1,969,761	$1,620,990	$1,268,053	$886,131
	1.00	$1,871,279	$1,521,644	$1,163,114	$771,849
	1.50	$1,674,313	$1,322,189	$945,142	$525,035

Table 18. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal mesohaline wetland** at $10 per ton + 5.0% increase per year in the Snohomish Estuary, WA.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$582,609	$232,439	$0	$0
	0.50	$484,127	$131,786	$0	$0
	0.75	$385,644	$15,970	$0	$0
	1.00	$286,436	$0	$0	$0
	1.50	$83,757	$0	$0	$0

Carbon costs, considering estimated upfront and ongoing monitoring costs, and general cost inflation, are estimated at $1.2 million over 40 years. This estimate is independent of project scale as these costs are largely fixed for most projects.

The net cash flows for each restoration scenario, considering carbon project revenues and costs, are also estimated and presented below (Tables 19 to 22) across a range of project scales and carbon price scenarios. The examples below reflect favourable assumptions on low soil carbon accumulation in the baseline and low soil CH_4 emission in the project scenario. Under these conditions, projects that restore tidal wetlands that are 1,000 ha or larger generate positive net cash flows at all carbon price scenarios evaluated. For projects that restored tidal forested wetlands, projects that are at least 500 ha also generate positive net cash flows over 40 years for all the carbon price scenarios evaluated.

Table 19. Summary of net cash flows over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,141,602)	($1,054,259)	($872,888)	$338,451
	500	($755,553)	($318,840)	$588,018	$6,644,711
	1,000	($272,991)	$600,435	$2,414,151	$14,527,537
	2,500	$1,174,693	$3,358,259	$7,892,548	$38,176,013

Table 20. Summary of net cash flows over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering one third of the wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($914,745)	($602,301)	$59,721	$4,575,451
	500	$378,729	$1,940,952	$5,251,063	$27,829,713
	1,000	$1,995,573	$5,120,019	$11,740,240	$56,897,541
	2,500	$6,846,103	$14,657,218	$31,207,772	$144,101,012

Table 21. Summary of net cash flows over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering two thirds of the wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha	**100**	($733,860)	($234,381)	$830,130	$8,133,484
	500	$1,283,155	$3,780,552	$9,103,104	$45,619,875
	1,000	$3,804,424	$8,799,217	$19,444,323	$92,477,864
	2,500	$11,368,230	$23,855,215	$50,467,978	$233,051,830

Table 22. Summary of net cash flows over 40 years for 100-ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,107,511)	($992,434)	($753,987)	$835,990
	500	($585,097)	($9,714)	$1,182,520	$9,132,406
	1,000	$67,921	$1,218,687	$3,603,154	$19,502,926
	2,500	$2,026,973	$4,903,888	$10,865,056	$50,614,486

The NPVs of the estimated net cash flows over 40 years are also calculated and provided below for the same favourable condition of low baseline soil carbon and low project soil CH_4 emissions (Tables 23 to 26). Under these conditions, and similar to net cash flow analysis, projects that restore tidal forested wetland generate positive NPVs across all price scenarios when the project area is 500 ha or greater; and projects that restore tidal wetlands (with no forest component) generate positive NPVs across all carbon price scenarios when the project area is 1,000 ha or greater.

Table 23. Summary of NPV over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($549,359)	($520,721)	($465,728)	($134,396)
	500	($391,290)	($248,731)	$26,238	$1,682,895
	1,000	($195,120)	$91,257	$641,196	$3,954,508
	2,500	$395,278	$1,111,222	$2,486,068	$10,769,349

Table 24. Summary of NPV over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering one third of the wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($463,106)	($365,174)	($171,440)	$1,037,386
	500	$39,346	$529,004	$1,497,678	$7,541,806
	1,000	$667,411	$1,646,727	$3,584,076	$15,672,332
	2,500	$2,551,606	$4,999,896	$9,843,268	$40,063,908

Table 25. Summary of NPV over 40 years for 100-ha restoration of abandoned land to **tidal freshwater wetland with Sitka spruce covering two thirds of the wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($397,363)	($243,002)	$65,277	$2,008,754
	500	$368,062	$1,139,867	$2,681,262	$12,398,648
	1,000	$1,324,844	$2,868,452	$5,951,242	$25,386,015
	2,500	$4,195,188	$8,054,210	$15,761,18	$64,348,116

Table 26. Summary of NPV over 40 years for 100-ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Snohomish Estuary, WA.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($533,787)	($495,794)	($423,191)	$12,446
	500	($314,058)	($124,094)	$238,919	$2,417,105
	1,000	($39,397)	$340,532	$1,066,557	$5,422,929
	2,500	$784,587	$1,734,408	$3,549,471	$14,440,400

4.2.7 Key Outcomes and Next Steps

A key finding from this carbon finance feasibility study in the Snohomish Estuary is that carbon offset and revenue generation is unlikely when restoring emergent tidal wetlands with high rates of carbon sequestration (e.g. reed canarygrass pasture) in the baseline and increased rates of CH_4 emissions from the project. However, further research is required to quantify baseline carbon sequestration rates, and both baseline and project scenario methane emissions for the Snohomish estuary.

By contrast, the restoration of forested tidal wetlands is expected to lead to significant carbon revenues under most baseline soil carbon and project CH_4 conditions. Forested tidal wetlands are a habitat that provide important ecosystem benefits and are recognized as being needed for future restoration actions (Rustay, personal communications 2019). Strategic restoration planning will be needed to provide for appropriate elevations for Sitka spruce growth before tidal flow is restored to sites and to ensure that enough saplings are planted within these zones to promote carbon storage from the onset of the project. While the initial costs for restoring forested tidal wetlands are likely greater than those for mesohaline or herbaceous-dominated systems, tidal forested wetlands can provide increased carbon storage potential and represent an important ecosystem that is now largely absent from the current estuarine landscape.

4.3 Coos Estuary, Oregon

4.3.1 Site Introduction

Coos Bay is the largest estuary in Oregon south of the Columbia River and is a drowned river mouth estuary type, approximately 5,400 ha in size with many tidal sloughs (Figure 5). The majority of fine sediment inputs to the system is delivered during the winter floods; otherwise, the estuary is marine dominated. Sand can be transported and deposited upstream onto wetlands especially in the lower reaches of the estuary. Since the 1850s, roughly 70% of the estuary was converted to other land uses, representing a 2,391-ha loss of vegetated tidal wetlands (Coos Watershed Association 2010; Brophy et al. 2019). Many of the former oligohaline and freshwater tidal wetlands are managed by tide gates. Extensive eelgrass beds are present within the project area (Thom et al. 2003); however, they are not incorporated into this feasibility assessment.

Source: ESRI, Digital Global, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Figure 5. Imagery of Coos Estuary, OR.

4.3.2 Local Partners

The local project partners within the Coos Estuary that provided key information and data were the Coos Watershed Association, South Slough National Estuarine Research Reserve, Coquille Indian tribe, and the University of Oregon. They facilitated tours of current and future restoration sites, proposed plans for future wetland restoration targets, and/or provided key insight into local knowledge and current land uses.

4.3.3 Analytical Approach

a) Baseline Scenario

The baseline scenarios considered are on former pasturelands located in the riverine and lower salinity portions of the estuary (Table 27). Although not explicitly measured, soil carbon accumulation rates of 0.25- 1.50 t C ha^{-1} yr^{-1} (1.84-5.50 t CO_2e ha^{-1} yr^{-1}) are assessed. The proportion of allochthonous carbon is greater than in the other two estuaries due to a greater influence of tidal water through aging and leaking tide gates. Aboveground biomass is based on abandoned farm fields biomass

(Steinshamn et al. 2018) and carbon content of 47% (Verchot et al. 2006). Methane and N_2O emissions are based on measurements made in disturbed former wetlands sites in coastal Oregon (Schultz 2019).

b) Project Scenario

In the project scenarios, two predicted habitat types are examined – oligohaline and mesohaline tidal wetlands (Table 27). Since none of the potential restoration sites are former polyhaline wetlands, this scenario is not considered. Under all project scenarios, a soil carbon accumulation rate from North Ebey Island, an oligohaline restoration site in the Snohomish estuary, is used (Crooks et al. 2014) and full restoration (and carbon accumulation) is assumed to occur after five years. Under both mesohaline and freshwater tidal restoration conditions, the dominant herbaceous tidal wetland plant is assumed to be *Carex lyngbyei*[18], a sedge that dominates at low to mid wetland elevations. The herbaceous plant C stock is calculated using an aboveground biomass value of 5.3 t C ha^{-1} (Ewing 1986) and percent C value of 45% (Emmer et al. 2015), which is multiplied by 0.5 to account for seasonality in growth. An illustrative project size of 100 ha is used, which is based on planned restoration site areas. Methane and N_2O emissions assumptions are derived from observations of meso and oligohaline tidal wetlands in coastal Oregon (Schultz 2019).

[18] While using *C. lyngbyei* as the dominant colonizing species for mesohaline and oligohaline wetlands within PNW estuaries is appropriate, its use as the dominant colonizing species for freshwater wetlands is undertaken provisionally due to the lack of local or regional biomass data for *Carex obnupta, Scirpus microcarpus*, and *Juncus effusus*, the three dominant native freshwater wetland species.

Table 27. Greenhouse gas flux data used in the analysis for carbon financing in the Coos Estuary, OR. Negative values refer to **GHG removals** and positive values refer to **GHG emissions**.

