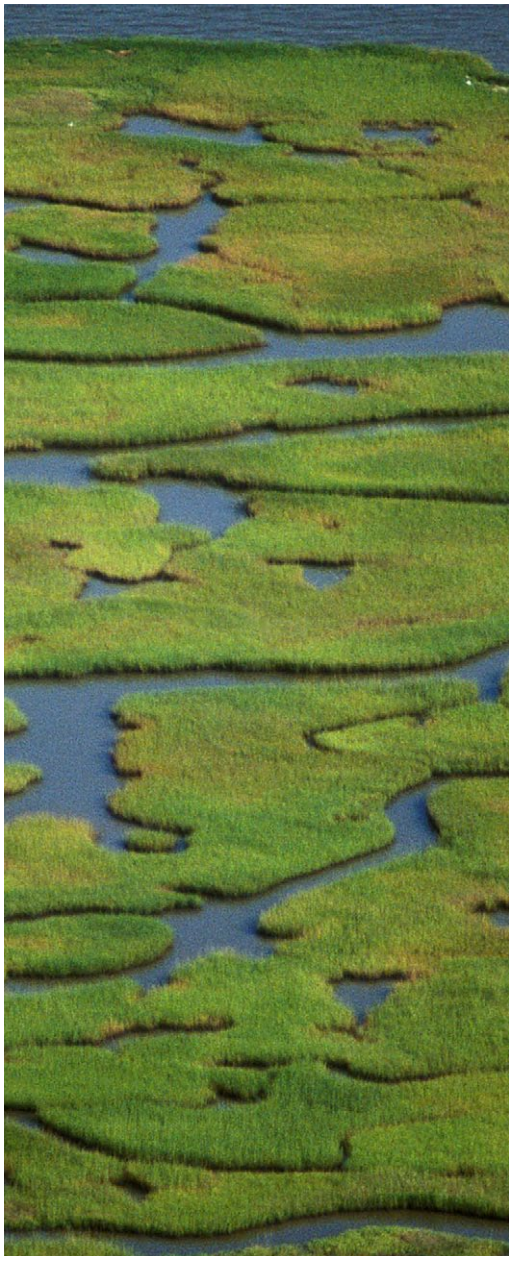

Findings of the
National Blue Ribbon Panel
on the Development
of a **Greenhouse Gas Offset**
Protocol for **Tidal Wetlands**
Restoration and Management

ACTION PLAN TO GUIDE PROTOCOL DEVELOPMENT

Based on a workshop convened by Restore America's Estuaries and held April 12-13, 2010

Prepared by Restore America's Estuaries, Philip Williams & Associates, Ltd., and Science Applications International Corporation.

August 2010

RESTORE AMERICA'S ESTUARIES

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EXECUTIVE SUMMARY

Background

The restoration and avoided loss of tidal wetlands[1] and coastal habitats offers significant potential for the sequestration of carbon, simultaneously restoring ecosystem health while reducing greenhouse gas (GHG) emissions. Wetlands restoration and management projects could therefore be used as GHG offsets while meeting other ecosystem restoration and protection climate adaptation objectives. However, a protocol for GHG offsets for wetlands does not yet exist and there are several challenges to developing one. This document describes an Action Plan for addressing these challenges and developing such a protocol.

Restore America's Estuaries (RAE) is leading a national effort to develop a protocol for tidal wetlands GHG offsets. A protocol will provide the necessary guidance to calculate, report, and verify GHG emission reductions associated with offset projects. It will also provide a reliable framework for implementing tidal wetlands projects to create offset credits that are likely to be recognized by current climate markets and registries, and under emerging climate change laws and regulations.

Working with many partners, RAE identified and convened a Blue Ribbon Panel to review the status of the science and policy and establish an action plan for developing a tidal wetlands GHG offset protocol. The Panel consists of experts in wetlands science and management, carbon sequestration, GHG accounting, and offsets protocols and markets.

The Panel met in April 2010 and found that:

1. Significant opportunities exist to improve wetlands management to achieve GHG reductions as well as develop a protocol to bring wetlands projects into the carbon market; however, challenges and information must be addressed to do so.
2. The methods necessary to quantify, measure and monitor carbon sequestration and GHG flux from wetlands projects are achievable with existing science.
3. The potential for carbon sequestration should be quantified more fully.
4. Projects that are already required by law or regulation, such as wetlands mitigation projects, should be excluded from participation in an offsets process.
5. Projects should be ecologically appropriate.

