NERRS SCIENCE COLLABORATIVE

2016 FUNDING OPPORTUNITY

Project title: Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands

Project type: Collaborative Research

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Name of Reserves: South Slough NERR, Padilla Bay NERR

Budget Request: $750,000

Project Duration: November 1, 2016 – October 31, 2019

Project Summary

The Pacific Northwest (PNW) Blue Carbon Working Group formed in 2014 to address gaps in regional blue carbon science. Our project includes three objectives: 1) engage end users to provide blue carbon information for policy and management; 2) develop a regional blue carbon database; 3) conduct research to determine blue carbon stocks in major PNW coastal wetland habitats. Our research will comprise the first comprehensive blue carbon assessment in PNW tidal wetlands, driven by four questions: 1) What is the range and variability of carbon stocks of intact tidal wetlands?, 2) How do carbon stocks of converted coastal wetlands (e.g., pastures) compare with least disturbed habitats?, 3) What are the potential greenhouse gas emissions that could arise from tidal wetland loss?, and 4) How do PNW carbon stocks compare with carbon pools in other North American wetlands? We will generate a user-friendly database that compiles regional blue carbon data to support end user use of blue carbon data. Input from end users will guide the design, scope, outputs and outcomes of the project. This project will contribute to national and international efforts to incorporate blue carbon science into coastal management and climate change mitigation and adaptation.

Project Narrative

1) Problem Statement and Response to End User Needs

Research questions: Research will be driven by the following research questions formed from end user input (see Project Approach below):

1. What is the range and variability of carbon stocks of intact coastal ecosystems (blue carbon ecosystems) of the Pacific Northwest (PNW)? How do ecosystem carbon stocks differ between low marsh, high marsh, forested tidal swamp (*Picea sitchensis*) and eelgrass (seagrass) meadows? How do major environmental and edaphic variables such as inundation and salinity control carbon stabilization in coastal wetlands? What are historic rates of sequestration in intact coastal wetlands (based upon marker-horizons from past tsunamis)?
2. What are the carbon stocks of converted (degraded) coastal wetlands (farm field, cattle pastures) that were formed on sites previously occupied by marshes or tidal swamps?
3. What are the potential greenhouse gas emissions that could arise from conversion of coastal wetlands?
4. How do carbon stocks of the PNW wetlands compare to other North American tidal wetlands and how do losses associated with conversion compare to potential greenhouse gas (GHG) emissions from other land uses?

Issues this Project Addresses

Issues and their Importance and Context: Blue carbon ecosystems (including tidal wetlands) are recognized for their important role in global carbon sequestration and their potential to become significant sources of GHG emissions when converted to other land uses (Fourqurean et al. 2014, Pendleton et al. 2012). The substantial quantities of carbon captured and stored by tidal wetlands is an ecosystem service of great interest to those developing regional, national, and global climate change adaptation and mitigation strategies, including carbon markets (IPCC 2013). While carbon stocks data, a fundamental blue carbon information need, are being collected on the east and gulf coasts of the US and in other parts of the world to quantify the carbon sequestration potential of tidal wetlands, there is a distinct paucity of such information in the PNW. PNW land managers, policy makers, planners, and scientists lack the reliable regional and site-specific information needed to:

- Develop local and regional plans for the coastal zone that support integrated responses to climate change, including both mitigation (expanded mechanisms for sequestering carbon and GHG emissions reductions) and adaptation approaches;
- Incorporate the value of tidal wetland ecosystem services (including carbon sequestration) into new or expanded coastal resource management plans and policies;
- Help support coastal resource management actions through carbon finance mechanisms (e.g., wetland restoration and conservation supported by voluntary or compliance carbon markets); and
- Evaluate the vulnerability and resilience of PNW coastal ecosystems to climate change drivers such as sea-level rise.

To effectively contribute to national and global climate change adaptation and mitigation strategies, and develop those strategies for PNW communities, we propose to collect and disseminate carbon stocks data from intact (least disturbed) and converted (disturbed) coastal wetlands across the PNW. This project will work with end users to pursue four primary objectives:

- Identify and prioritize PNW carbon data information needs and assess how end users will be able to access and use those data;
- Collect new data on carbon stocks and associated data on climatic, environmental, and geomorphic variables (environmental variables) from representative PNW tidal wetlands that address project research questions;
- Develop a PNW Blue Carbon Database for regional blue carbon data (including new carbon stocks data from this project and other available data) in response to end users' data needs;
- Share project results and the blue carbon database with end users in the PNW and more widely, to support initiatives for which quantitative blue carbon data are needed such as local and landscape-scale coastal ecosystem restoration and coastal zone planning.

Tidal wetlands provide a wealth of ecosystem services to coastal estuaries including fisheries functions (Barbier et al. 2011), protection from extreme water events (Shepherd et al. 2011), and nutrient removal (Allred and Baines 2016). Our proposal will generate new data on the blue carbon functions of these critical habitats that will yield a better understanding of their cumulative values for Pacific Northwest coastal ecosystems and human communities along the coast.

How the project addresses Padilla Bay and South Slough NERR management needs: The distribution and dynamics of blue carbon—including stocks, sequestration rates, and potential emissions from wetland loss—have been identified as a significant research need and management priority in many coastal regions, including the Padilla Bay and South Slough NERRs. Padilla Bay NERR has one of the largest contiguous eelgrass beds in North America, and a management responsibility to work with regional stakeholders to preserve existing eelgrass habitat and contribute to the science of eelgrass bed restoration. Reserve priorities include quantifying long-term sequestration and storage of atmospheric and oceanic carbon in eelgrass beds, and the potential for eelgrass habitats to provide refuge for marine organisms potentially affected by changing ocean pH. Yet no studies have quantified the ecosystem carbon stocks of eelgrass communities in this region of North America (CEC 2013). Quantifying blue carbon stock values for eelgrass habitat will give incentive to the Puget Sound Partnership Eelgrass Restoration Initiative by providing data on the ecosystem services of carbon storage and sequestration potential of eelgrass.

South Slough NERR seeks to improve the understanding of ecosystem services provided by estuarine tidal wetlands and eelgrass beds, including characterizing blue carbon stocks, sequestration rates, and environmental variables affecting blue carbon storage. In addition, South Slough NERR recognizes the need to identify local and regional management needs and

priorities related to these ecosystem services. This project is directly applicable to South Slough NERR's ongoing research on wetlands, carbon dynamics in estuarine waters, and the effects of climate change on ecosystem function in PNW marine and estuarine environments, which are prioritized within the Reserve's 2016-2021 Strategic Plan.

Leveraged Outputs/Outcomes from previous NERRS Science Collaborative Support: Project team members founded the PNW Coastal Blue Carbon Working Group (Working Group; see description, next section) in 2014 through a series of workshops, the largest of which was supported by NERRS Science Collaborative (NSC) Science Transfer funds. The workshop outputs included the Working Group's Biophysical Research Framework (Cornu et al. 2014), which articulates the collaborative rationale and approach that Working Group members will use to collect and share PNW blue carbon data. The outcomes of the workshop included the development of proposals to the NERRS Science Collaborative and other entities requesting funding to implement the Working Group's Research Framework.

Project End Users

Project end users are represented in growing list of Working Group members (see "Pacific Northwest Coastal Blue Carbon Working Group" membership list, Appendix I). The Working Group has been a strong collaborative multidisciplinary team of biophysical, social, and economic scientists, coastal planners, land managers, restoration scientists and practitioners, representing state and federal agencies, academic institutions, consulting firms, nonprofit organizations from Oregon, Washington, California. In recent months, through simple networking (see Project Approach below) we've expanded our membership to include conservation finance and carbon accounting interests, policy makers, and an environmental economist, and others. Table 1 lists the newest Working Group members and highlights how they anticipate using our project's outputs (corroborated by letters of support, Appendix F), combined with the interests and anticipated output uses articulated by some of our most active long-time Working Group members.

Table 1. Planned application of the results of the proposed project, by end user and organization.

End User, Organization/Position	**Application of Results of the Proposed Research**
David Antonioli, Verified Carbon Standard, Washington DC/ Chief Executive Officer	Verified Carbon Standard will share project outputs with VCS' stakeholders interested in developing carbon mitigation projects, helping remove an important barrier in the design and implementation for projects in the PNW; with buyers of carbon credits to provide needed assurance of the emission reductions provided by these projects. VCS will share the blue carbon database with US states and Canadian provinces developing programs to reduce GHG emissions (e.g., British Columbia's carbon tax, and the proposed Washington State Clean Air Rule) to provide robust and complete data to allow wetlands and other blue carbon activities to be included in these efforts.
Steve Crooks, Stephen Crooks San Francisco, CA /Owner, Lead Principle Investigator, US Coastal Wetland Carbon Working Group, EPA Source Lead for Coastal Wetlands, Science Team Member, NASA Carbon Monitoring System	Through NOAA's US Coastal Wetland Carbon Working Group (US Working Group), Crooks will use this project's outputs to help quantify the IPCC-recommended "emissions factors" with which GHG fluxes associated with anthropogenic changes to tidal marshes, tidal swamps, and seagrass beds can be calculated— which supports the US Working Group's efforts to develop higher-tier assessments of carbon emissions and removals being developed for the U.S. National Greenhouse Gas Inventory's 2017 submission to the United Nations Framework Convention on Climate Change.