Scenario #	Phase	Scenario conditions	Soil C accumulation (t CO_2e ha^{-1} yr^{-1})	Proportion alloch. C	AGB C stock (t CO_2e ha^{-1})	CH_4 (g m^{-2} yr^{-1})	CH_4 (t CO_2e ha^{-1} yr^{-1})	N_2O (t ha^{-1} yr^{-1})	N_2O (t CO_2e ha^{-1} yr^{-1})
1	Baseline	Former pasture, seasonally wet	-1.8 – -5.50	0.256	-1.62	1.39	0.35	0.0012	0.36
	Project	Oligohaline, herbaceous	-12.91	0.329	-9.72	10 - 40	2.50 – 10.00	0.0034	1.01
2	Baseline	Former pasture, seasonally wet	-1.84 – -5.50	0.259	-1.62	1.39	0.35	0.0012	0.36
	Project	Mesohaline, herbaceous	-12.91	0.329	-9.72	10 - 40	2.50 – 10.00	0.00053	0.16

4.3.4 GHG Reductions and Emissions Results

As with the analyses conducted within the Skagit Delta and Snohomish Estuary, no specific restoration sites are discussed as examples within the Coos Estuary. In the hypothetical examples of restoring abandoned agricultural fields in the Coos Estuary to either tidal mesohaline or oligohaline wetlands, changes in carbon emissions and removals occur (Tables 28 and 29). For soil carbon accumulation rates, the amount of carbon accumulated increased with restoration activity; 32% of this gain, however, is allochthonous material and thus does not count towards crediting. There is more organic carbon within the soils of the Coos Estuary compared to the sites within the Puget Sound further north; therefore, the deduction for allochthonous carbon is lower under project scenarios. If the increase in soil carbon accumulation exceeds the increase in soil CH_4 emissions due to restoration, then carbon offsets should be generated. Restoration to either wetland type also results in a modest increase in herbaceous vegetation carbon storage that can also contribute to carbon offset generation. Detailed calculations for a scenario assuming low baseline soil carbon accumulation (0.50 t C ha^{-1} yr^{-1}) and project soil CH_4 emissions (0.10 t CH_4 ha^{-1} yr^{-1}) are provided in Appendix A (Table A-3).

Table 28. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal oligohaline wetland** in the Coos Estuary, OR

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	19,924	9,924	-	-
	0.50	17,605	7,605	-	-
	0.75	15,286	5,286	-	-
	1.00	12,968	2,968	-	-
	1.50	8,330	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

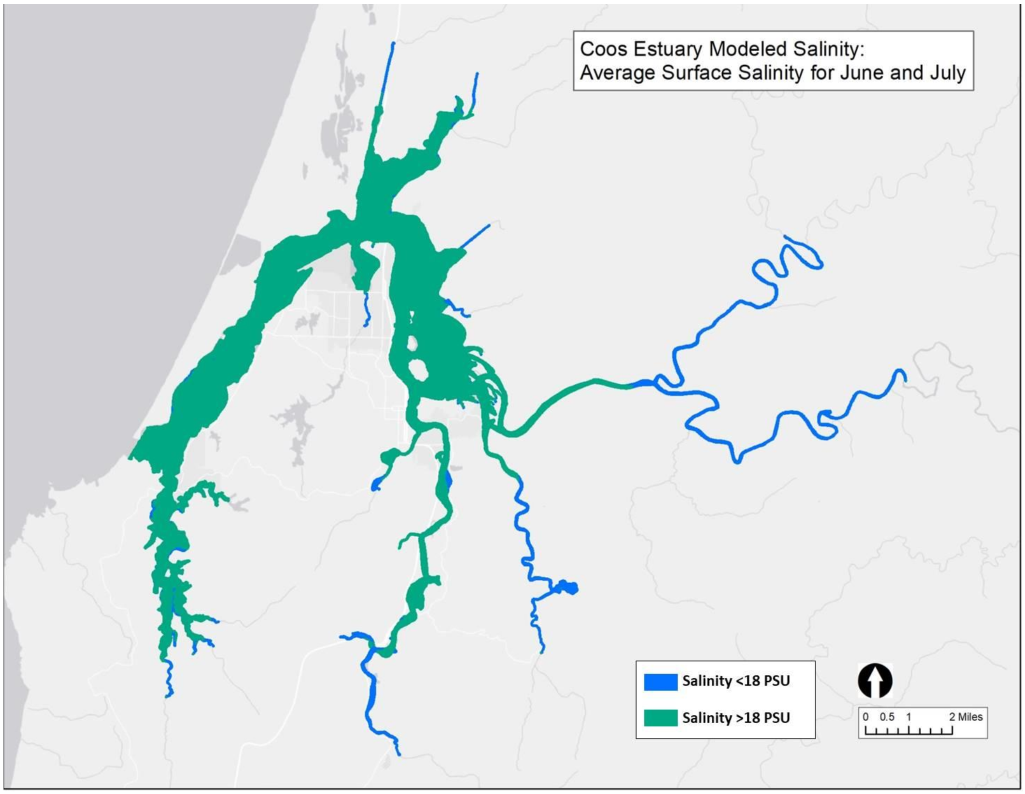
Table 29. Summary of carbon offset generation over 40 years for a 100-ha restoration of abandoned land to **tidal mesohaline wetland** in the Coos Estuary, OR.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	18,550	8,550	-	-
	0.50	16,231	6,231	-	-
	0.75	13,912	3,912	-	-
	1.00	11,593	1,593	-	-
	1.50	6,956	-	-	-

Note: Positive values correspond to carbon offset generation and a negative symbol represents no carbon offset.

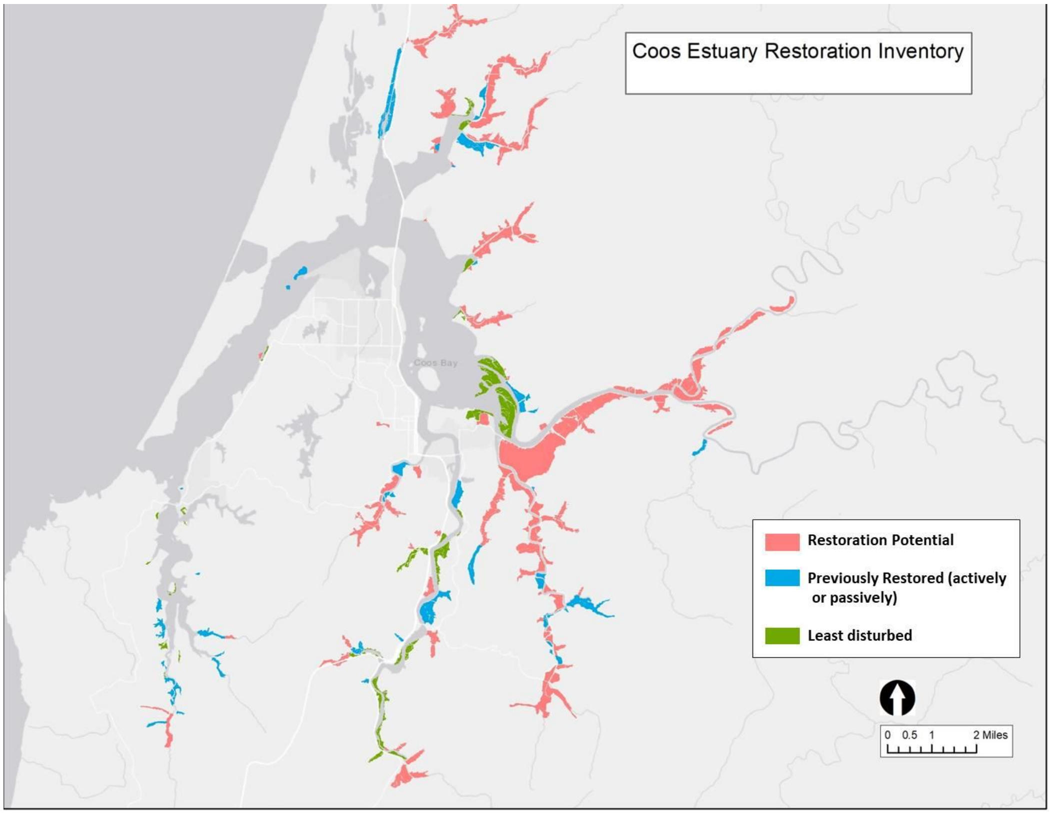
4.3.5 Uncertainties

Soil carbon sequestration in the baseline scenario and soil CH_4 emissions in the project scenario are two key assumptions that can vary based on site-specific conditions including vegetation and salinity. The summer salinity concentrations within the estuary are largely over the threshold for significant CH_4 emissions (Figure 6); areas denoted in green with high salinity over 18 PSU are likely to have low or negligible CH_4 emissions, whereas CH_4 emissions are likely in areas with salinity under 18 PSU, denoted in blue. Additionally, the majority of the potential restoration sites are within the lower salinity upstream parts of the estuary (Figure 7). This estuary is the only one examined in this assessment where local CH_4 and N_2O emissions are available, so there is less uncertainty in these emissions estimates. Data on soil carbon accumulation within active or abandoned agricultural lands are lacking within the region and this data input can significantly impact estimates of baseline conditions. Soil carbon accumulation data have been collected in disturbed and former tidal wetland sites in neighboring estuaries within Oregon, yet there is uncertainty as to whether these rates are applicable in the Coos estuary and if the rates measured within areas dominated in reed canarygrass are demonstrative of accumulation dynamics in the long term As illustrated above, carbon offset generation is positive in all restoration scenarios when project soil CH_4 emissions are less than or equal to 0.20 t CH_4 ha^{-1} yr^{-1} and baseline soil carbon sequestration is less than or equal to 1.00 t C ha^{-1} yr^{-1}.



Source: Partnership for Coastal Watersheds 2019

Figure 6. Map of modelled water salinity within the Coos Estuary, OR during June and July.



Source: Partnership for Coastal Watersheds 2019

Figure 7. Inventory of potential tidal wetland restoration sites, previously restored sites, and tidal wetlands that are least disturbed in the Coos Estuary, OR.

The lower CH_4 emissions in the project scenario, and the lower soil C accumulation rates in the baseline scenario, the more likely a project is to generate carbon credits. However, the data are not available to identify where these conditions are met primarily due to the scarcity and variability of methane measurements observed in low salinity systems in the PNW.

4.3.6 Carbon Finance Results

Based on the above offset estimates, the potential carbon revenues have been calculated for each restoration scenario (Tables 30 and 31). As illustrated below, potential revenues over 40 years are estimated at $0.0-$0.7 million for a 100-ha tidal wetland restoration depending on baseline soil carbon accumulation and project soil CH_4 emission rates.

Table 30. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal oligohaline wetland** at $10 per ton + 5.0% increase per year in the Coos Estuary, OR.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$717,812	$369,040	$0	$0
	0.50	$636,939	$288,167	$0	$0
	0.75	$556,065	$206,427	$0	$0
	1.00	$475,192	$124,373	$0	$0
	1.50	$313,446	$0	$0	$0

Table 31. Summary of carbon revenue generation over 40 years for 100-ha restoration of abandoned land to **tidal mesohaline wetland** at $10 per ton + 5.0% increase per year in the Coos Estuary, OR.