In addition, the Panel outlined clear steps to address the science and policy questions necessary for protocol development. This document reflects the recommendations of the panel and is an action plan for developing a national GHG offset protocol for tidal wetlands restoration and management.

[1]Tidal wetlands are found in coastal settings at elevations that are regularly or occasionally flooded by tidal waters.

EXECUTIVE SUMMARY
(Continued)

Recommendations

The key focus of this Action Plan is the formation of working groups to address the major issues identified by the Panel, and the implementation of regional case studies to demonstrate GHG reduction methods and potential. Taking the steps described in the Action Plan will provide the necessary science and recommendations to enable the full development and adoption of a national protocol by GHG registries and other interested parties.

The Panel makes detailed recommendations in four foundational, or core, areas to advance protocol development. For each area, RAE will establish and coordinate working groups to address key action items. The four foundational working groups are:

1. **Eligible Project Activities**

   The Panel discussed four project activities that could be included in a protocol: avoided wetlands loss, wetlands restoration, wetlands management, and wetlands creation. The tasks of this working group are to refine these definitions and ensure they meet the needs and realities of tidal wetlands systems and GHG protocols.

2. **Eligibility**

   This working group will recommend clear eligibility guidelines for tidal wetlands projects. It will address key additionality issues such as: regulations governing tidal wetlands projects, public lands and funding, to what extent restoration is common practice, documenting the scale of the opportunity for tidal wetlands restoration, stacking GHG credits with other ecosystem service credits, and environmental impacts and benefits.

3. **Permanence**

   The Panel recommends that this working group examine issues related to ensuring the permanence of GHG reductions and removals, and credits generated from tidal wetlands projects. Project failure or other interruptions may lead to intended or unintended releases of carbon stored in a wetland, thereby reversing the credits gained from the project. This working group will examine the potential for such reversals to occur as well as methods for managing risk and preventing this from happening. It will also consider ways to quantify potential secondary impacts of projects, also referred to as leakage.

4. **Quantification**

   This working group will coordinate and help advance research and analysis related to the quantification of carbon storage and GHG flux from tidal wetlands, focusing on ways that GHG quantification can be standardized for use in protocols. The group will work closely with the scientific working group sponsored by the National Center for Ecological Analysis and Synthesis to develop a carbon sequestration and GHG emissions model for salt marshes.

Geographic Case Studies

The Panel recommends that case studies be conducted to demonstrate proof of concept of applicable activities for high-priority wetlands types, specifically: the Sacramento-San Joaquin Delta, a managed, freshwater tidal marsh; the Mississippi Delta, a large deltaic system that requires large scale restoration; and restoration, creation, or management of a coastal salt marsh at a location to be determined. Results from these case studies will be coordinated and integrated with the working group activities to support protocol development. In some cases, these studies are already underway or being developed, led by regional teams that are coordinating with the national protocol development effort to ensure sharing of information and consistency of approaches when possible.

Conclusion

This Action Plan provides guidance on the information gaps, research, and other steps that are needed to develop a GHG offset protocol and to inform wise carbon management in tidal wetlands. There is a critical need for a coordinated effort that combines an emphasis on central issues with site-specific case studies. To accomplish this effort most efficiently, we recommend focused actions to provide proof of concept. We hope this Action Plan will provide a clear pathway to guide the academic, agency, and private sector communities that are concerned with the need for a GHG offset protocol for wetlands projects. We believe that this plan will lead to timely development of a protocol that is effective, transparent, rigorous, cost-effective, and broadly applicable to the requirements of registries and resource managers.

Findings of the National Blue Ribbon Panel on the Development of a Greenhouse Gas Offset Protocol for Tidal Wetlands Restoration and Management—Action Plan to Guide Protocol Development

The restoration and avoided loss of tidal wetlands and coastal habitats offers significant potential for the sequestration of carbon, simultaneously restoring ecosystem health while reducing greenhouse gas (GHG) emissions. Wetlands restoration and management projects could therefore be used as GHG offsets while meeting other ecosystem restoration and protection objectives. Currently, a protocol does not exist for creating GHG offsets through wetlands restoration and management. This document describes an Action Plan for developing such a protocol.