Steve Emmett-Mattox, Restore America's Estuaries, Arlington, VA/ Senior Director for Strategic Planning and Programs	Emmett-Mattox will use this project's outputs to help further Restore America's Estuaries' (RAE's) efforts to advance the science and application of blue carbon in support of the restoration and conservation of coastal wetland ecosystems nationally; specifically RAE will share and interpret project outputs with federal agencies (e.g., White House Council on Environmental Quality) for whom securing more and better data quantifying GHG gas fluxes in tidal wetlands is a national priority. RAE will also use its web site and other means to share lessons learned from the science team (e.g., best practices in field data collection) with a broader national audience and share the data with policy and decision makers in DC to demonstrate the important climate mitigation and ecosystem service values of coastal wetlands in support of their restoration, conservation, and adaptation initiatives.
Jeffrey Gaeckle, Washington State Department of Natural Resources, Olympia, WA/ Seagrass Ecologist	Gaeckle is collaborating on another project that will assess carbon sequestration and storage potential in eelgrass beds throughout the PNW and will use this project's outputs to compare with the other project's results-conducting cross-comparisons between sites and ecosystems. Gaeckle will also use project outputs to guide management decisions that enhance protection of critical nearshore habitat and incentivize effort to increase eelgrass habitat by 20% by 2020. Gaeckle will use his participation as an end user to develop more formal eelgrass research collaborations between WA DNR,the Padilla Bay NERR, and other stakeholders
Joel Gerwein, Michael Bowen, Evyan Borgnis, California Coastal Conservancy/ North Coast Project Managers (Gerwein, Bowen), and South Coast Project Manager (Borgnis)	Gerwein, Bowen, and Borgnis will use this project's outputs to encourage the California Air Resources Board's formal adoption of proposed blue carbon-related actions associated with California's cap and trade program (identify blue carbon project opportunities; implement a range of blue carbon pilot projects); to support the standardization of coastal blue carbon data by encouraging general use by all researchers of the PNW Blue Carbon Database, one of the project's main outputs; to use quantitative carbon storage potential and avoided emissions data to strengthen rationale for tidal wetland restoration actions in funding proposals (to e.g. CA Dept of Fish and Wildlife) and to use for GHG analyses in environmental compliance documents (e.g., CA Environmental Quality Act).
Jenny Liu, Portland State University, Portland, OR/Assistant Professor, Toulan School of Urban Studies & Planning; Assistant Director, Northwest Economic Research Center (NERC)	Liu will use this project's outputs to help develop a more comprehensive understanding of blue carbon's market potential for the PNW; to add empirical blue carbon research results to NERC's economic analyses of proposed GHG emissions reduction and mitigation legislation (e.g., "cap and invest") conducted for the OR Legislature.
Sean Penrith, The Climate Trust, Portland, OR/ Executive Director	Penrith will use this project's outputs to help improve The Climate Trust's understanding of blue carbon's market potential in the PNW, possibly catalyzing the development of blue carbon finance pilot projects in the region.
Sheida Sahandy, Puget Sound Partnership, Seattle/Tacoma, WA/Director Amber Moore, Puget Sound Partnership, Seattle/Tacoma, WA/Ecosystem Recovery Coordinator	Sahandy and Moore will use this project's results to raise public awareness of the co-benefits of restoration and protection of blue carbon habitats within Puget Sound, incorporate blue carbon into climate adaptation and response planning, and explore potential market and offset opportunities in Washington State, including working with the Department of Ecology to include coastal habitats and blue carbon market opportunities in the development of their carbon rule. Results from this project will potentially allow for better management of blue carbon habitats within Puget Sound, and overall recovery of Puget Sound through the estuary and eelgrass Vital Sign targets.
Jude Apple, Research Coordinator, Padilla Bay NERR	Apple will use information on carbon stock assessment for multiple purposes. Carbon stock values for eelgrass meadows will allow Apple and Padilla Bay NERR Stewardship Coordinator to make decisions regarding the long-term management of Padilla Bay and to also guide research priorities. Involvement in the project will help build experience and capacity necessary to conduct our own blue carbon inventories and thus investigate physical and environmental drivers related to carbon storage and sequestration. In this regard, the project will allow Padilla Bay NERR to make a fundamental contribution to the basic science regarding blue carbon in the Pacific Northwest, and make substantive contribution through publications to the broader scientific community regarding assigning blue carbon values to seagrass, eelgrass and saltmarsh ecosystems.
Laura Brophy, Estuary Technical Group, Institute for Applied Ecology, Corvallis, OR / Director	Brophy will use this project's outputs to help guide the Pacific Marine and Estuarine Fish Habitat Partnership's (PMEP's) prioritization of tidal wetland and conservation opportunities for the U.S. West Coast; and guide strategic planning on the Oregon Coast by the Oregon Central Coast Estuary Collaborative. Brophy and other Estuary Technical Group members and partners will use the project's outputs to help evaluate blue carbon ecosystem services and climate change resilience for dozens of tidal wetland restoration projects in the Pacific Northwest. These projects' funders are very interested in quantifying the ecosystem services achieved through their restoration investment, and they place strong emphasis on climate change resilience for funded projects.

John Bragg, South Slough National Estuarine Research Reserve, Charleston, Oregon / Coastal Training Program Coordinator	Bragg will use this project's results to help plan three workshops for end users in order to share outcomes, data, and provide training in the use of data tools that may be developed as a result of this work, and coordinate/present two of the workshops. Training development will be coordinated with the Padilla Bay NERR Coastal Training Program.
Heida Diefenderfer, Pacific Northwest National Laboratory, Marine Sciences Laboratory, Coastal Ecosystems Research Team Leader	Carbon stocks information from this project would be used by Diefenderfer to help inform scientists and managers restoring tidal marshes, shrub-dominated wetlands, and forested wetlands for juvenile salmon habitat through the Columbia Estuary Ecosystem Restoration Program. It would also support evaluating regional variability relevant to ongoing PNNL research into the functional responses of wetland soil microbial communities to climate-driven perturbations.
Shawn McMahon, Environmental Services Inc, North Lawrence OH/Senior Mgr, Lead Auditor	As a carbon sequestration project auditor, McMahon would use the project outputs, particularly the blue carbon database, as his source for vetted carbon sequestration data when validating/verifying PNW blue carbon projects when they are implemented and become ready for auditing. The database offers potential for reducing the overall time and cost associated with auditing.
Christopher Janousek, Oregon State University/Research Associate	The database information and new carbon stocks measurements obtained in this project will help inform changes in coastal wetland services and function that may occur with sea-level rise and other climate change drivers. Blue carbon data can be coupled with our team's recent sea-level rise (SLR) modeling effort in the Pacific Northwest to project changes in carbon storage capacity with SLR.
Lisamarie Windham-Myers, USGS, Menlo Park, CA/Research Ecologist	Windham-Myers will use the project outputs in her work to help fill large data gaps in the understanding of coastal carbon cycling in the Pacific Northwest and will coordinate this project's blue carbon database development with the Global Science and Data Network for Coastal Blue Carbon database under development by the USGS, NOAA, and other partners organized under the United States Carbon Cycle Science Program.
Bree Yednock, South Slough National Estuarine Research Reserve (South Slough NERR), Charleston, OR/ Research Coordinator	South Slough NERR is involved in research and restoration projects that will benefit from the proposed project. We're currently collaborating on a project to assess blue carbon storage in seagrassess along the Pacific Coast; the proposed project would complement this effort by providing additional empirical information on carbon stocks and ecosystem drivers of other wetland environments and add to our understanding of carbon storage potential in our estuary. The information will be used to help us quantify carbon stocks in our undisturbed and restored project areas. Access to the database and visualization tools will help us compare our local carbon stocks to other areas across the region, as well as provide a format for us to disseminate our own data and findings.

The Working Group will continue expanding its membership as part of the first year of project implementation. Through a needs assessment, meetings and workshops (described below) we will incorporate the guidance of a broad complement of PNW blue carbon end user perspectives into our research and database development plans designed to address our current understanding of end-user needs. We anticipate our understanding of end user needs to evolve with the growing number of end users guiding the project.

The approach for which we'll be requesting end user guidance is to: 1) quantify carbon stocks and associated environmental variables in representative reference tidal wetlands and wetlands converted for agricultural uses in the PNW's three geographically distinct regions, the Puget Sound, Columbia River estuary, and other smaller outer coast estuaries; 2) compile existing and new blue carbon data into a PNW Blue Carbon Database (Database) to provide an easily accessible and expandable repository of information for regional, national, and international end-users; 3) share the database with PNW end users through workshops and trainings; and 4) contribute to the specific information needs of individual Working Group members. See Project Approach below.