		Project soil CH_4 (t CH_4 ha^{-1} yr^{-1})			
		0.10	**0.20**	**0.30**	**0.40**
Baseline soil C accumulation rate (t C ha^{-1} yr^{-1})	**0.25**	$664,291	$315,520	$0	$0
	0.50	$583,418	$234,647	$0	$0
	0.75	$502,545	$153,080	$0	$0
	1.00	$421,672	$70,331	$0	$0
	1.50	$259,926	$0	$0	$0

Carbon costs, considering estimated upfront and ongoing monitoring costs, and general cost inflation, are estimated at $1.2 million over 40 years. This estimate is independent of project scale as these costs are largely fixed for most projects. Thus, carbon revenues for a 100-ha project under all baseline soil carbon and project soil CH_4 scenarios and using the price assumptions (per above) are not enough to cover all these costs.

However, for projects with low baseline soil carbon and project soil CH_4emissions, larger project scales and / or higher carbon prices could generate carbon revenues that exceed carbon costs and provide additional net funding for the restoration project (Tables 32 and 33). For example, a 1,000 ha project to restore oligohaline tidal wetlands with baseline soil carbon accumulation of 0.50 t C ha^{-1} yr^{-1} and project soil CH_4 emissions of 0.10 t CH_4 ha^{-1} yr^{-1} could generate $5.1 million in net cash flows over 40 years assuming a $10 per ton initial carbon price that increases at 5.0% per annum. Net cash flows over 40 years in this same scenario increase to $25 million if carbon prices increase 10.0% per annum. The NPV of these cash flows in today's dollars have also been calculated for each restoration scenario (Tables 34 and 35). In the prior examples, the net present values of the cash flows are equal to $1.6 million and $7.3 million respectively (Table 34).

Table 32. Summary of net cash flows over 40 years for 100-ha restoration of abandoned land to **tidal oligohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Coos Estuary, OR.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,062,061)	($911,769)	($601,176)	$1,465,813
	500	($357,850)	$393,609	$1,946,579	$12,281,521
	1,000	$522,414	$2,025,332	$5,131,272	$25,801,156
	2,500	$3,163,206	$6,920,501	$14,685,350	$66,360,062

Table 33. Summary of net cash flows over 40 years for 100 ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Coos Estuary, OR.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($1,075,806)	($938,418)	($654,696)	$1,232,442
	500	($426,575)	$260,366	$1,678,977	$11,114,668
	1,000	$384,964	$1,758,846	$4,596,068	$23,467,450
	2,500	$2,819,580	$6,254,287	$13,347,342	$60,525,795

Table 34. Summary of NPV over 40 years for 100 ha restoration of abandoned land to **tidal oligohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Coos Estuary, OR.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($512,085)	($462,049)	($366,996)	$200,517
	500	($205,547)	$44,631	$519,896	$3,357,463
	1,000	$177,625	$677,981	$1,628,512	$7,303,645
	2,500	$1,327,141	$2,578,031	$4,954,358	$19,142,192

Table 35. Summary of NPV over 40 years for 100 ha restoration of abandoned land to **tidal mesohaline wetland** at baseline soil C of -0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1} in the Coos Estuary, OR.

		Annual carbon price increase			
		0.0%	**2.5%**	**5.0%**	**10.0%**
Project Area (ha)	**100**	($517,442)	($471,598)	($384,647)	$133,782
	500	($232,332)	($3,113)	$431,639	$3,023,788
	1,000	$124,056	$582,494	$1,451,998	$6,636,296
	2,500	$1,193,218	$2,339,313	$4,513,073	$17,473,819

4.3.7 Key Outcomes and Next Steps

A key finding from this carbon finance feasibility study in Coos Bay is that carbon offset and revenue generation is unlikely when restoring emergent tidal wetlands with high rates of carbon sequestration (e.g. reed canary grass pasture) in the baseline and increased rates of CH_4 emissions from the project. However, further research is required to quantify baseline carbon sequestration rates, as well as baseline and project scenario methane emissions for tidal wetland restoration in low salinity parts of Coos Bay.

5 Implications for Using Carbon Finance in PNW Tidal Wetland Restoration Efforts

This investigation does not find a positive result for the application of carbon finance to support conversion of wet pastureland to emergent wetland in mesohaline and oligohaline estuary conditions. However, restoration of tidal freshwater forest, such as Sitka spruce tidal forests, do offer net GHG removals over a project lifetime of 40 years or longer. For small projects, on the order of 100 ha, project costs would outweigh revenue generated, but at larger scales positive cashflow is generated. **Small projects can be grouped into a single project and the cost is shared among them. Add in something about whole estuary scale**

The largest data gap revealed through this project is the dearth of trace GHG emission measurements within the PNW. Only one study presented CH_4 and N_2O emissions data within degraded, restored and natural tidal wetlands in two estuaries in Oregon (Schultz 2019). Considering the degree to which CH_4 emissions within a project scenario can negate any carbon sequestered within the soil or vegetation, it is imperative to assess the range and magnitude of emissions across seasons, salinities, estuaries and site conditions so that the most accurate and applicable emissions are incorporated into future blue carbon finance feasibility assessments. This is particularly important in estuaries that are dominated by river flow and, resultingly, are dominated by water and soil salinities below 18 PSU, a value under which default values cannot be used and local or regional field data are required.

One surprising finding that occurred during data collation is that nontidal degraded wetlands appear to be accumulating carbon (Crooks et al. 2014, Brophy et al. 2018, Rybczyk and Poppe unpublished data), and may be doing so at higher rates in sites invaded by reed canarygrass. Further investigations need to occur to substantiate this supposition and to examine the impact of reed canarygrass on trace gas emissions.

Comparing the Snohomish (carbon-rich soils and biomass) and the Skagit systems (carbon-deficient soils and biomass) highlights the speed at which carbon stocks can recover in this landscape with changes in land use practice.

The conversion of unwanted agricultural land to wet pasture opens a simple opportunity for carbon sequestration. This may be undertaken as part of a process of installing self-regulating tide gates, a partial but incomplete form of wetlands restoration.

The carbon sequestration benefits of restoring forested tidal wetlands appear promising. Forested tidal wetlands were once expansive in the PNW and have historically been mostly converted to human land uses. Restoring these ecosystems in the upper estuary through lower floodplain reaches will bring GHG emissions reduction benefits as well as other beneficial ecosystem services.

Potential viable project alternatives to consider further include:

1) Modified agricultural practice soil carbon management;
2) Agricultural land conversion to pasture and or wet grassland;
3) Agricultural land conversion to wetlands (including an option of creation grassland as an interim phase to full wetland restoration);
4) Restoration of tidal wetlands in saline conditions.
5) Tying forest carbon projects with collocated tidal wetland restoration carbon projects
6) Reconnection of saline flows to fresh or low saline waters impounded behind barriers.

Other research needs include:

1) Long-term carbon storage benefits of wetland grassland in disturbed sites (including of reed canary grass) should be explored. An outstanding question remains as to the rate and duration of carbon sequestration on such wetlands. This includes quantification of carbon

sequestration rates and CH_4 emissions across the landscape, including for managed and unmanaged diked lands and least-disturbed tidal wetlands.

2) Understanding the fate of carbon produced in tidal wetland and then exported to the near shore. Some proportion of this will be buried in marine sediments contributing to carbon sequestration. Understanding the deposition of transported carbon is a growing field of interest, bringing in other coastal ecosystems such as kelp forests that are currently not recognized in carbon budgets for climate mitigation.

3) Understanding the changing CH_4 budget on coastal lands as sea levels and ground waters rise. At some point in the future gravity drains will no longer be functional to drain coastal lowlands, driving up water tables and CH_4emissions. Under such conditions reconnection to full tidal connection may not have a substantial increase in CH_4emissions compared to baseline conditions.

4) Long-term carbon storage benefits of wetland grassland (including of reed canarygrass) should be explored. An outstanding question remains as to the rate and duration of carbon sequestration on such wetlands.

5) Approaches and design guidance for restoring forested tidal wetlands.

Overall, this project highlights the value of accounting for emissions and removals across the entire landscape. High ecological value and climate change resilience is derived from restoring a connected mosaic of habitat from the marine to floodplain and terrestrial environments. Over the long term (100+ years) all coastal wetlands will be net sinks of GHGs but at shorter time frames not all will be significant to climate mitigation. For Blue Carbon finance projects, climate mitigation strategies will understandably be focused on the near-term needs, but they should not overlook the continuing needs and opportunities over longer timeframes.

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Appendix 1: Detailed Carbon Offset Calculations

Table A-1. Summary of carbon offset generation over 40 years for two restoration scenarios for 100 ha of abandoned pasture (t CO_2e) in the Skagit Delta, WA assuming baseline soil C accumulation of 0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1}.

Results	Tidal oligohaline wetland	Tidal mesohaline wetland
Total baseline soil removals/(emissions) (a)[19]	-3,814	-3,814
Total project soil removals/(emissions) (b)[8]	-13,481	-16,890
Net emissions reductions/(emissions) from soil (c = b – a)	-9,668	-13,077
Net emission reductions/(emissions) from biomass (d)	-810	-381
Net emission reductions/(emissions) (e = c + d)	-10,478	-13,458
Emissions reductions from project (f = -e)	10,478	13,458
Non-permanence buffer (g)	-3,253	-3,189
Carbon offsets (f + g)	7,225	10,269

[19] This value incorporates methane and nitrous oxide emissions, if applicable.

Table A-2. Summary of carbon offset generation over 40 years for two restoration scenarios for 100 ha of abandoned pasture (t CO_2e) in the Snohomish Estuary, WA assuming baseline soil C accumulation of 0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1}.

Results	Tidal freshwater wetland	Tidal freshwater wetland w/ 1/3 Sitka spruce	Tidal freshwater wetland w/ 2/3 Sitka spruce	Tidal mesohaline wetland
Total baseline soil removals/(emissions) (a)[20]	-16,756	-22,791	-22,791	-20,166
Total project soil removals/(emissions) (b)[8]	-3,565	-3,565	-3,565	-3,565
Net emissions reductions/(emissions) from soil (c = b – a)	-13,192	-19,226	-19,226	-16,601
Net emission reductions/(emissions) from biomass (d)	-99	-20,754	-42,034	-99
Net emission reductions/(emissions) (e = c + d)	-13,291	-39,980	-61,260	-16,700
Emissions reductions from project (f = -e)	13,291	39,980	61,260	16,700
Non-permanence buffer (g)	-3,640	-7,643	-10,835	-3,640
Carbon offsets (f + g)	9,651	32,337	50,425	13,060

[20] This value incorporates methane and nitrous oxide emissions, if applicable.