Wetlands sequester carbon by supporting a standing biomass of plant material, but more importantly, by continuously burying a portion of this carbon within soils. Historically, expansive areas of once existing wetlands have been drained, filled, and converted to other uses. Once they are converted, these lands release considerable quantities of carbon, through natural oxidation, from soil reservoirs that have accumulated over millennia. Remaining coastal wetlands are under threat from rising sea level and other human impacts. Without space to migrate and adjust in response to sea level rise and other geomorphic forces, some of these wetlands will be lost, removing their future carbon sequestration potential and possibly resulting in the release of some of their carbon stores back to the atmosphere in the form of carbon dioxide (CO_2).

Early estimates indicate that restoring tidal wetlands and avoiding future loss of wetlands offer significant GHG offset potential[2]. These GHG offsets may be attractive to private and public parties facing GHG reduction commitments under future U.S. climate change laws and in the regional, state, and voluntary climate offset markets. Offset purchases could, in turn, provide a new revenue stream for tidal wetlands restoration efforts in the United States. It is also significant that coastal restoration and management will have important climate adaptation benefits, while supporting biodiversity, ecosystem functioning, and local economies, and reducing risks such as flooding.

GHG offsets have long been promoted as an important element of a comprehensive climate change policy approach. By enabling offsets to be developed where the cost may be lower, offsets projects and programs can reduce the overall cost of achieving a given emissions reduction goal, a finding supported by economic analysts[3]. Furthermore, offsets have the potential to deliver ecosystem sustainability co-benefits and to develop human and institutional capacity for reducing emissions in sectors and locations not capped or otherwise regulated in a cap-and-trade system or mandatory government policies.

In 2008, noting the significant GHG offsets potential associated with tidal wetlands projects, the Climate Action Reserve (CAR, formerly the California Climate Action Registry) commissioned an issues paper to assess the feasibility of developing a GHG offset protocol for tidal wetlands projects. A protocol would provide the necessary guidance to calculate, report, and verify GHG emission reductions associated with offset projects. It would also provide a reliable framework for implementing tidal wetlands restoration and management projects designed to create offset credits that are likely to be recognized as creditable

[2]Laffoley, D.A. and Grimsditch, G., eds. *The Management of Natural Coastal Carbon Sinks.* Glands, Switzerland: IUCN, 2009.

[3]Kollmus, A., Lazarus, M., Lee, C., LeFranc, M., and Polycarp, C. *Handbook of Carbon Offset Programs: Trading Systems, Funds, Protocols and Standards.* Earthscan, 2010.

under emerging state, regional, and federal climate change laws and regulations. The Kerry-Lieberman climate legislation introduced in the U.S. Senate in May 2010 specifically identifies "projects to restore or prevent the conversion, loss, or degradation of vegetated marine coastal habitats"[4] as eligible climate offset project types.

Implementing a high quality offsets program also requires transparency, credible verification, and a degree of administrative flexibility over time. Offsets programs include clear and transparent project documentation requirements, independent verification to support regulatory review, and regular program review and adjustment.

A tidal wetlands GHG offset protocol is a set of requirements and procedures adopted by registries and markets that enables the creation of and accounting for offset credits from a specific project. GHG offset registries and markets have varying standards and required elements for offset protocols, but share many commonalities, as described and defined in Table 1.

Table 1. Key Protocol Aspects and Terms	
Real	Demonstrate that reductions have actually occurred.
Additional	Confirm reductions result from activities that would not happen in the absence of a GHG market.
Permanent	Provide procedures for assessing and managing the risk of reversal of GHG reductions or removals.
Verified	Provide for independent verification that reported emission reductions and removals are achieved.
Owned unambiguously	Ensure that ownership of GHG reductions is clearly delineated.
Not harmful	Avoid negative environmental and social impacts.
Practical	Minimize project implementation barriers.

The paper produced for CAR, *Greenhouse Gas Mitigation Typology Issues Paper: Tidal Wetlands Restoration*[5] (CAR Issues Paper), determined that strong potential exists for protocol development, and that creating a GHG offset protocol for wetlands would have significant benefits. The authors concluded that the science, economics, and policy supporting protocol development are incomplete. They recommended coordinated action to provide the foundational science, economics, and policy to support protocol development.