Governmental and Non-Governmental End-User Audiences
In addition to the networking already under way, the Coastal Training Programs (CTP) at South Slough NERR and Padilla Bay NERR are recommending an approach to identifying and "recruiting" more land and resource managers and conservation interests. One subset of this group includes talking to additional state, local, and tribal agency representatives, as well as private entities, whose stewardship, management, or regulatory duties include tidally influenced estuaries and bays. Another subset includes private landowners and managers who may desire the guidance of carefully thought out blue carbon policies and rules to inform their land use decisions. These audiences will be included among those targeted by additional interpersonal networking, the needs assessment, and follow-up workshops (see Project Appriach)

Project Steering Committee and Teams
The project team (Project Lead, Technical Lead, Collaboration Lead, Researcher…etc.) and interested users will become part of a Project Steering Committee (Steering Committee) formed to oversee project planning and implementation. Because this project consists of multiple elements, the membership of the Steering Committee will be made up of four teams—Project Leadership Team, End User Engagement Team, Database Development Team, and Research Team—each focused on different aspects of project implementation as described in the Project Approach section below, in the Appendix I "PNW Blue Carbon Project Organization Chart," and shown in the Project Timeline (Appendix B).

2) Outputs and Outcomes

2.1. End user recruitment and needs assessment

Output: Members of the End User Engagement Team will begin by recruiting additional end users to help guide the work of the project teams, specifically targeting those policy makers and planners who would benefit from access to blue carbon data. (We have already initiated our efforts to enlist additional end users as described in Project Approach.) The End User Engagement Team will then conduct a comprehensive needs assessment to: 1) identify PNW end users with interests not yet represented in the working group or project; 2) determine how well informed those end users are; 3) determine the specific data needs and data access preferences of informed end users, and 4) identify barriers to implementation of carbon mitigation strategies. The needs assessment will include two phases in which we conduct: 1) an analysis of end user needs, implementing assessment methods typically applied by the NERRS CTP Program; and 2) follow-up interviews with key end users, in which to further articulate specific needs especially from those less familiar with blue carbon concepts.
Outcomes: Additional end users will provide the policy advocacy, economic, carbon finance, and planning perspectives that are currently underrepresented on the Working Group. Through the needs assessment, end users will help ensure the current project (and the future direction of the Working Group) is responsive to the full suite of PNW blue carbon science needs. The Research Team will refine the experimental design to address carbon stock knowledge gaps and the Database Team will be able to design database structure and content to best meet end user

needs and discuss the types of data visualization tools that end users might find the most useful (to be developed in a subsequent proposal).

2.2. Analyses of blue carbon stocks in the Pacific Northwest

Output: We will quantify carbon stocks in five major PNW tidal wetland habitats (eelgrass, low tidal marsh, high tidal marsh, forested tidal swamp, and tidal wetlands converted to agricultural uses) addressing questions related to the variability of carbon stocks among habitat types, and how land use history (e.g., intact versus converted wetlands) and key environmental gradients (e.g., salinity, hydrology, soil characteristics) affect carbon stocks. Results will be synthesized in the Database, reports, one or more peer-reviewed publications by the research team, and will be shared at end user workshops/meetings and the NERRS annual meeting.

Outcomes: End users will acquire new data on actual and potential carbon stocks and sequestration values for coastal and estuarine habitats across the PNW. This information will help guide coastal restoration efforts and provide valuable information for regional and national climate change adaptation and mitigation projects. Carbon stock information will also meet previously-identified management needs of Padilla Bay and South Slough NEERS.

2.3. Blue carbon database

Output: The Database Development Team will create an expandable database populated with all existing carbon stock values in PNW tidal wetlands to establish a single repository of PNW blue carbon data readily accessible to end users. We will populate the database with newly collected blue carbon data provided by this project, and provide an expandable framework to accommodate the addition of new blue carbon data in the future. The database will be designed in response to end user suggestions, including the suggestions of database developers (e.g., Windham-Myers, Table 1, Appendix F) associated with the United States Carbon Cycle Science Program's Global Science and Data Network for Coastal Blue Carbon, envisioned as a global repository for blue carbon data which will influence the design of our database to ensure cross-compatibility.

Outcomes: The database will provide managers, policy makers, and coastal scientists information on blue carbon stocks for major coastal wetlands types in the Pacific Northwest, including geographic differences in carbon stocks. The database also will facilitate the dissemination of information on the 'state of the science' to agencies interested in supporting future blue carbon research in the PNW and elsewhere and provide key regional data to national and international blue carbon research scientists investigating large-scale patterns of carbon sequestration (e.g., links with and contributions to the Global Science and Data Network for Coastal Blue Carbon). The Working Group, broader research community will be able to use the database to inform experimental design in the current project and to guide future research efforts to address blue carbon data gaps in the region. Coastal zone planners and managers, and coastal conservation interests will be able to access carbon stock values for habitats and ecosystems in their watersheds and/or management areas and make informed decisions and recommendations regarding restoration and conservation efforts, including effort to include blue carbon finance mechanisms in the California's cap and trade program (e.g., CA Coastal Conservancy, Table 1, Appendix F). The End User Engagement Team will be able to develop products for end users

that are based on the most recent synthesis of data available about PNW blue carbon ecosystems and habitats.

2.4. Results Dissemination and Database Training Workshops

Output: To facilitate the dissemination of project results to the broader community of end users not already contributing to this project, the End User Engagement Team will work with end users during the YR 3 Steering Committee meeting to design what are currently planned as a series of workshops to be convened during the final months of the project. At the workshops we will share project results, introduce and train participants in the use of the database and invite suggestions to improve its usefulness. As knowledge and interest grows over the three year life of this project, new stakeholders or a broader community of end users may emerge needing information about blue carbon so dissemination planners will make sure we cast a broad net when soliciting participation in these workshops. As described below, end users may suggest better dissemination options by the time we get to the last year of the project, so our approach is to remain flexible about the planned workshops so we can be responsive to responsive to end user suggestions.

Outcomes: The workshops will improve regional decision-makers' understanding and access to scientific data on blue carbon stocks in the PNW. The data produced will help the research community establish priorities for future coastal research and identify knowledge gaps. Our workshops will help coastal managers and planners, policy makers, carbon finance interests, environmental economists and others make more informed decisions and help improve the decisions of others (see examples in Table 1).

3) Project Approach

3.1 End User Engagement

The role of the project **End User Engagement Team**, consisting of project team members (co-collaborative leads) and end users (team loosely in place now, but will be more formally established at the beginning of the project), will be to: 1) expand end user representation to ensure a broader range of blue carbon information "consumers" (current and potential) are helping guide the project; 2) establish and manage a process in which end users are providing input to the project at its beginning and throughout project implementation; and 3) work with end users to design and implement informed and targeted dissemination/database training methods.

We have already begun to broaden the range of end users guiding the project and have identified one or two as potential End User Engagement Team members. Our engagement methods consist of simple networking: queries to current contacts and focused Internet research, followed by email solicitations, and then phone contacts, almost always leading to additional leads, followed by more email and phone contacts…etc. Through years of experience leading and managing collaborative projects, we have found that nothing takes the place of simply putting in the time to talk to people and establish an ever-expanding interpersonal network over time. We have found that the relationships established through interpersonal networking are stronger, more productive and more long lasting than any other collaborative methods we've attempted. Because this kind

of networking does take time, we began our conversations with end users months before our project's start date at no cost to the grant.

Over the past several weeks we have established and begun to build productive relationships with end users with widely varying interests (see Table 1 and letters of support in Appendix F); they have already influenced the development of our research approach (having articulated a particular interest in comparisons of carbon storage between least disturbed and converted tidal wetlands).

These networking efforts, which typically lead to already blue-carbon-informed end users, will continue after the project begins, and will be augmented by a needs assessment, the implementation of which will be led by the South Slough NERR CTP coordinator (Bragg). The needs assessment will be designed to: 1) identify PNW end users with interests not yet represented in the working group or project; 2) determine how well informed those end users are; 3) determine the specific data needs and data access preferences of informed end users, and 4) identify barriers to implementation of carbon mitigation strategies. It should be noted that the needs assessment will inform the current as well as future blue carbon research efforts. Staff from South Slough NERR and Padilla Bay NERR will collaborate to develop the needs assessment questions and identify target end users. The preferred method for conducting the assessment is using a series of telephone interviews rather than a survey. We anticipate that the audience of end users will not be large (tens rather than hundreds). The small size of the audience cautions against a broadcast survey, but lends itself to structured personal interviews with potential end users, augmented by one or more follow-up workshops to more-fully elicit end users' needs (see below).