Table A-3. Summary of carbon offset generation over 40 years for two restoration scenarios for 100 ha of abandoned pasture (t CO_2e) in the Coos Estuary, OR assuming baseline soil C accumulation of 0.50 t C ha^{-1} yr^{-1} and project soil CH_4 of 0.10 t CH_4 ha^{-1} yr^{-1}.

Results	Tidal oligohaline wetland	Tidal mesohaline wetland
Total baseline soil removals/(emissions) (a)[21]	-2,626	-2,626
Total project soil removals/(emissions) (b)[8]	-24,508	-22,287
Net emissions reductions/(emissions) from soil (c = b – a)	-21,882	-19,661
Net emission reductions/(emissions) from biomass (d)	-810	-810
Net emission reductions/(emissions) (e = c + d)	-22,693	-20,472
Emissions reductions from project (f = -e)	22,693	20,472
Non-permanence buffer (g)	-5,087	-4,241
Carbon offsets (f + g)	17,605	16,231

[21] This value incorporates methane and nitrous oxide emissions, if applicable.

Appendix B: Workshop Notes

Snohomish Estuary Workshop: January 29, 2019

Tulalip Tribes Administration Building

SUMMARY

Workshop Goals

Explain context and purpose of blue carbon feasibility study for the Snohomish estuary

Describe proposed content and approaches to assess carbon project feasibility

Engage end-users in feasibility planning and provide opportunity for input into design

Project Specs

Landowners: Snohomish County, WA Dept of Fish and Wildlife, Tulalip tribes, private landowners
Potential blue carbon sites: Smith Island, Spencer Island, Dike District 6, Bob Herman park near Thomas Eddy

Action Items

WA is part of states that have made GHG commitment to support Paris agreement (US Climate Alliance?). Need to review. (Scott)

Washington low carbon fuel standard should also be reviewed/tracked for offset implications. (Scott)

Talk to Mike/Gretchen, Cindy (subsidence rates data) and Laura B about elevations and where tidal forested wetlands could be. (Lisa)

Check also on study done by Amy Hoss (TNC?) on historical loss of forested wetlands (in WA? Snohomish?)(Lisa)

Follow up with Department of Ecology's nitrate data in Snohomish (Lisa)

Reach out to Terry about cattle work (?) (Lisa)

Data Considerations/Opportunities/Sources (some overlap with above):

Cindy Dittbrenner– map of shrinking land base in Snohomish- assessment of areas that will remain most productive, drainage area maps, land use, ag practices, restoration practices, groundwater for methane emissions; Mike Rustay can sit in; and Mark Stamey for groundwater

Morgan Ruff – local institutional structure

Laura Brophy– head of tide and ecotone, model for high water elevations (PMEP) (already sent to Lisa)

Mike Rustay- Snohomish estuary salinity model

Morgan Ruff and Mike Rustay- potential restoration sites to focus on— Spencer Island, Smith Island, Bob Herman Park, possibly Diking District 6 (DD6)

Sean Penrith– scaling up, innovative financing concepts

Summer Montacute – help with scaling up

Elizabeth Butler- deed restrictions, legal case studies…etc.

Mark Stamey– Earth Economics Study- including Snohomish land use and other relevant information

TNC— SLR assessment/flood predictions for next 100 years.

No CH4 or N2O data in the Snohomish BC report- Crooks et al. 2014 (need to find other sources)

WA Department of Ecology may have some info on N2O

John Rybczyk has additional Snohomish data from restored sites- data all within the range of current data.

Mark Stamey may also be able to help interpret National Wetland Inventory maps for the purposes of helping map saturation patterns in ag land. Cindy Dittbrenner can help too.

Presentations from Project Team

Feasibility Planning for Pacific Northwest Blue Carbon Finance Introduction— Steve Emmett-Mattox Feasibility Assessment Approaches – Introduction and Market Analysis— Steve Crooks

Feasibility Assessment Approaches – Technical Analysis— Steve Crooks Feasibility Assessment Approaches – Financial Analysis— Scott Settelmyer Feasibility Assessment Approaches – Legal Analysis— Scott Settelmyer Feasibility Assessment Approaches – Organizational Feasibility— Steve Crooks

Discussion Highlights

Project and Final Report Audience

Question raised by Sean Penrith about the intended audience for the project's final products. Crooks and SEM: Project audience is workshop participants, project and other end users. Feasibility assessment results will be presented in a technical report, from which a separate report could be developed, targeted to "impact investors."

Project Co-benefits

There was a discussion about the application of rigorous CCD (?) and climate community and biodiversity (CCB) standards in blue carbon project development; the idea of adding sustainable development goals to generate greater potential return from blue carbon projects. Co-benefits like these included as monetized standards are still being worked out. Adding co-benefit standards adds complexity to an already complex valuation process. So far this approach is not providing sufficient returns in ag projects. But as marketing elements in projects supported by investors from the voluntary carbon market, there's still value— projects with many co-benefits can still raise the perceived value of the project and can raise voluntary market's carbon price for projects.

Potential Adjustments to Verra Blue Carbon Standards

Large scale projects are required currently to make blue carbon financing work. Blue carbon practitioners are working with Verra to try making standards more workable for smaller scale projects. Also, Verra is considering changes to VCS rules to promote biosequestration projects (e.g., blue carbon), including potential forward crediting and longer look-back on start dates (some changes, e.g., reducing project longevity requirement, will be in next VCS standard version to be released as soon as June, and others released early 2020). Also, Verra is considering adjustments to project longevity requirements – b/c for e.g., reversal for belowground biomass is less likely than aboveground biomass— likely dropping requirement to a minimum of 20 years. The permanence requirement is also probably going to drop from 100 yrs to fewer years.

Project Area

Snohomish project area should be expanded to include to lands up to the confluence of the Snohomish and Skykomish River in the upper reaches of the floodplain. General agreement that focus of restoring forested tidal wetlands should be high priority. Project grouping- need blue carbon project areas that are about 1,000 acres or more. Projects can be grouped within that area.

Local Funding

Restoration funding from the state- through Recreation and Conservation Office (RCO)- cannot be used for mitigation (mitigation bank of about 360 acres from restoration at Union Slough). Government mitigation policy is changing from no net loss to net gain, but relevant only as much as it reduces the number of restoration acres eligible for blue carbon funding. RCO does not allow transfer of property interests on lands acquired with RCO grant funding (includes salmon recovery funding); Elizabeth sent Scott some follow-up links, however, unclear if restriction only applies to property interests that are inconsistent with the intended use (read section on conversions again).

New Funding Opportunity

Opportunity zone incentives: a new national community investment tool that connects private capital with low-income communities in the US. People with well performing stock portfolios engage in "tax-harvesting" at the end of the year to lower their tax liability on capital gains. Opportunity zone incentives allow people to roll their capital gains into an opportunity zone funds which are invested in designated opportunity zones across the US. Designation requires zones to be 25% of low income census tract data- typically rural economies. WA governor has approved opportunity zones for WA and Snohomish could be included. This fund, if applicable to the Snohomish area, could be a way to access private market capital without investors expecting a return. Another idea: establishing closed loop fund with salmon industry since they have a vested interest. Sean P to provide details.

<u>Existing Land Management and Drainage</u>

Upper Snohomish estuary is intensively managed ag land. Lands are diked and drained but also saturated in winter— seasonal wetlands. No standing water but water in root zone. Need to map these areas— Mark can help with this kind of mapping. Cindy can also help and will link to people with groundwater information. As far as livestock goes— dairy activity occurs in some locations but it's mostly upstream. WA Dept. of Ecology website has N loading data associated with ag activities (but may not be very spatially explicit).

<u>Local Government Policies Supporting Restoration</u>

King and Snohomish counties, city of Everett, and Tulalip Tribes have all developed net gain wetland policies in place of no net loss. They're trying to get the state to make the same shift to net gain wetland policies and shift the policy into state statute. Under a net gain policies/statutes the legal driver to restore former wetlands would theoretically be stronger and facilitate more restoration.

<u>Practical Concerns about Blue Carbon Projects</u>

Restoration projects are already complex undertakings that require many different funding sources. Why would local organizations add additional layers of blue carbon finance complexity for a relatively small return? Concerns about validation monitoring: who does it, how much does it cost, where does the monitoring funding come from? Monitoring funding is already hard to find and local organizations struggle to make adequate monitoring happen. Adding a requirement to prove carbon benefit before receiving the blue carbon funding is not an appealing prospect. They might rather just be happy knowing that the projects they do are providing blue carbon benefits but not have to prove it and keep funding the projects in the ways that they already know how. But the blue carbon finance piece is a way to bring potentially new stakeholders/funders to the table- to broaden the funding source options for projects. BC finance is opportunity to plan at a different scale. New funders could potentially support required long term carbon monitoring, and management— and the long term monitoring could potentially also be structured to include ecological monitoring that's currently so hard to find funding for. Project financing could also be structured to include project's up-front costs, if there's a motivated carbon offset buyer. BC financing may not be the barrier that it seems. Potential buyers of blue carbon credits have not yet been identified but they're out there— bigger challenge is to develop blue carbon projects that will work at scales that will be attractive to buyers.

Local Landownership Dynamics

Sustainable culture agreement between Tulalip Tribes and ag community— tribes would support ag culture and lifestyle and ag community would support tribal culture. Created mechanism to work through future issues including climate-related issues such as salt intrusion, loss of river shore lands due to erosion…etc. This 10 year old collaboration and associated relationships could be useful for facilitating large scale/long term blue carbon planning in the Snohomish estuary.

Snohomish Project Developer

Need a group that can connect to government, rules/regs, can connect to technical people, and can connect to community. In the Snohomish, typically they've had multiple project sponsors – lots of landowners – there isn't one obvious group who would lead this. The project developers have typically been local government and Tulalip Tribes— who are also the major landowners— operating with partners as part of a working group. Not necessarily talking about a single entity to lead the blue carbon project efforts- could be done as a consortium of the multiple groups already involved in Snohomish restoration work— with additional technical expertise. Restore America's Estuaries could play a role, bringing their technical expertise to the table. Another option could be a land trust-type model: working group has worked well but it may be time to consider creating a lead organization that would rely on the capabilities of the existing working group but with more landowner connections. Another possibility would be to establish an entity that would be established under tribal corporation rules which would come with various benefits. Tulalip Tribes has done something similar and could make that happen.