Two blue carbon experts (Crooks and Restore America's Estuaries' Emmett-Mattox) with experience with PNW audiences from past blue carbon workshops will assist with the design of the needs assessment, and will help plan and convene the follow-up workshops which will focus on those potential end users who may need more information before becoming more engaged, as identified in the needs assessment. One of the challenges we face is the widely varying levels of familiarity among land and resource managers, policy makers, planners and others of climate change in general, and more specifically, the need for, and methods associated with GHG emissions mitigation, blue carbon being the basis of an emerging coastal wetland-based carbon mitigation sector. By engaging the services of Crooks and Emmett-Mattox, both deeply knowledgeable about blue carbon policy, valuation methods and associated research in the PNW and in coastal regions in the US and other countries, we'll inform end users needing assistance understanding what their blue carbon information requirements and preferences might be. From these efforts we expect to engage a full range of end users with a variety of perspectives and information needs, ready to help guide the project as participants in the project's Steering Committee meetings.

The End User Engagement Team will convene four Steering Committee meetings: two in-person and two virtual (using GoToMeeting, BlueJeans or similar virtual meeting technology). The purpose of the meetings will be to allow end users to review the project plans/approach and make adjustments as needed to improve the research's relevance to their needs. The first project kickoff meeting will be in-person in early 2017, as will be the final meeting in late 2019. The kickoff meeting will convene all teams and end users to review and finalize research questions,

field methods (ensuring consistent methods employed by field teams), data analyses and data management plans, and database development plans. The final meeting will focus on reviewing project results, training participants in the use of the blue carbon database, and working with end users to develop dissemination strategies for results, including facilitating the research team's development of a manuscript reporting project results in a peer-reviewed scientific journal. The mid-project virtual Steering Committee meetings will be held late 2017 and 2018 for the purpose of allowing end users to review progress and make adjustments to the project during its implementation.

The End User Engagement Team will lead the delivery of project results to blue carbon information consumers and train participants in the use of the blue carbon database during the final months of the project, following end user-approved strategies developed at the final Steering Committee meeting. Our working concept is for the CTP staff at the two reserves to lead the development of the three formal workshops budgeted for in this proposal; workshops that will be designed to be responsive to the needs of the three regional audiences and with reference to each state's unique management framework. One workshop would be convened in the Puget Sound region, at or near the Padilla Bay NERR; one in the lower Columbia estuary region; and one in Coos Bay, at or near the South Slough NERR. Presentations and posters will also be presented at various meetings conferences by project team members and end users (including NERRS annual meetings).

We should note that our working concept is flexible by design because it needs to respond to the guidance offered by end users. For example, end users have already raised the possibility of organizing the workshops, possibly more cost effectively, in association with regionally-convened conferences convening distinctly different (but sometimes overlapping) audiences, such as estuarine scientists/restoration practitioners, climate change policy advocates, and environmental economists. End users have also suggested targeting dissemination at meetings associated with highly relevant organizations such as the Oregon Global Warming Commission which, according to end users, draws a "who's who" of climate change-engaged academic, policy, business, and government leaders. We are keeping options open and will be guided by end users in results dissemination and database training.

3.2 Blue carbon stocks in PNW tidal wetlands

The **Research Team** will quantify blue carbon stocks and associated environmental factors (e.g., wetland surface elevation, salinity, inundation, and vegetation composition) in the Pacific Northwest. This effort will constitute the first comprehensive quantification of blue carbon stocks in the PNW. The team will sample approximately 31 different wetlands in estuaries representing the PNW's three geographically distinct coastal regions: Puget Sound, Columbia estuary and outer coast estuaries from northern California to the Washington coast. Sampling will focus on least-disturbed sites, but also include converted tidal wetlands (e.g., pastures) to assess the magnitude of changes in blue carbon stocks related to land use change. At each site, the team will quantify total ecosystem blue carbon stocks using approved IPCC methods, including partitioning blue carbon stocks into aboveground live vegetation, belowground vegetation (roots), dead vegetation and litter, and soil carbon components. Where possible, the research team will measure depth to diagnostic soil horizons (e.g., tsunami sand layers) to obtain estimates of blue carbon sequestration rates over the past 250-300 years.

Carbon stocks assessment. The wetlands to be sampled cover a broad range of salinity, soil and hydrologic/tidal conditions. Field methods will follow those outlined in recent methods manuals describing the quantification of carbon stocks for coastal ecosystems written by one of the project scientists (Kauffman and Donato 2012, Kauffman et al. 2014, Fourqurean et al 2014). We have successfully used these same methods in sampling coastal ecosystems in Central and South America, Africa, Asia, and Micronesia (see also Adame et al. 2013, Kauffman et al. 2014).

Representative sites will be selected via remote sensing, field reconnaissance, and end user consultation. Some of these sites, within and outside of NERRs, will have been the subject of long-term collection of important related data on sediment accretion, plant cover, and growth which can be leveraged to generate a more complete picture of ecosystem processes and response (e.g., Thom 1992, Thom et al. 2002, Thom et al. 2015). At each site, six 7 to 10-m fixed-radius randomly-selected plots will be established 20-25 m apart along a 100 m transect established perpendicular to the marine ecotone (Fig.1). At each plot, we will collect data necessary to calculate total carbon stocks derived from aboveground live biomass, belowground biomass, litter and dead vegetation including downed wood (where present) and soils to the depths of the marine sands or bedrock.

At forested swamp sites, composition, tree density, and basal area will be quantified through measurements of the tree species and diameter at 1.3 m height (dbh) of all trees rooted within each plot of each transect. Plot size for tree measurements will be at least 154 m^2 (7 m radius) for trees >5 cm dbh and a nested plot with a radius of at least 2 m for trees with a dbh of <5 cm. The final radius will be determined based upon tree density. For woody vegetation that is <2 m in height the diameter of the main branch will be measured at 30 cm from the ground (D_{30}).

Allometric equations will be used to calculate tree biomass for each site. Sitka spruce (*Picea sitchensis*) is typically the tree dominant, with other tree and shrub species occurring in plant associations that differ across the region (Callaway et al. 2012). Large wood accumulations are extensive (Diefenderfer and Montgomery 2009). Allometric equations for some of these woody species have been developed. Tree carbon will be calculated from biomass by multiplying mean carbon concentration of aboveground and belowground vegetation by biomass estimates (Kauffman and Donato 2012). Standing dead trees will be included in aboveground biomass calculations.

Aboveground biomass in seagrass and marsh communities will be determined through harvest of all aboveground materials within two 50 by 50 cm quadrats within each of the 6 plots (n=12 quadrats/sampled site). The samples will be returned to the laboratory and oven-dried to a constant weight at 45°C to determine vegetation dry weight.

In each plot, a soil core will be collected to determine belowground biomass. Each core will be separated into four 25 cm segments based on depth, placed in a paper bag, and transported to the laboratory. In the laboratory, the roots will be extracted from the soil core with a

Hydropneumatic Elutriation System (Gillison's Variety Fabrication, Benzonia, Michigan, USA). They will them be dried as above to determine mass.

Carbon concentration of subsamples of aboveground and belowground plant biomass will be determined in the laboratory with a CN analyzer (induction furnace method) as described for soils below.

The mass and carbon pool comprised of dead and downed wood will be determined using the planar intersect technique adapted for swamp forests (Kauffman and Donato 2012). At the center of each plot, four 14 m transects will be established. The first will be established in a direction that is offset 45° from the azimuth of the main transect. The other three will be established 90° clockwise from the first transect (Fig 2). At each transect, the diameter of any downed, dead woody material (fallen/detached twigs, branches, stems and buttress roots of trees and shrubs) intersecting the transect will be measured. Wood debris ≥2.5 cm but <7.5 cm in diameter (at the point of intersection will be measured along the last 5 m of the transect. Wood debris ≥7.5 cm in diameter at the point of intersection will be counted from the second meter to the end of the transect (12 m in total). Large downed wood will be separated in two decay categories: sound and rotten. Carbon pools of downed wood will be determined through multiplication of the mean carbon concentration by it biomass (Kauffman and Donato 2012).

At each plot, soil samples will be collected for bulk density, and carbon and nitrogen concentration using a specialized peat auger (Kauffman and Donato 2011, Adame et al. 2013, Kauffman et al 2016, Donato et al. 2013). The core will be systematically divided into depth intervals of 0-15 cm, 15-30 cm, 30-50 cm, 50-100 cm and >100 cm (if parent materials were not encountered before 100 cm depth). Samples of a known volume will be collected in the field, dried to constant mass, and then weighed to determine bulk density. The depth to the parent materials (marine sediments/sands) will be measured at three locations near the center of each plot using a graduated aluminum probe. In the laboratory, the concentration of carbon and nitrogen will be determined using the dry combustion method (induction furnace) with a Leco CNS-2000 Macro Analyzer (the OSU Central Analytical Laboratory). Bulk density and carbon concentration will be combined with plot-specific soil depth measurements to determine the soil carbon stocks.

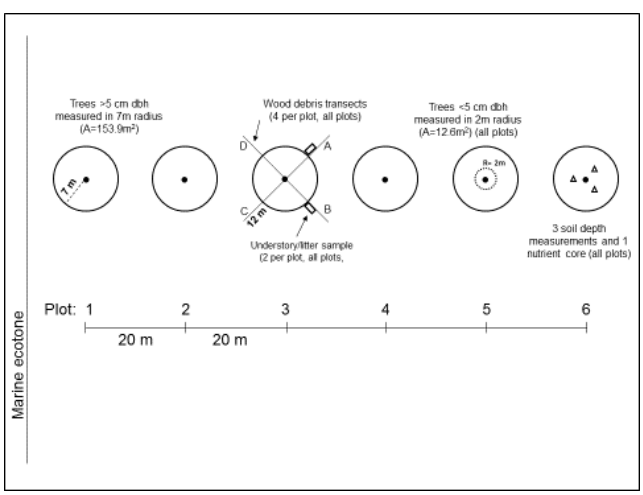

Figure 1. Schematic plot layout to quantify structure and carbon stocks of coastal ecosystems. This design has been used to quantify ecosystem carbon stocks of coastal ecosystems throughout the world (Kauffman et al. 2012). Aboveground marsh and eelgrass vegetation is sampled in the 2 microplots of each larger plot. Marsh and eelgrass

Total ecosystem carbon stocks (TECS; Mg C ha^{-1}) in this study are defined as:

$$\textbf{TECS} = \sum C_{AB} + C_{BB} + C_{DW} + C_L + C_{SOC}$$

where C_{AB} = aboveground biomass C pool, C_{BB}= belowground biomass C pool, C_{DW}= dead wood C pool, C_L = litter and duff, and C_{SOC}= soil organic C pool.

From our measurements we can also determine net primary productivity by calculating the sum of the carbon sequestered in the current year's aboveground and root vegetation. This requires separation of the current year's growth from past years growth.

Based upon data from the carbon stocks of intact and converted coastal wetlands, we can also calculate the potential carbon emissions from conversion of intact coastal ecosystems to agricultural pastures using a modified stock-difference approach (IPCC 2003) also referred to as a biomass equivalence approach (Kauffman et al. 2016).

Potential carbon emissions will be determined using the formula:

$$C_{emis} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{SOC}$$

where C_{emis} = Total C emissions (or sequestration) due to land use. (Mg CO_2e ha^{-1}), ΔC_{AB} = change in aboveground biomass C pool of intact wetlands compared to converted sites, ΔC_{BB}= change in belowground biomass C pool, ΔC_{DW} = change in dead wood C pool, and ΔC_{SOC}= change in soil organic C pool.

While reported as the CO_2e, these estimates account only for changes in ecosystem carbon *in situ*. While likely to be small compared to greenhouse gas emissions, some of the carbon lost in the pastures may be transferred to other communities via erosion or groundwater transfer.

We will compare carbon stocks among wetland habitat types with appropriate statistical analyses including nested ANOVA or ANCOVA.

3.3 Associated environmental, climatic and geomorphic variables

At each study site, we will quantify key environmental variables that are hypothesized to affect long-term carbon accumulation in PNW coastal wetlands: tidal and groundwater hydrology, soil and channel salinity, and soil grain size distribution. Blue carbon stock assessments in eelgrass, marsh, and forested tidal swamp habitats will be coupled with environmental data collected at the site and watershed scale to construct predictive statistical models of relationships and to inform predictions about spatial variation in blue carbon stocks.

At each site, we will measure changes in shallow groundwater level and salinity with pressure and conductivity sensors installed in shallow groundwater wells (1.5 m deep) similar to USACE

(2000) methods. The loggers will collect data on 6-30 (water level) or 30 minute (conductivity) intervals to assess changes in groundwater conditions at tidal, monthly, and seasonal time scales. In tidal channels near the sites, we will deploy additional water level and conductivity sensors to assess broader hydrologic conditions in the estuary. All water level data will be barometrically compensated with barometric pressure loggers placed in each estuary.

At each site, we will collect tidal elevation data with real-time kinematic (RTK) GPS measurements at the wetland surface. Geodetic elevation will be converted to tidal elevation and percent time inundated using water level time series from loggers deployed in nearby channels or NOAA tide gauges. We will use water level time series in the channels to determine percent time inundated for all plots where blue carbon stocks data are collected (Janousek et al. 2016).

Additional environmental data collection will also include spot sampling of soil grain size (surface cores) at each site, vegetation composition of each blue carbon plot, and climate and geomorphic data on watershed characteristics such as annual temperature and precipitation.

Within each habitat type sampled, we will statistically test for relationships between environmental variables and blue carbon stocks data using linear or non-linear models, including partitioning of variance techniques to evaluate the strength of relationships between different environmental factors and response variables (Chevan and Sutherland 1991). Data on blue carbon stocks and associated environmental variables will be synthesized into one or more peer-reviewed publications.

3.4 Blue carbon database

In year 1 of the project, the **Database Development Team** will develop the blue carbon database structure and begin synthesizing existing information on carbon stocks and associated ecosystem driver data to populate the database. The database will be designed to be compatible with existing related coastal ecosystem databases including the Sound IQ and 'Floodplains By Design' coastal resilience partnership tools in Puget Sound, and a Global Science and Data Network for Coastal Blue Carbon currently under development by USGS and others. The database will include relevant metadata and citations for each study or dataset compiled, including citation source, methods, and measurement errors. The Research Team will provide new blue carbon stocks data to the Database Team for inclusion in the Database.

Access to PNW carbon stock data by end users will include geospatially-linked data on carbon stocks through a two-dimensional, web-based map interface that overlays blue carbon stock values. The maps will include specific locations of sampling sites and/or data sources, as well as shaded regions representing shoreline carbon stock values derived from extrapolating existing carbon stock data for different ecosystem types across the region. Research scientists will be able to query database content in several formats upon request.

4) Data Accessibility

Data on carbon stock analyses and environmental variables will be collected during the first two years of the project and included in the blue carbon database. Following sample processing, laboratory analyses, and data aggregation and synthesis, these data will be available to project end-users and stakeholders (i.e. Year 2). Towards the end of the project (i.e. Year 3) and once

significant progress has been made on data analyses related to the proposed blue carbon manuscripts, the blue carbon database will become publicly available. The Database Development Team will work with GeomaticsResearch to create a relational blue carbon database to serve as a repository of blue carbon stock values (and associated environmental parameters) for PNW tidal wetlands. The database will use standard, interoperable web services and will be designed to be compatible with existing related coastal ecosystem databases including Sound IQ and 'Floodplains By Design' coastal resilience partnership tools in Puget Sound. This database will be a significant resource to emerging large-scale BC databases in development (e.g. Global Science and Data Network for Coastal Blue Carbon and NASA "Blue" Carbon Monitoring System databases) and we have established plans for two-way linkages of the data on these databases and the PNW Blue Carbon Database (see Appendix F; letter of support from Dr. Windham-Myers).

The database will be readily accessible to end-users by several means. There will be a web-based query interface which will allow users to search and filter data specific to their needs. Data in the database will be stored in relational tables, such that users can access data at a coarse level (e.g., mean values for eelgrass meadows) or at finer-scales (e.g., carbon content profile in a single core). Users who wish to do extensive analyses of data on their own can download raw data (e.g., in .csv format) for manipulation in other statistical packages, much like downloads offered by NERR CDMO. Finally, summary statistics of carbon stock data will be available to provide a broad overview of the range and variability of carbon stock values in PNW coastal habitats. In this regard, the database will provide managers, policy makers, and coastal scientists customizable access to data on the variability and range of blue carbon stocks for major coastal wetlands types in the Pacific Northwest. Coastal zone planners and managers will be able to access carbon stock values for habitats and ecosystems in their watersheds and/or management areas and make informed decisions regarding restoration and conservation efforts. Near the completion of the project, the database will be made fully available to the public on the Oregon Explorer web platform. Interested end-users in the Pacific Northwest and beyond will have the capability of querying the database for existing blue carbon data by geographic region. Use of the database will be a topic in the three end-user engagement workshops envisioned during the final phase of the project, where further accessibility of data will be achieved by training end-users to utilize the BC database.