Nature Conservancy could be a good lead with connections to national organization— NatureVest.

Process Recommendation- If Assessment Indicates BC Project **Is Not** Viable for Snohomish

There's value in communicating blue carbon benefits for restoration project fundraising, community support, etc. There's also value in not accepting a "not viable" result but rather analyze exactly why Snohomish was deemed not viable and determine what needs to happen/what conditions need to change to make a blue carbon project viable in the Snohomish. The latter approach offers the Snohomish project partners a roadmap for making blue carbon project financing work in the system.

Process Recommendation- If Assessment Indicates BC Project **Is** Viable for Snohomish

First step, even before worrying about how local organizations should move forward, should be to validate the assessment's results with the targeted market. Share it with multiple entities who take

carbon projects to market to gauge interest from the market- months long process. And pursue a non- binding letter of intent with those entities to document their interest in considering entering into an agreement to take the project to the next step. Only with a letter of intent in hand will you know if you have a potentially viable blue carbon project so you can start organizing yourselves accordingly.

Workshop Participants

Steve Emmett-Mattox - Strategic Collaborations, LLC

Craig Cornu - Institute for Applied Ecology

Scott Bridgham - University of Oregon (remotely connected)

Chris Janousek - Oregon State University (remotely connected)

Steve Crooks - Silvestrum Climate Associates

Lisa Beers - Silvestrum Climate Associates

Cindy Dittbrenner - Snohomish Conservation District

Lindsey Desmul - Washington Department of Fish and Wildlife

Summer Montacute - VERRA

Laura Brophy - Institute for Applied Ecology

Elizabeth Butler - Washington Recreation and Conservation Office

Sean Penrith - Gordian Knot Strategies

Gretchen Glaub - Snohomish County

Terry Williams - Tulalip Tribes

Brad Warren - National Fisheries Conservation Center

Wolf Lichtenstein - Evergreen Carbon

Scott Settelmeyer - TerraCarbon

Mike Rustay - Snohomish County

Beth Ledoux - King County

Jamie Bails - WDFW

Morgan Ruff - Tulalip Tribes

Phil North - Tulalip Tribes

Colin Wahl - Tulalip Tribes

Stefanie Simpson - Restore America's Estuaries

Erin Murray - Puget Sound Partnership

Katrina Poppe - Western Washington University

Jeff Gaeckle - WA Dept of Natural Resources

John Rybczyk - Western Washington University

Mark Stamey - ICF International

Preston Hardison - Tulalip Tribes

Skagit Estuary Workshop: January 31, 2019

Padilla Bay NERR

SUMMARY

Workshop Goals

Explain context and purpose of blue carbon feasibility study for the Skagit estuary

Describe proposed content and approaches to assess carbon project feasibility

Engage end-users in feasibility planning and provide opportunity for input into design Potential Blue Carbon Project Sites (see Fig 8-3 in Skagit HDM Report)

Telegraph Slough 1 and 2— currently in ag production; higher salinity, further from river so less FW influence

Sullivan Hacienda – currently in ag production, water management is similar to other ag sites, salinity 5 to 15-ish ppt; restored plant community would be mix of Carex and bulrush

Rawlins Rd Distributary Channel – project to re-establish sediment delivery to eroding marshes

Rawlins Road – currently in ag production, salinity 5 to 15-ish ppt; restored plant community would be primarily bulrush

North Fork Left Bank Levee Setback – currently in ag production, borders river, small section that's not in production now, some nurseries but mostly crops, some homes

North Fork Right Bank Levee Setback– a lot of homes, a road, farm buildings, blueberries and a couple dairies, and a digester

Miltown Island – dike actively breached (2000 and in 1970s)—developing plant community dominated by invasive spp (Typha and RCG); need more dike removal for plant community improvements and more fish use; salinities likely won't change with improvements; more connections on the FW side, it would increase tidal and fluvial inundation but might be a wash in re: BC benefits

Deep Water Phase 2 – currently in ag production, all food for waterfowl – corn barley fava beans, millet, smartweed, mowed pastures; water management is similar to other ag sites

South Fork Levee Setback – some ag production in the past 10 years in part of the site; the other part is scrubby with a drainage ditch; project would move levee and produce more scrub/shrub habitat

Outside Dike Line – potential for habitat enhancement

Notes on sites:

The assessment report should not be organized around, nor should it mention specific sites— and it should not include the site map.

The degree of subsidence for all diked sites is unknown

Action Items

Check with Sean Penrith on scope of activities, regions for ag carbon interests

Follow up with Belinda about remnant dikes in existing marshes outside the dike line

Allen Rozema will contact Chad Kuger (Washington State University) to talk with our BC project team

Check with Polly for elevations at all sites; also, Greg Hood's data would be useful (he's with Skagit River System Cooperative)

Abbreviated Presentations from Project Team

Feasibility Planning for Pacific Northwest Blue Carbon Finance Introduction— Steve Emmett-Mattox

Feasibility Assessment Approaches – Financial Analysis— Scott Settelmyer

Feasibility Assessment Approaches – Technical Analysis— Steve Crooks Discussion Highlights

Local Landowners

Most restorable land in the Skagit delta is currently being used to cultivate crops. There's significant resistance from ag community to habitat restoration. They're feeling pressured by restoration interests and environmental policies coming from the WA legislature. Additional ag operations are moving into the Skagit from the south (CA) due to changing climate, and from the north (Canada) due to regulatory changes. There may be interest among landowners in exploring possible carbon benefits of ag producers shifting to specific carbon-friendly ag practices along with exploring restoration opportunities. For example, are there any carbon benefits to shifting to perennial crops (like blueberries) from annual crops (that require soil tillage)? Recommendation made to ask Skagit landowners what they can do on the landscape in terms of carbon management/benefits, including coastal forest land management, lowland ag land management, wetland management...etc. Ag producers are getting used to the idea of strategic retreat from areas affected by SLR.

Skagit HDM Report

Project designed to "create and advance mutually beneficial strategies that support the long-term viability of agriculture and salmon while reducing the risks of destructive floods (in the Skagit Delta)." Project goal is to restore 2,700 acres of estuarine fish habitat, the estimated amount of additional estuarine habitat needed for a sustainable local Chinook salmon population. Effort takes into consideration the needs of Skagit Delta stakeholders such as ag interests, tribes, drainage districts, local government, along with state and federal mandates. Blue carbon project needs to be responsive to, and help facilitate the implementation of the priority projects outlined in this carefully developed alternatives analysis.

Site Qualities/Ag Practices

Ag lands are ditched and drained, but ditches are not being dug deeper (soil is apparently finished subsiding?), just being maintained. There's standing water seasonally (winter) on ag lands before temporary V ditches (aka, surface ditches) are dug to help draw water off early in the spring (to help maximize the length of the local growing season). V ditches drain into permanent ditch networks that are regularly maintained. Soils from ditch maintenance are thin-spread on ag fields. Not much no-till ag practices, but more conservation/minimum till starting to happen. There's an emerging interest in cover cropping to facilitate crop rotation. Fields are cover cropped for 2-4 years. But cover cropping is expensive. Water fowl damage can be extensive which complicates things for landowners. Sometimes ag practice rotations include rotations into pasture/livestock production for 2-3 years and then rotate back to crop production. Gut feel of the project team is that ag lands in the Skagit have lost most or all their carbon from years of heavy ag production— soils have emitted most of the greenhouse gases they've got to emit. It's possible that the sometimes significant benefit of eliminating GHG emissions that occurs when restoring ag lands is not likely to amount to much in the Skagit delta ag lands.

Most of the irrigation that occurs in ag lands is done through water table management (temporary surface ditches in spring; slow water using check dams in irrigation/drainage ditch networks in the summer) and not so much overhead irrigation (supplemental irrigation strategy only).

Local interest in discussing outside dike line (ODL) projects; habitat enhancements outside of diked ag areas that may also have carbon benefits? Such a strategy would be viewed favorably by local community. Most ODL projects may not amount to much carbon benefit (minimal, if any change in plant community or salinity) and would be compromised by SLR in a short amount of time— with no ability to migrate inland. One possible exception is the restoration of tributary flows that would resume delivery of sediments to sediment-starved and now eroding marsh plains, enhancing their C seq functions and possibly allowing them to keep pace with SLR?

Adaptive Approach to Blue Carbon Project Development

Can we create a functioning "carbon market landscape" that works with existing land uses instead of displacing them? And which also benefits fish and wildlife (especially salmon) and helps control local flooding? Local participants encouraged the project team to think about blue carbon adaptations locally to fit within local ag production as well as ecological benefits. There was also a request to elevate local land use/local economy/traditional culture issues in restoration and blue carbon project planning to acknowledge the reality of those issues; need recognition that they're not just someone else's problem. Request that those issues be documented in assessments (see unintended consequences below).

What carbon-beneficial adaptations could occur in ag practices? Is no-till ag production possible? Yes but it's expensive— ultimately there needs to be some sort of tillage. Crop aesthetics drives tillage –

e.g., less lumpy potatoes with more tillage. Some larger scale farms are experimenting with different types of tillage. Would be good to know emissions difference between conservative tillage vs no tillage – cover crop for 3-4 years and then till it –net balance data are needed, gaps possibly soon to be addressed by Washington State University soil scientists and perhaps PBNERR research. Marin County CA example was cited: by increasing compost on the land, ag producers get greater production from livestock. Composting would be of great interest in Skagit– would add a lot of biomass and help rebuild soil structure. Sean Penrith could be a resource to help flesh out this approach.

Also, there's been more berry production (blueberry, raspberry) which are more permanent crops. Soils can be built around the berries – 11-15 year rotation. What happens to woody biomass at the end of the 15 year rotation is an issue.

Potential Unintended Consequences

Concern among local landowners about external habitat restoration interests, and now potentially those with interests in carbon-related activities (given possible regulatory carbon market created in WA), driving land use changes that may lead to significant changes in local economy and traditional local culture— with no thought to helping local landowners or the local economy make that transition successfully. Blue carbon project-related restoration efforts are not intended to be used to affect local land use decision-making— but it may end up having those kinds of unintended consequences nonetheless. Are potential blue carbon project effects on local economies and traditional local cultures to be considered under the blue carbon "Do No Harm" principal? Question was raised about whether there are possible financial mechanisms in the blue carbon project process that could be developed to help offset the financial and other costs associated with those unintended consequences?

Skagit Assessment Approach

Suggestion to use a per-hectare approach and focus on the 2,700 acres articulated in the Skagit HDM report. And suggest using elevation bands (?) that gives flexibility for future work. Focus on the most appropriate 4 or 5 different scenarios for baseline land uses/ag practices. Climate adaptation strategy for the whole delta and culture would be an excellent way to go— blue carbon project might not be viable now but the potential for future would be included in overall strategy. Not within the scope of current project but the project could be a first step. Also, the assessment report should not be organized around or mention specific sites— and it should not include the site map.

Workshop Participants

Steve Emmett-Mattox- Strategic Collaborations, LLC

Belinda Rotton- Washington Department of Fish and Wildlife

Scott Settelmeyer –TerraCarbon

Jude Apple- Padilla Bay NERR

Allen Rozema- Skagitonians to Preserve Farmland

Stefanie Simpson- Restore America's Estuaries

Craig Cornu- Institute for Applied Ecology

Roger Fuller- Padilla Bay NERR

Jenny Baker- Washington Department of Fish and Wildlife

Lisa Beers- Silvestrum

Polly Hicks- NOAA Restoration Center Steve Crooks- Silvestrum

Coos Estuary Workshop: February 7, 2019

South Slough NERR

SUMMARY

Workshop Goals

Explain context and purpose of the blue carbon feasibility study for the Coos estuary

Describe proposed content and approaches to assess carbon project feasibility

Engage end-users in feasibility planning and provide opportunity for input into design

Project Specs

Landowners: State of Oregon (South Slough NERR sites), various private landowners

Potential project sites: Wasson Creek Marsh (forested/scrub shrub wetland restoration with upland forest management component in South Slough), Winchester Creek Floodplain (forested/scrub shrub wetland restoration in South Slough), South Slough Tidal Flats (eelgrass bed restoration in South Slough), Millicoma Confluence Project, Palouse Slough Project(s)?, Willanch Slough Project?, Echo Valley Project?, Kentuck Slough Marsh (if not used for Jordan Cove project mitigation)?

Action Items

Follow up with South Slough NERR staff on University of Oregon's Dave Sutherland and his hydrodynamic model of the Coos estuary— models salinity in the estuary

Look at carbon stocks project's Coos pasture cores for pasture soil carbon content- Sause Bros and Hampel pasture sites (Boone Kauffman data)

Follow-up with Chris Janousek about GW well time series data from Sause Bros and Hampel pasture sites in the Coos estuary and South Slough

Investigate tax benefits for landowners who maintain even unproductive ag land as pasture

Follow up with Jenni Schmitt about the South Slough NERR's forest management policies for possible inclusion of forest carbon element into overall feasibility assessment

Follow up with Scott Bridgham for emissions, C seq rate and C stocks data from Larry Mangan and South Slough sites

Follow-up with Cheryl Brown about C seq rate data from South Slough and upper Coos estuary sites

Investigate how blue carbon finance might be integrated with wetland restoration and enhancement grant programs such as CREP and the Wetland Reserve Program

South Slough NERR and CoosWa staff will share early drafts of Coos estuary restoration inventory (currently under development) with the feasibility assessment team

Investigate how the Oregon Watershed Enhancement Board would view projects that included blue carbon financing— would blue carbon financing be considered a mitigation-related activity?

<u>Presentations from Project Team</u>

Feasibility Planning for Pacific Northwest Blue Carbon Finance Introduction— Steve Emmett-Mattox
Feasibility Assessment Approaches – Financial Analysis— Scott Settelmyer

Feasibility Assessment Approaches – Technical Analysis— Lisa Beers

Feasibility Assessment Approaches – Legal Analysis and Organizational Feasibility— Scott Settelmyer

<u>Discussion Highlights</u>

<u>Coos Site Considerations</u>

Potential blue carbon project sites in the Coos estuary (mostly diked pastures) will almost all be in brackish or tidal freshwater parts of the estuary. Except for sites managed by the South Slough NERR, restorable lands are owned mostly by private landowners in relatively small parcels. Large scale restoration in any given system (e.g., Palouse) would likely require the cooperation of many different private landowners. Best to work with those folks through diking districts which most landowners would be associated with. Diked pastures are commonly inundated in winter and dry in summer. High levels of methane emissions can be emitted from freshwater and even mesohaline (10-18 ppt) sites.

Emissions vary with location along the estuarine salinity gradient but seasonally as well (though emissions in winter are lower during cold temperatures). Coos sites long ago converted to pasture may have emitted all the GHG they have to emit (look at carbon stocks project's Coos pasture cores-Hampel and Sause Bros sites).

Wintertime ponding is highly variable. Pasture lands that pond with freshwater in the winter that would convert to meso- or polyhaline tidal wetlands if restored might be found in Coalbank, Palouse, and Larson Sloughs. Those pasture lands that flood the most during winter and are therefore the least productive from a farming perspective, and most likely to strand fish would be the highest priority targets for restoration.

There's great interest in the restoration of forested and scrub shrub tidal wetlands in South Slough and wherever possible in the Coos estuary. The Coos system has lost virtually all of its forested and scrub- shrub wetlands. The South Slough NERR staff is also planning to engage in eelgrass restoration in South Slough since about 500(?) acres of eelgrass beds have been lost there over the past 5-10 years.

Total tidal marsh area in the Coos estuary is somewhat limited. There are larger diked former tidal wetlands (privately owned) in the Coquille estuary to the south. The Coquille River is much bigger than the Coos and as a result the estuary is mostly tidal freshwater influenced. Restoration to former habitat types would include vast areas of scrub-shrub wetlands and forested tidal swamps. CoosWA has a good relationship with CoquilleWA if further discussions need to happen. It should be noted that potential political barriers to restoration are likely greater in the Coquille than they are in the Coos (and that's not to say there aren't barriers in the Coos too).

<u>Land Management Considerations</u>

CoosWA engages in an increasing amount of estuarine wetland restoration but is also looking to work with landowners on a "grow fish in the winter, cows in the summer" strategy. Strategy focuses on increasing habitat opportunities for juvenile salmonids in lands actively managed for livestock production during the growing season. Tide gates would be managed to allow pastures to flood all winter and early spring to allow fish (for rearing) and sediments (to improve/"green up" pastures) access to the pastures. Pastures would then be drained as early as possible in spring so ranchers can get their livestock on the pastures as early as possible. But ranchers needing to drain pastures as early as possible may overlap with peak juvenile salmonid out-migration (April), which sets up a potential timing conflict. C benefits from an improvement of managed lands approach might work at a large scale— but that strategy may not be consistent with requirements of the blue carbon methodology since winter flooding could increase methane emissions which would probably not be offset by any change in site plant community during the growing season (C sequestration would not change).

Landowners maintain even unproductive lands as pastures in the Coos estuary to receive tax benefits— a possible policy barrier to converting lands for other perhaps more productive land uses. Eliminating the tax benefit would likely be very controversial.

There are a range of pastures in the Coos estuary that have been abandoned with no water management. Soils are saturated but are not fluctuating (?). Tide gates are being used in the Coos estuary for base irrigation in the summer and raising water elevations during summer months when water salinity is highest for weed management in ditches.

Lots of forestland ownership on the edge of the estuary in the Coos, including lands managed by the South Slough NERR and the Coquille Indian Tribe. Many of the forest lands are overstocked and in need of thinning to increase forest productivity. There may be opportunities to engage landowners in forest carbon projects (e.g. improved forest management by extending rotations or selective harvesting/thinning) which could provide funding for wetland restoration and also generate carbon credits. The Coquille Indian Tribe may be interested in moving from clear-cut forest management to selective harvesting. The South Slough NERR management commission would need to amend current reserve policy to make revenue generation from reserve-managed forests possible.

Are landowners in the Coos estuary ready to restore their lands now or in the near future? Not many now but there may be more in the future through approaches that include CREP and Wetland Reserve Program. There's also a flood irrigation bonus associated with the CREP (CREP's flood irrigation bonus worked on a TerraCarbon project in the lower Mississippi but at much larger scale). Perhaps blue carbon finance could fit with these? On one hand, the addition of blue carbon finance could make the WRP and CREP-facilitated projects more attractive; on the other hand, adding the blue carbon finance process to processes that to some are already more bureaucratic trouble than they're worth (in terms of benefits to landowners), may not help. CoosWA staff could help make this work since they currently play the role of technical partners/project facilitator. A very useful, if not critical next step would be the development of a tool that quantifies both C benefits and benefits to landowners associated with various land uses. This would be an essential tool for project developers, potential funders and landowners.

<u>Coos Watershed Association</u>

CoosWA is probably the best positioned "honest broker" in the area to play the role of blue carbon project developer, but they would need to overcome capacity issues. CoosWA is looking down the road at engaging in larger-scale initiatives (mostly tide gate at this point) issues partnering with other watershed associations— they feel blue carbon project planning and financing may be useful as a component of these larger initiatives. They would collectively be able to undertake greater numbers of projects per year.

<u>Coos Data</u>

Scott Bridgham's grad student is measuring CH_4 and N_2O in least disturbed wetlands, restoring wetlands, and diked wetlands, in upper Coos estuary (Larry Mangan property) and in South Slough (Kunz mesohaline marsh, Tom's Creek FW marsh, and Wasson FW marsh—a long-ago abandoned pasture)…and more. Check with Scott for additional detail …. So far data suggest that CH_4 does vary with salinity and soil temperature and with groundwater levels. Wetter pastures will be a larger source of CH_4 than dryer pastures and fresher areas emit more CH_4 than saline areas. Higher soil temps will generate more CH_4 than lower temps. Data also suggest that N_2O is low and episodic at all sites—not a significant portion of GHG emissions.

Scott is confident in the project's use of his lab's data from least disturbed sites in place of national default values. Less confident with data collected at the disturbed sites because of the range of factors that drive emissions. Need more data collected at pasture sites.

Cheryl Brown has unpublished C seq rate data from 50 cm cores taken at South Slough sites and sites in the upper Coos estuary (including Mangan).