APPENDIX B: Project Timeline

2016 NERRS Science Collaborative Research Project Timeline

Project Lead: Craig Cornu, Institute for Applied Ecology/Estuary Technical Group
Project Title: Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands
Project Start Date: November 1, 2016 (funding notification: August 2016)
Project End Date: October 31, 2019

Project Task/Activity	Associated Outputs	2017																2018												2019									
		8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
Leadership Team																																								
Initiate grant administration; facilitate environmental compliance review	Successfully completed Environmental Compliance Review, IAE-NSC grant agreement signed, Lead Field Tech and Field Tech positions filled,	■	■	■	■																																		
Plan Project Steering Committee meetings	Meeting goals, objectives, agendas, presentations, facilitation strategies, etc.	■	■	■												■												■											
Develop progress reports; submit to NSC	Progress reports (2)																■												■											
Develop final report; submit to NSC	Final report (1)																																				■	■	■	■
Present project results at NERRS meeting	Project presentation and/or poster (prepared for NERRS mtg).																																							■
Project Steering Committee																																								
The kickoff meeting will convene all teams and end users to review and finalize research questions, field methods (ensuring consistent methods employed by field teams), data analyses and management plans, database development plans	Finalized project approach, finalized field methods and YR1 field schedules								■																														
Yearly all-team meetings (2 virtual, 1 in-person) to coordinate the work of teams, share results internally, solicit additional end user feedback, address emerging issues, plan next steps Note: individual teams will meet in person or remotely as needed	Outputs for YR3 in-person meeting will be 1) finalized end user-approved project results dissemination plan; 2) manuscript preparation plan for tech team members. (Outcomes of YR1 and YR2 virtual meetings will be project approach adjustments, as deemed necessary by meeting participants, plans for subsequent field, and other activities, preliminary data sharing with end users.)																■												■										■	
End User Engagement Team																																								
Recruit additional end users through a growing network on end users to the Working Group and project teams (new recruiting began spring 2016)		■	■	■	■																																		
Project approach is reviewed/ finalized/updated by end users at Steering Committee meetings					■												■												■											
Develop needs assessment to: 1) identify PNW end users with interests not yet represented in the working group or project; 2) determine how well informed those end users are; 3) determine the specific data needs and data access preferences of informed end users, and 4) identify barriers to implementation of carbon mitigation strategies.	Needs assessment survey and results				■																																		
Needs assessment survey is distributed to end users and returned to End User Engagement Team						■	■																																
Needs assessment workshops following up on needs assessment results								■																															
Project approach is reviewed/ finalized/updated by end users at Steering Committee meetings									■								■												■											
End-users engage in iterative process of feedback and revision for blue carbon database	End user-strengthened blue carbon database																												■	■	■									
Engagement team develops trainings/workshops, identifies relevant meetings and discussions at which project results/tools are shared with key additional end-users	Finalized end user-approved project results dissemination plan; manuscript preparation plan for tech team members; workshop materials, database training plan, and presentations based on project results and blue carbon database																														■	■	■							
Engagement team delivers project results/tools to end users at workshops/trainings, relevant meetings/discussions																																		■	■	■	■	■	■	
Database Team																																								
Team membership, methods, etc. are reviewed/ finalized/updated; results shared internally at Steering Committee meetings					■												■												■											
Database structure and content is established to meet end user needs (from Steering Committee meeting and needs assessment results)										■	■																												
Blue Carbon Database is established; populated with existing carbon stock values for PNW	Blue carbon database									■	■	■	■																										
Blue carbon database is populated with data collected by Research Team														■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Ongoing revision of database structure to accommodate new research team findings														■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Database is shared with additional end-users for initial feedback on structure, content and accessibility																													■	■	■								
Research Team																																								
Team membership, research priorities, experimental design is reviewed to meet end user needs; results shared internally at Steering Committee meetings	Finalized project approach, finalized field methods and yearly field work plans and schedules				■												■												■											
Two field seasons of Carbon stock sampling and related "spot" ecosystem driver data collection during sampling (includes 31 sites total, plus time for lab work and data analyses)	Carbon stocks data and associated analyses to be incorporated in the the blue carbon database									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
One water year of time series ecosystem driver data collection (collected separate from C stock sampling), plus time for logger acquisition, calibration, and data analyses	Ecosystem driver data to help interpret carbon stocks data															■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Manuscrip preparation	Publishable manuscript																																				■	■	■	■

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19 May 2016

NERRS Science Collaborative
U-M Water Center
214 S. State St., Suite 200
Ann Arbor, MI 48104

To Whom It May Concern,

On behalf of the Verified Carbon Standard (VCS), I am writing to express my enthusiasm and support for the Pacific Northwest (PNW) Coastal Blue Carbon Working Group (Working Group) proposal, "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands" submitted to the NERRS Science Collaborative.

The VCS Program is the world's leading voluntary GHG program, with more than 1300 projects certified that have collectively removed more than 185 million tonnes of GHG emissions from the atmosphere. The VCS Program is also one of the first GHG programs to include blue carbon activities to restore wetlands, marshlands, and seagrass meadows as eligible activities. Additionally, VCS is currently working with our partners to develop and approve quantification methodologies for avoided conversion of wetland ecosystems. These are important ecosystems, and their restoration and protection from conversion are important both to sequester carbon dioxide and for their contribution to sustaining fisheries, improving water quality, and protecting against storm damage and flooding.

When developing GHG reduction or sequestration projects, one of the most difficult aspects of project design and verification is finding quality data. As such, the Working Group's proposal to quantify the carbon storage potential of PNW tidal wetland types, estimate carbon losses in converted wetlands, and develop a readily accessible PNW blue carbon database populated with existing and new blue carbon data will be invaluable for VCS' stakeholders interested in developing projects. These data will help remove an important barrier in the design and implementation for projects in the PNW, as well as add more assurance to buyers of the emission reductions from these projects that they were developed with robust data.

As more states and provinces in the US and Canada develop programs to reduce GHG emissions, such as British Columbia's carbon tax, and the proposed Washington State Clean Air Rule, the proposed PNW blue carbon database will be provide robust and complete data to allow wetlands and other blue carbon activities to be included in these efforts.

VCS therefore strongly supports the Working Group's proposal and recommends that the NERRS Science Collaborative support this important effort.

Sincerely,

David Antonioli
Chief Executive Officer, Verified Carbon Standard

College of Urban and Public Affairs
Northwest Economic Research Center (NERC)

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May 11, 2016

NERRS Science Collaborative
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Ann Arbor, MI 48104

To whom it may concern,

Please accept this letter as an indication of my strong support for the Pacific Northwest Coastal Blue Carbon Working Group's (Working Group) NERRS Science Collaborative proposal entitled, "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands."

As a member of the project's end user team, I have been helping guide the development of the Working Group's project approach, offering suggestions to help strengthen project context and results dissemination methods, and providing links to Portland State University collaborators for possible Pacific Northwest blue carbon modeling efforts to be developed as a future use of the Working Group's blue carbon research results and database development.

As an environmental and resource economist, I'm excited by the prospect of using the project's results to help develop a more comprehensive understanding of blue carbon's market potential for the PNW. I'm not only interested in helping address the potential for the participation of wetland blue carbon in regional and international carbon credit markets by remedying the distinct scarcity of quantitative blue carbon data for Pacific Northwest wetlands, but also invested in how this project's results, especially if built upon with future project results, could contribute to the Northwest Economic Research Center's economic evaluations of proposed greenhouse gas emissions reduction and mitigation legislation (e.g., carbon tax or "cap and invest") conducted for the Oregon Legislature and other agencies to address Oregon's greenhouse gas emission goals.

I urge you strongly to consider the Working Group's proposal for full funding. Those of us in the Pacific Northwest working to provide market specialists and decision makers with accurate economic evaluations of various strategies designed to reduce and mitigate regional greenhouse gas emissions (especially those that propose the inclusion of emerging market sectors such as wetlands) are hampered by the lack of quantitative region-specific data. The Working Group's project represents a significant opportunity to begin filling some of these information gaps.

Thank you for the opportunity to express my keen support for this project.

Sincerely,

Jenny H. Liu, Ph.D.
Assistant Professor, Toulan School of Urban Studies & Planning
Assistant Director, Northwest Economic Research Center
Portland State University

THE CLIMATE TRUST

May 3, 2016

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Ann Arbor, MI 48104

To Whom It May Concern,

I am writing to express my enthusiastic support for the Pacific Northwest Coastal Blue Carbon Working Group proposal, "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands" submitted to the NERRS Science Collaborative. The project's collaborative goals to quantify Pacific Northwest blue carbon stocks and associated key drivers that affect C sequestration potential, develop a regional blue carbon database, and provide project results to participating and other policy makers will be extremely helpful in filling data gaps that impede our ability to fully evaluate the potential for a Pacific Northwest blue carbon market.

Our mission is to mobilize conservation finance to maximize environmental returns. For nearly 20 years, The Climate Trust, a pioneer and nationally recognized leader in the carbon market, has invested in, and sold offsets from quality greenhouse gas reduction projects to mitigate emissions in several regions of the US.

Because we're committed to the development of market-based C mitigation strategies as fundamental components of comprehensive regional and national plans and policies designed to reduce greenhouse gas emissions in the US, we're very interested in facilitating the development of new carbon market sectors and are intrigued by the potential of a blue carbon market in the Pacific Northwest. But, without better information to help improve our understanding of blue carbon's market potential, we remain wary of undertaking the investments needed to facilitate the development of that market sector.

With our guidance as "end users", the Working Group has developed a research plan that holds great promise for improving our understanding of blue carbon's market potential by helping address uncertainties

associated with valuing blue carbon in the Pacific Northwest. Application of the Working Group's project results, including the development of a regional blue carbon database populated with existing and new research results, could very well catalyze interest in developing pilot blue carbon finance projects in the region.

We understand The Climate Trust representatives will continue to have opportunities to help guide the research as it's being conducted so we can ensure the project results are relevant our work and other end-user participants.