No emissions or other blue carbon data have been collected at actively managed sites (except GW level/salinity and carbon stocks at Sause Bros and Hampel pasture sites— see below). Need also data about the areal extent of managed pastures in the Coos estuary. An estimate could be created from the CMECS emergent marsh layer. 90% of Coos estuary marshes have been converted so mapping exercise could ID least disturbed, restored and filled former emergent marshes which would result in a reasonable estimate of pasturelands in the Coos estuary.

Are there groundwater data for Coos pastures? The carbon stocks project is collecting GW level, temperature and salinity data at two paired pasture/high marsh sites in the Coos estuary— Sause Bros pasture/Millicoma high marsh, and Jerry Hampel pasture/Hampel high marsh. GW data are available from Chris Janousek. CoosWA has not yet begun collecting GW data in pastures.

Project Funding and Legal Considerations

Need to ensure that the long term, VCS-required commitments associated with blue carbon finance projects (at least 30 years, 60 would be better) are included in easements that are recorded and become part of the property titles for affected lands (apparently CREP easements have not always been recorded with property titles which has caused problems). It's possible that before funding from OWEB or other state and Federal programs can be used to support projects with blue carbon financing, those funding programs would need to determine that blue carbon financing is not related to any kind of compensatory mitigation. As a matter of policy, most government wetland restoration granting programs do not provide funding for compensatory mitigation projects. Carbon offset buyers may be different than developers who have traditionally undertaken compensatory wetland mitigation projects— offset buyers have other options (purchase allowances, other offsets).

Workshop Participants

Steve Emmett-Mattox- Strategic Collaborations, LLC

Shon Schooler- South Slough NERR

Scott Settelmeyer –TerraCarbon

Jenni Schmitt- South Slough NERR

Cyndi Park- Coos Watershed Association

Al Solomon- Coos Watershed Association

Scott Bridgham- University of Oregon

John Bragg- South Slough NERR

Ed Hughes- Coos Watershed Association

Steve Crooks- Silvestrum

Lisa Beers- Silvestrum

Mark Healy- Coquille Indian Tribe

Natalie Wilson- Coquille Indian Tribe

Cheryl Brown- EPA (remotely connected)

Craig Cornu- Institute for Applied Ecology

JOINT NERRS SCIENCE COLLABORATIVE BLUE CARBON PROJECTS RESULTS-SHARING WORKSHOP

Everett, WA Blue Carbon Workshop Agenda

Tuesday, October 8, 2019

Click on presenters' names in the agenda below to start video clip

Tulalip Tribes Administration Building, Everett, WA

Workshop Goals

- Share and discuss the results of the:
  - Draft blue carbon finance feasibility analysis for Snohomish estuary restoration initiatives
  - PNW carbon stocks research
  - PNW blue carbon database development
- Identify and discuss remaining blue carbon information gaps for the PNW and come to consensus on next steps for PNW blue carbon research and proposal development opportunities

8:30 AM	Workshop participants arrive	Check-in, morning coffee, tea, breakfast snacks
9:00 AM	Craig Cornu, Institute for Applied Ecology	Meeting goals, agenda review, projects background Introductions
9:15 AM	Steve Emmett-Mattox, Strategic Collaborations	Feasibility Planning for Pacific Northwest Blue Carbon Finance Project/Overview of the project's approach to assessing the feasibility of blue carbon project finance for Coos estuary tidal wetland projects
9:30 AM	Lisa Schile-Beers, Silvestrum Climate Associates	Feasibility planning results/review and discussion of results of technical analyses
10:30 AM	Break	
10:45 AM	Scott Settelmyer, TerraCarbon	Review and discuss results of technical, financial, legal, and organizational analyses for the PNW Blue Carbon Finance Project

11:30 AM	Steve Crooks, Silvestrum Climate Associates	Present recommendations from the feasibility assessment and discuss the most logical next steps- what opportunities exist for blue carbon project development in the Snohomish estuary? What are this project's implications for other PNW estuarine systems? What are the key remaining data gaps?
Noon	Break for Lunch	
1:00 PM	Amy Borde, Pacific Northwest National Laboratory	PNW Carbon Stocks and Database Project/Overview of the project's comprehensive approach to quantifying carbon stocks for PNW tidal wetland classes and developing a PNW blue carbon database
1:15 PM	Boone Kauffman, Oregon State University	Review and discuss results of PNW carbon stocks research— Carbon stocks potential in least-disturbed PNW tidal wetlands; Effects of land use on carbon stocks—and implications for next step PNW blue carbon research priorities
2:00 PM	Chris Janousek, Oregon State University	Review and discuss results of PNW carbon stocks research— Correlation between ecosystem drivers and carbon stocks potential in least-disturbed PNW tidal wetlands; Decomposition rates of organic material in PNW tidal wetlands— and implications for next step PNW blue carbon research priorities
2:45 PM	Break	
3:00 PM	Chris Janousek, Oregon State University	Review and discuss the status of the DRAFT PNW blue carbon database, partnership with Smithsonian Environmental Research Center's Coastal Carbon Research Coordination Network, the database's potential utility for blue carbon project developers and regional policy makers, and next steps for the database

3:45 PM	Craig Cornu, Institute for Applied Ecology	Next steps for the PNW blue carbon working group—Given the results presented and discussion undertaken during today's sessions, discuss priority data gaps identified and how those needs will be addressed in the next PNW blue carbon working group project proposals; discuss funding opportunities to support those projects.
4:45 PM	Adjourn	

Workshop Participants

Aaron Jones- Tulalip Tribes
Amy Borde- Pacific Northwest National Laboratory
Ben Lubbers- Tulalip Tribes
Boone Kauffman- Oregon State University
Chris Janousek- Oregon State University
Colin Wahl- Tulalip Tribes
Craig Cornu- Institute for Applied Ecology
David Grover- Tulalip Tribes
Erin Meyer- Seattle Aquarium
Erin Murray- Puget Sound Partnership
Heida Diefenderfer- Pacific Northwest National Laboratory
Jamie Robertson- The Nature Conservancy
Jude Apple- Padilla Bay NERR
Julia Gold- Tulalip Tribes
Kirsten Feifel- WA Department of Natural
Resources Kurt Wilson- Tulalip Tribes
Kyler Sherry- The Climate Trust
Lindsey Desmul- Washington Department of Fish and Wildlife
Lea Anne Burke- Tulalip Tribes
Lisa Schile-Beers- Silvestrum Climate Associates
Lizzy Stone- University of Washington
Lucas Rabins- Tulalip Tribes
Mark Stamey- ICF Jones and Stokes
Michelle Totman- Tulalip Tribes
Mike Rustay- Snohomish County
Molly Bogeberg- The Nature Conservancy

Morgan Ruff- Tulalip Tribes
Phil North- Tulalip Tribes
Pipo Bui- Earth Corps
Roger Fuller- Padilla Bay ERR
Ron Thom- Pacific Northwest National Laboratory (emeritus)
Scott Settelmeyer –TerraCarbon
Steve Crooks- Silvestrum Climate Associates
Steve Emmett-Mattox- Strategic Collaborations
Steven Fry- Seattle 2030 District
Valerie Streeter- Tulalip Tribes
Wolf Lichtenstein- Evergreen Carbon

Skagit Delta Results Sharing Workshop: October 9, 2019

Padilla Bay NERR

SUMMARY

Workshop Goal: Share and discuss the results of the draft blue carbon finance feasibility analysis for Skagit Delta tidal wetland restoration

Presentations from Project Team

- Workshop Context: Background of the two PNW blue carbon working group projects— Craig Cornu
- Overview of the Carbon Finance Feasibility Planning Project- Steve Emmett-Mattox
- Analytical Approach and GHG Reductions and Emissions Results- Lisa Beers
- Carbon Finance Results— Scott Settelmyer
- Key Outcomes and Next Steps— Steve Crooks

Results Highlights

The Scoping Assessment for PNW Blue Carbon Finance Projects provides an initial assessment of the opportunity and key considerations of connecting carbon finance to tidal wetland restoration projects in the PNW and identifies remaining PNW blue carbon data gaps that need to be addressed before developing project-level carbon finance feasibility assessments in the region.

Estimates of soil and plant carbon accumulation and non-CO2 GHG emissions, specifically CH4 and nitrous oxide (N2O), were compiled for disturbed and undisturbed lands in the Skagit Delta. The amount of allochthonous carbon (carbon imported from outside the system rather than produced within) was estimated using organic carbon content from locally collected wetland soil cores. No planned restoration projects were specified in the assessment but rather a range of illustrative scenarios were explored. Baseline scenarios included seasonally flooded agricultural and pasturelands containing various grasses and forbs. Project scenarios included tidal wetland restoration to mesohaline (5.0-18.0 PSU), oligohaline (0.5-5.0 PSU), and freshwater conditions.

The financial feasibility of developing a tidal restoration carbon project was analyzed by calculating the cash flows over the first 40 years for each illustrative project. Prices for tidal wetland restoration offsets are likely to be at the high end of the range for land-based offsets (assumed to be $10 per ton of CO2) given the scarcity of projects and high interest from traditional voluntary buyers.

The potential for carbon finance is highest in project scenarios where biomass and soil carbon sequestration exceed soil methane emissions in restored tidal wetlands. Projects occurring in more polyhaline (18.0-30.0 PSU) tidal wetland restoration areas are likely to generate low methane (CH4)emissions while those occurring in lower salinity areas may generate higher CH4 emissions (although more research is needed on low salinity tidal wetlands in the PNW- see below). While restoration projects in lower salinity portions of the Delta may not be well suited to carbon financing, the restoration of Sitka spruce-dominated forested tidal wetlands was estimated to generate significant carbon offsets and revenues over 40 years in project areas as small as 500 hectares.

Due to several uncertainties in the available GHG emissions data, results were presented using varying baseline and project assumptions, specifically soil carbon accumulation in the baseline scenario and CH4 emissions in the project scenario. The results can be used to identify conditions that would likely lead to carbon offset generation in each restoration scenario.

This investigation did not find a positive result for the application of carbon finance to support conversion of wet pastureland to emergent wetland in mesohaline and oligohaline river-estuary conditions. However, as noted previously, restoration of tidal freshwater forest did offer net GHG removals over a project lifetime of 40 years or longer. At a scale of 100 ha project costs would outweigh revenue generated, but at larger scales positive cashflow is generated.