Thank you for the opportunity to express our support for this important project.

Yours,

Sean Penrith
Executive Director
The Climate Trust
Portland, OR

ENVIRONMENTAL SERVICES, INC.
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20 May 2016

NERRS Science Collaborative
U-M Water Center
214 S. State St., Suite 200
Ann Arbor, MI 48104

To Whom It May Concern,

On behalf of the Environmental Services, Inc. (ESI), I am writing to express ESI's support for the Pacific Northwest (PNW) Coastal Blue Carbon Working Group (Working Group) proposal, "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands" submitted to the NERRS Science Collaborative.

ESI is an approved third-party validator and verifier of carbon offsets under the Agriculture, Forestry and Other Land Use sector (AFOLU). We are certified to verify projects for the Verified Carbon Standard, Climate Action Reserve, California Air Resource Board, American Carbon Registry, Climate, Community, and Biodiversity Alliance, British Columbia (BC) Carbon Registry, Natural Forest Standard, Plan Vivo, The Climate Registry, BC Reporting Regulation, and Ontario Reporting Regulation. Our experience includes having served as lead validator and/or verifier on greater than 150 carbon offset and GHG projects. Additionally we have served as lead assessor for 14 AFOLU carbon sequestration methodologies under the Verified Carbon Standard, including two wetland restoration and enhancement methodologies.

While terrestrial carbon sequestration projects have seen the greatest success to date, the carbon sequestration potential of Blue Carbon, combined with the substantial overall ecosystem service benefits, has well positioned it to surpass terrestrial carbon. Arguably, the largest barrier currently faced by Blue Carbon projects is a lack of quality data and the costs associated with obtaining it. PNW's carbon database would serve as a critical element to support the development of new wetland restoration and enhancement projects, particularly those supported by carbon finance. Further, from a validation/verification perspective the proposed database has the potential to reduce the overall time and cost associated with auditing a carbon sequestration project by providing a vetted source of data for carbon sequestration models.

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It is for these reasons that ESI offers its strong support for the Working Group's proposal and recommends that the NERRS Science Collaborative support this vital effort.

Sincerely,

Shawn McMahon
Senior Manager / Lead Auditor
Environmental Services, Inc.
(sjmcmahon@esinc.cc)

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May 18, 2016

NERRS Science Collaborative
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To Whom It May Concern:

I would like to offer my full support for the proposal submitted to the NERRS Science Collaborative by the Pacific Northwest Coastal Blue Carbon Working Group (Working Group): "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands."

In my capacity as the Washington State Department of Ecology's Special Assistant for Climate Policy, I am keenly aware of the information gaps that impede our state's ability to develop fully informed policies that respond to our constituents' call for action on climate change adaptation and mitigation measures. For example, Washington is considering adopting new, and amending existing rules associated with the state's Clean Air Rule designed to reduce greenhouse gas emissions in the state. The proposed rules include options for "emitters'" compliance through greenhouse gas emissions market programs, which could be used with greater confidence if the carbon values these markets rely on were better supported by more complete research conducted in Pacific Northwest environments.

The Working Group's proposed research and establishment of a blue carbon database for the Pacific Northwest represents a giant step towards filling some of the information gaps that impede our work—specifically relating to the development of the wetland sector of the regional carbon market. We are excited about the prospect of working with the Working Group and partners to better defining the capacity for tidal wetland restoration and conservation actions specific to our region to contribute to Washington's, Oregon's and California's emissions mitigation programs and projects.

Thank you for considering my strong support for this project during your review process.

Yours,

Sarah Rees
Special Assistant for Climate Policy
Washington State Department of Ecology

Coastal Conservancy

NERRS Science Collaborative
U-M Water Center
214 S. State St., Suite 200,
Ann Arbor, MI 48104

May 10, 2016

To Whom It May Concern,

The California State Coastal Conservancy (SCC), a State agency that has worked for more than 40 years to implement tidal wetland restoration projects along California's 1,600 mile coastline, strongly supports the Pacific Northwest Coastal Blue Carbon Working Group (Working Group)'s efforts. In particular, we support the Working Group's proposal to the NERRS Science Collaborative entitled, "Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands."

By way of background, the passage of AB 32, the California Global Warming Solutions Act of 2006, marked a watershed moment in California's history. By requiring in law a sharp reduction of greenhouse gas (GHG) emissions, California set the stage for its transition to a sustainable, low-carbon future. AB 32 was the first program in the country to take a comprehensive, long-term approach to addressing climate change, and does so in a way that aims to improve the environment and natural resources while maintaining a robust economy. Restoring tidal marshes and estuaries, or "blue carbon" restoration is a key part of this effort, but one that has not been fully advanced due to insufficient information about key topics. This is particularly true in the Northwest, including northern California.

The confidence of estimates of carbon sequestration in California's coastal environment is hampered by the lack of carbon stock, carbon sequestration, and greenhouse gas emissions data. These shortcomings are compounded by errors, omissions and the lack of standardization (e.g. units and methods.) in reported and published data. These data and methods gaps make it difficult to address the key question— what carbon sequestration rates can we use to value blue carbon benefit and where? The Working Group's proposal describes a logical, end-user driven approach to finally begin addressing these frustrating and adverse information gaps. We are encouraged that they have extended their analytical approach to California.

We encourage the NERRS Science Collaborative to award full funding to this important project. When that happens, the SCC expects to continue guiding the project's implementation. SCC has already offered comments on the structure, content and function of the proposed database, and plans to use project results and tools to: 1) facilitate the standardization of coastal blue carbon methods and data by encouraging general use by all researchers of the PNW Blue Carbon Database (one of the project's main products); and 2) encourage the California Air Resources Board's formal adoption of proposed blue carbon-related actions associated with California's cap and trade program (identify blue carbon project opportunities; implement a range of blue carbon pilot projects).

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Coastal Conservancy

Thank you for taking our support for the Working Group's proposal into account during your review process. Please let us know if you have any questions.

Sincerely,

Samuel Schuchat
Executive Officer

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May 9, 2016

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To Whom It May Concern:

The Puget Sound Partnership is pleased to offer our support for the Pacific Northwest Coastal Blue Carbon Working Group's (Working Group) proposal, "*Enhancing coastal zone policy, management, and research through end user-driven quantification and public dissemination of carbon stocks data for Pacific Northwest tidal wetlands.*"

Through the mobilization of hundreds of partners, the Puget Sound Partnership leads the region's collective effort to restore and protect Puget Sound's coastal wetlands and associated ecosystem services important to our human and ecological communities. The Partnership created, and now manages, the infrastructure needed to enable and encourage partners to come together to develop and implement priority actions needed to accelerate ecosystem recovery.

The Working Group's project uses an end user-driven approach to undertaking the bio-physical research needed to begin filling key data gaps that currently prevent us from quantifying the extent to which the carbon capture and storage services provided by Puget Sound's tidal wetlands can mitigate regional greenhouse gas emissions. With these gaps filled, the Puget Sound Partnership will be able to facilitate the development of much more accurate assessments with which to evaluate the potential for emerging blue carbon markets (voluntary and possibly regulatory) to help support regional tidal wetland restoration and protection strategies.

We're very interested in joining with other regional end users to help guide the Working Group's efforts to provide regional end users the information they need, and to ensure the project results are relevant to our work and the work of partners. For our part, we anticipate the results of this project informing the scientific basis of the Puget Sound Action Agenda and Vital Sign targets, a collaborative effort to effectively allocate habitat recovery resources, as well as our efforts to ensure that coastal decision makers are well informed.

We appreciate the opportunity to express our support for this important project.

Sincerely,

Sheida R. Sahandy
Executive Director

United States Department of the Interior

U. S. GEOLOGICAL SURVEY

WATER RESOURCES DIVISION
345 Middlefield Road, MS470
Menlo Park, CA 94025

13 May 2016

Craig Cornu, Principal Scientist
Institute for Applied Ecology/Estuary Technical Group
90962 Oxford Lane
Coos Bay OR 97420

Dear Craig,

I am writing in support of the Collaborative Research proposal "*Enhancing coastal zone policy, management, planning and research through assessment of carbon stocks in Pacific Northwest coastal ecosystems*" being submitted by the Institute of Applied Ecology (and collaborators) to the NERRS Science Collaborative. I have been familiar with this effort through the work of the PNW Blue Carbon Workgroup and previous submission to the Science Collaborative Program and am enthusiastic that they are continuing this effort.

I understand that you will be conducting an assessment of carbon stocks in a range of coastal wetlands (eelgrass, salt marsh, scrub/shrub and forest) throughout the Pacific Northwest and working to identify ecosystem drivers that may contribute to the variability in carbon stock among these habitat types. These data will populate a PNW blue carbon (BC) database, which will ultimately be used to communicate findings and inform coastal planning and management decisions and priorities.

These data on coastal habitat carbon stocks and associated environmental conditions will work towards filling a large data gap in the understanding of coastal carbon cycling in the Pacific Northwest. Throughout the US, the PNW has a notable paucity of blue carbon data and this effort will make a valuable contribution to that body of knowledge and our ability to estimate carbon storage values in coastal regions of the US and globally. I understand these data are to be maintained in a publicly accessible, query-able PNW BC database that will be maintained and hosted by the project staff. The query-able structure will ensure that the data and metadata are intercomparable and accessible to end-users, with plans for the subsequent development of data mapping and visualization tools to communicate this information to end-users to increase the accessibility of the data.

This database will be a significant resource to emerging large-scale BC databases in development (e.g. Global Science and Data Network for Coastal Blue Carbon and NASA "Blue" Carbon Monitoring System databases). Being a PI in the development of these databases, I will support this proposed work by offering structural advice and guidance to the Proposal Database Team to facilitate two-way linkages of the data. To this end, I have already spoken with members of the proposal development team and offered insight on database development. I have been assured that this contribution was very helpful and has been used to refine the proposed structure, content and functioning of their database to better serve end-users and scientists, and to be compatible with other current and developing BC databases.

Sincerely,

Lisamarie Windham-Myers, Ph.D.
Research Ecologist
EMAIL: lwindham@usgs.gov TEL: 650-329-4447

WASHINGTON STATE DEPARTMENT OF
Natural Resources
PETER GOLDMARK *Washington State Commissioner of Public Lands*

Caring for
Your natural resources
... now and forever

January 28, 2016

Craig Cornu, Principal Scientist
Institute for Applied Ecology
Estuary Technical Group
90962 Oxford Lane, Coos Bay OR 97420

Dear Mr. Cornu,

I am writing in support of the proposal *"Enhancing coastal zone policy, management, planning and research through assessment of carbon stocks in Pacific Northwest coastal ecosystems"* being submitted to the NOAA Science Collaborative Research program. I understand that an important aspect of this project will be quantifying carbon stock in a wide range of coastal ecosystems across the Pacific Northwest and transferring this information to appropriate coastal zone managers, planners, policy makers and other relevant end-users. The project outcomes will provide us with important information to improve management of coastal ecosystems.

Values for carbon sequestration and carbon stock potential are poorly constrained for SAV in the PNW. The assessment of carbon stock (and ultimately sequestration) associated with this project will help incentivize our state-wide effort of increasing eelgrass habitat by 20% by 2020. Identifying the carbon storage potential of eelgrass beds identifies an important ecosystem service and added value regarding atmospheric carbon sequestration. It will also help preserve existing habitat by identifying the carbon that will be released as a result of conversion from existing vegetated areas to mudflat or other habitat types with less storage potential.

The project will provide an opportunity for more formalized collaboration regarding eelgrass research and monitoring between scientists at DNR and the Padilla Bay National Estuarine Research Reserve, which hosts a large percentage of eelgrass in Washington State. This synergy among agencies involved in eelgrass research and monitoring will be valuable.

This project will provide synergy with other research investigating blue carbon in PNW estuaries. I am collaborating on a project to assess carbon sequestration and storage potential in eelgrass throughout the PNW and there is value in comparing results from each project for eelgrass and conducting cross comparisons between ecosystems.

Please let me know if there is any other information I can provide. I wish you the best of luck in the upcoming proposal review, and I stand ready to assist if the project moves forward.

Sincerely,

Jeffrey Gaeckle, Ph.D.
Seagrass Ecologist

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January 28, 2016

NERRS Science Collaborative review team,

I would like to express support in the name of Environmental Science Associates and the Coastal Wetland Carbon Working Group (CWCWG) for the Pacific Northwest Coastal Blue Carbon Working Group's NERRS Science Collaborative pre-proposal**.** If funded, this work will significantly improve our understanding of the mechanisms that control carbon storage and flux in coastal wetlands for an important and under-researched region of the country, and which will improve the assessment and valuation of ecosystem services in coastal wetlands.

In 2013, the UNFCCC encouraged Parties to begin accounting for emissions and removals from coastal wetlands, using the guidance as provided by the 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories: Wetlands. The intent is for countries to report back to the UNFCCC on experiences and lessons learned by 2017. According to the IPCC Wetlands Supplement, emission and removal estimates from coastal wetlands are calculated for each of three coastal habitats (tidal forested wetlands including, seagrasses, and tidal marshes (tidal fresh and salt marshes) based on changes in land use and management over time that are attributed to a specific list of anthropogenic activities. This requires the development of "emissions factors" upon which GHG fluxes with changes to biomass and soils carbon stocks due to human impacts can be calculated. Data is particularly lacking for the Pacific Northwest.

NOAA— in close partnership with EPA—is leading U.S. efforts to incorporate GHG emissions and removals from coastal ecosystems into the US Inventory of GHG Emissions and Sinks. It is expected that the U.S. will meet Tier 1 level, and possibly more detailed Tier 2 level reporting, depending on the availability of country-specific data, by the 2017 submission of the U.S. GHG Inventory. In years following the inventory will be refined and updated incusing as regional data becomes available. It is also expected that the IPCC will engage in an update to the Wetland Supplement for peer reviewed emissions factors will be requested.

To meet these goals, NOAA has established a new U.S. Coastal Wetlands Carbon Working Group (CWCWG) that will help advance this component of the inventory work. The CWCWG is comprised of around 25 experts from the Federal government and broader research community that represent expertise in coastal wetlands, carbon cycling, inventory development, land use change monitoring and modeling, and coastal management. The CWCWG and NOAA contractors will undertake the following activities: (1) review the IPCC Guidelines and the U.S. GHG Inventory to gain knowledge of the methods and experiences of other experts that are implementing the methods for other land use

categories, (2) develop a detailed process for estimating and tabulating the area of land use change, management activities as identified in the IPCC Wetlands Supplement, emissions factors, and then estimating carbon emissions and removals, (3) clarify subcategories to be used for reporting of coastal land use and activity-based changes, (4) identify existing and forthcoming sources of data to support the analyses required in the IPCC guidelines and utilized for other U.S. land use categories, and (5) summarize monitoring and modeling needs for improving to a Tier 2 analysis and advancing to Tier 3 analysis of management activities.

Because the Pacific Northwest Coastal Blue Carbon Working Group's proposed work directly quantifies the ability of Pacific Northwest coastal wetlands to sequester and store carbon, it clearly supports our efforts to develop higher-tier assessments of carbon emissions being developed for the U.S. National Greenhouse Gas Inventory. Furthermore, because portions of the Pacific Northwest coast represents one of the most potentially resilient coastal systems to sea level rise but for which we have very little data on carbon stocks, it is important that we develop quantification of carbon stocks to inform holistic coastal climate change response planning (as well as GHG emissions and carbon sequestration rates in future research efforts). The proposed research activity and expandable database will be paramount in informing improved coastal management at the local, national and international level.

Sincerely,

Stephen Crooks, Ph.D.
Coastal Wetland Carbon Working Group: Lead Principle Investigator and Source Lead to EPA for Coastal Wetlands.
NASA Carbon Monitoring System, Science Team Member.
Climate Change Program Manager, Environmental Science Associates

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January 25, 2016

NERRS Science Collaborative
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To Whom It May Concern,

I am writing to express strong support for the Pacific Northwest Blue Carbon Science Working Group pre-proposal. The need for advancing blue carbon science in this region that can be directly utilized by and beneficial to coastal managers, policy makers and advocates is tremendous. I am familiar with the team submitting the pre-proposal and have the highest confidence that they are well-qualified to carry out the work – including end-user engagement, field work, modelling and analysis.

For the past six years, Restore America's Estuaries has led a national blue carbon initiative to advance the science and application of blue carbon to support increased commitment to the restoration and conservation of coastal wetland ecosystems. The field of blue carbon has grown significantly in that time, and national, international, and regional networks of scientists, practitioners and managers, advocates and policy-makers are organizing around this initiative.

Two years ago, RAE led two blue carbon workshops in the Pacific Northwest – one in Oregon in coordination with the South Slough NERR and the other in Washington on Puget Sound. The workshops laid the groundwork for future steps to advance science and connect it with management and policy needs. Since that time, a regional working group has been refining a science plan and reaching out to end-users. The NERRS Science Collaborative is an ideal funding opportunity for their next steps.

Restore America's Estuaries will gladly participate in and support the effort in any way that we can. Increased greenhouse gas data in tidal wetlands is a national priority for RAE, as well as for several federal agencies, including the White House Council on Environmental Quality. We would be glad to represent one segment of the end-user community and help to guide and advise the project, as well as promote the results.

We are grateful for the NERRS Science Collaborative's support of other blue carbon initiatives (several of which we are involved in) which has enable substantial progress over the past several years. We hope you will continue to prioritize this important ecosystem service as you consider this pre-proposal.

Thank you and sincerely,

Steve Emmett-Mattox
Sr. Director for Strategic Planning and Programs

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PNW Blue Carbon Project Organization Chart

Overview of the four working groups and their roles in project activities, including initial needs assessment, blue carbon database development, carbon stock assessment, database visualization tools and final end-user engagement.