The largest data gap revealed through this project is the dearth of trace GHG emission measurements from PNW tidal wetlands. Only one study presented CH4 and N2O emissions data within degraded, restored and natural tidal wetlands in two estuaries in Oregon (Schultz 2019). Considering the degree to which CH4 emissions within a project scenario can negate any carbon sequestered within the soil or vegetation, it is imperative to assess the range and magnitude of emissions across seasons, salinities, estuaries and site conditions so that the most accurate and applicable emissions are incorporated into future blue carbon finance feasibility assessments. This is particularly important in estuaries that are dominated by river flow and, are consequently dominated by water and soil salinities below 18 PSU, a value under which default values cannot be used and local or regional field data are required.

Discussion Highlights

Project Scope

Clarification of project scope for the Skagit system: lands at (and above- allowing for sea level rise) current head of tide down to the lower part of the Delta including all the coastal lowlands. Normal approach to blue carbon project is to consider the feasibility of multiple carbon-financed restoration projects within entire estuarine systems. Project concept centers around the Skagit Delta sites identified in the existing Skagit HDM Report, trying to answer questions about the extent to which carbon finance could facilitate restoration actions outlined in the HDM report.

Data Gaps

Further discussion centered on the lack of information about methane emissions from PNW mesohaline and oligohaline wetlands— in particular from disturbed former tidal wetlands affected by seasonal flooding and various sea level rise scenarios. Also discussed was the lack of data that would allow researchers in the PNW to quantify the lateral movement of carbon in least disturbed, disturbed or restored tidal wetland sites. Which means carbon sequestration figures reported as project results are underestimates of reality because in the absence of local lateral flux data, conservative default values are used. Carbon flux research is needed but will be very complex and will need to be conducted as part of a separate research project. Carbon flux includes quantifying carbon exported from wetland biomass and soils, fate of eroded carbon, fate of allochthonous carbon passing through estuary under a range of site conditions.

Key Issues Discussed

- Blue carbon finance in the PNW will be most successful supporting projects that restore disturbed seasonally flooded former tidal wetlands to polyhaline or marine tidal emergent marsh habitats and to forested tidal wetlands.
- Probably a good idea to test the VCS methodology's assumptions on leakage by undertaking some leakage assessments to more fully understand whether adjustments need to be made to the methodology. For example, methodology requires lands currently managed for agricultural purposes be abandoned for a minimum of two years before they become eligible for carbon-financed restoration. The working assumption is that farmers giving up ag practices on one piece of property may well re-start their carbon-emitting practices on another property, eliminating or significantly diminishing the benefits of the carbon-financed restoration project. This assumption could be reconsidered because, for example, in the Skagit region there's a very limited ag land base and farmers can't necessarily just move to another piece of property and start their ag operations again.
- Local Skagit Delta ag economy is a critical consideration. They can't lose too much farmland to restoration without threatening the critical land base needed for successful economic production in the Delta. Economic research is needed to better understand/quantify these dynamics. Blue carbon financing will not be able to compete with economically successful ag operations.

- Given the importance of forested tidal wetlands to the success for carbon financed restoration projects in the PNW, there was discussion about the location of historic forested tidal wetlands in the Skagit Delta. More research would be needed to map those areas if they haven't already been mapped.

Next Steps

- New funding to narrow down uncertainties: 1) methane; 2) C sequestration rates in both baseline and project scenarios; 3) lateral flux of carbon. Working group will pursue these topics in next funding proposals (most likely prioritizing methane emissions and C sequestration first).
- In terms of Skagit projects, there may be opportunities, as mentioned, for restoring forested tidal wetlands. But could some projects be jump-started by prior planting of Sitka spruce and other species behind levees in anticipation of later levee removal? Such a strategy would require very careful site selection with particular attention paid to site elevations. Also, projects that demonstrate the feasibility of improved ag management for reducing emissions and helping increase soil carbon sequestration could be considered (perhaps on Padilla Bay NERR's managed ag land holdings? See last bullet below). As well as opportunities for the restoration of sites with polyhaline and marine salinity regimes. It was reiterated that we also really need to improve understanding of the lateral flux of carbon between sites from seagrass beds, kelp beds and tidal marshes.
- Future assessments should review lessons learned related to how the VCS tidal wetland restoration methodology is applied in real-world situations. What are the challenges and possible solutions? Or better define the barriers that carbon project proponents will need to navigate for any given project.
- Padilla Bay NERR is interested in facilitating habitat restoration or enhancement with partners in both the ag community and natural resource agencies. As local partners begin recognizing how blue carbon financing may help incentivize restoration and conservation efforts in the Delta, this feasibility assessment (scoping assessment in reality) will help define those carbon financing-related opportunities and remaining challenges to help inform those efforts. One example might be possible carbon finance incentives associated with forested buffers that ag operators include in lowland ag sites- buffers that have multiple ecosystem service values including habitat and carbon sequestration (e.g., Conservation Reserve Enhancement Program buffers). Scale would be one of the big challenges- buffers associated with individual sites would not be economically feasible but might be for multiple landowners.

- Padilla Bay NERR has some modest funding from years of leasing reserve-managed ag land to ag operators and may soon be reviving a program that would investigate some of these carbon finance questions.

Workshop Participants

Craig Cornu- Institute for Applied Ecology

Janet Curran- NOAA Fisheries

Jenny Baker- Washington Department of Fish and Wildlife

Jude Apple- Padilla Bay NERR

Lisa Beers- Silvestrum

Roger Fuller- Padilla Bay NERR

Scott Settelmeyer –TerraCarbon

Steve Crooks- Silvestrum

Steve Emmett-Mattox- Strategic Collaborations, LLC

JOINT NERRS SCIENCE COLLABORATIVE BLUE CARBON PROJECTS RESULTS-SHARING WORKSHOP

Coos Bay, OR Blue Carbon Workshop Agenda

Tuesday, October 29, 2019

Click on presenters' names in the agenda below to start video clip

South Slough NERR Interpretive Center, Coos Bay, OR

Workshop Goals

- Share and discuss the results of the:
  - Draft blue carbon finance feasibility analysis for Coos estuary restoration initiatives
  - PNW carbon stocks research
  - PNW blue carbon database development
- Identify and discuss remaining blue carbon information gaps for the PNW and come to consensus on next steps for PNW blue carbon research and proposal development opportunities

8:30 AM	Workshop participants arrive	Check-in, morning coffee, tea, breakfast snacks
9:00 AM	Craig Cornu, Institute for Applied Ecology	Meeting goals, agenda review, projects background Introductions
9:15 AM	Steve Emmett-Mattox, Strategic Collaborations	Feasibility Planning for Pacific Northwest Blue Carbon Finance Project/Overview of the project's approach to assessing the feasibility of blue carbon project finance for Coos estuary tidal wetland projects
9:30 AM	Lisa Schile-Beers, Silvestrum Climate Associates	Feasibility planning results/review and discussion of results of technical analyses
10:30 AM	Break	
10:45 AM	Scott Settelmyer, TerraCarbon	Review and discuss results of technical, financial, legal, and organizational analyses for the PNW Blue Carbon Finance Project

11:30 AM	Steve Crooks, Silvestrum Climate Associates	Present recommendations from the feasibility assessment and discuss the most logical next steps- what opportunities exist for blue carbon project development in the Coos estuary? What are this project's implications for other PNW estuarine systems? What are the key remaining data gaps?
Noon	Break for Lunch	
1:00 PM	Amy Borde, Pacific Northwest National Laboratory	Overview of the project's comprehensive approach to quantifying carbon stocks for PNW tidal wetland classes and developing a PNW blue carbon database
1:15 PM	Boone Kauffman, Oregon State University- presentation at the Oct 8, 2019 Everett, WA Blue Carbon Workshop Due to persistent tech difficulties, Boone's remote presentation at the Coos workshop had to be cut short. The video of the same presentation from the Everett, WA workshop was presented in its place.	Review and discuss results of PNW carbon stocks research— Carbon stocks potential in least-disturbed PNW tidal wetlands; Effects of land use on carbon stocks—and implications for next step PNW blue carbon research priorities
2:00 PM	Chris Janousek, Oregon State University	Review and discuss results of PNW carbon stocks research— Correlation between ecosystem drivers and carbon stocks potential in least-disturbed PNW tidal wetlands; Decomposition rates of organic material in PNW tidal wetlands— and implications for next step PNW blue carbon research priorities
2:45 PM	Break	
3:00 PM	Chris Janousek, Oregon State University	Review and discuss the status of the DRAFT PNW blue carbon database, partnership with Smithsonian Environmental Research Center's Coastal Carbon Research Coordination Network, the database's potential utility for blue carbon project developers and regional policy makers, and next steps for the database
3:45 PM	Craig Cornu, Institute for Applied Ecology	Next steps for the PNW blue carbon working group— Given the results presented and discussion undertaken during today's sessions, discuss priority data gaps identified and how those needs will be addressed in the next PNW blue carbon working group project proposals; discuss funding opportunities to support those projects.

4:45 PM	Adjourn	

Workshop Participants

Amy Borde- Pacific Northwest National Laboratory
Amy Horstman- US Fish and Wildlife Service
April Silva- Columbia River Estuary Study Taskforce
Bree Yednock South Slough NERR
Craig Cornu- Institute for Applied Ecology
Cyndi Park- Coos Watershed Association
Dick Vander Schaaf- The Nature Conservancy (remote connection) Ed
Hughes- Coos Watershed Association
Fran Recht- Pacific States Marine Fisheries Commission Heida
Diefenderfer- Pacific Northwest National Laboratory Jason
Nuckols- The Nature Conservancy (remote connection) Jenni
Schmitt- South Slough NERR
John Bragg- South Slough NERR
Katrina Poppe- Western Washington University
Kelly Warren- Ducks Unlimited
Laura Brophy- Institute for Applied Ecology
Lisa Beers- Silvestrum
Mark Healy- Coquille Indian Tribe
Megan Hilgart- NOAA
Melissa Ward- University of California Davis (remote connection)
Narayan Elasmar- Columbia River Estuary Study Taskforce
Sarah Kidd- Lower Columbia Estuary Partnership
Scott Bridgham- University of Oregon
Scott Jones- US Geological Survey (remote connection)
Scott Settelmeyer –TerraCarbon
Shon Schooler- South Slough NERR
Sneha Rao Manohar- Lower Columbia Estuary Partnership
Steve Crooks- Silvestrum
Steve Emmett-Mattox- Strategic Collaborations, LLC