[4]Senate Bill 1733, The Clean Energy Jobs and American Power Act, discussion draft, p. 388.
[5]Philip Williams & Associates, Ltd. and Science Applications International Corporation. *Greenhouse Gas Mitigation Typology Issues Paper: Tidal Wetlands Restoration.* San Francisco, CA, 2009. PWA Reference 1957.

Introduction (Continued)

To meet these challenges, Restore America's Estuaries (RAE), a national non-profit organization dedicated to the protection and restoration of our nation's estuarine resources, convened a National Blue Ribbon Panel (Panel) to review the status of the science and policy and establish an action plan for the incorporation of tidal wetlands into a GHG offset protocol. This document reflects the recommendations of the Panel and serves as that Action Plan.

RAE has worked closely with, and is grateful for, the many project partners who have contributed to this effort, including: Philip Williams & Associates, Ltd.; Science Applications International Corporation; KBR; AECOM; California Coastal Conservancy and Ocean Protection Council; California Ocean Science Trust; Center for Collaborative Policy; CH2M HILL; Climate Action Reserve; Conservation Capital, LLC; Environmental Defense Fund; The Nature Conservancy; Louisiana Office of Coastal Protection and Restoration; The San Francisco Foundation; USDA Natural Resources Conservation Service; U.S. Fish & Wildlife Service; and U.S. Geological Survey.

RAE and the project partners hosted a 2-day workshop for the Panel on April 12-13, 2010. A half-day public stakeholder workshop immediately followed on April 14, 2010. The Action Plan is built on recommendations and information gained during these workshops and subsequent input and communications. It also builds on the CAR Issues Paper and represents a clear path forward to achieve a national GHG offset protocol for tidal wetlands projects.

The following key conclusions were made by the Panel:

1. Significant opportunities exist to improve wetlands management to achieve GHG reductions as well as develop a protocol to bring different types of wetlands restoration and management projects into the carbon market; however, challenges and information gaps must be addressed to do so.
2. The methods necessary to quantify, measure, and monitor carbon sequestration and GHG flux from wetlands projects are achievable with existing science.
3. The potential for carbon sequestration must be quantified more fully.
4. Projects that are already required by law or regulation, such as wetlands mitigation projects, should be excluded from participation in an offsets process.
5. Projects should be ecologically appropriate.

National Blue Ribbon Panel Members

The Panel includes individuals representing relevant sectors of society who possess expertise in wetlands management, carbon sequestration, GHG accounting, and offsets protocols and markets. Panel Members are:

- Stephen Crooks, Philip Williams & Associates, Ltd., Panel Chair
- Tim Dillingham, American Littoral Society
- Abe Doherty, California Coastal Conservancy and Ocean Protection Council
- Jette Findsen, Science Applications International Corporation
- Kathryn Goldman, Climate Action Reserve
- Patrick Megonigal, Smithsonian Environmental Research Center
- Ken Newcombe, C-Quest Capital
- Lydia Olander, Nicholas Institute for Environmental Policy Solutions, Duke University
- Brad Raffle, formerly of Conservation Capital, LLC
- Debbie Reed, DRD Associates
- Diane Ross-Leech, Pacific Gas and Electric Company
- Eric T. Sundquist, U.S. Geological Survey
- Robert Twilley, Louisiana Office of Coastal Protection and Restoration
- Michael Wara, Stanford Law School

ACTION PLAN

Process for Protocol Development

The process for the development of an offsets protocol for tidal wetlands projects can be divided into two phases; the first focusing on synthesis and planning and the second involving research and implementation.

Phase I of this process is nearly complete and centers on defining issues to be resolved in order to develop a credible and effective protocol. It also involves outreach to potential stakeholders who can assist in addressing these issues. The authors will also revise the CAR Issues Paper based on reviews from Panel members and include the latest research results and other developments related to the development of a tidal wetlands GHG offset protocol.

Phase II of the protocol development process involves organizing working groups, implementing case studies, and funding research projects to address the necessary action items that have been identified during Phase 1 and are described in this Action Plan. It is envisioned that these activities will take place over the next two years, with efforts to begin drafting recommended protocol language beginning in early 2011. The goal of Phase II is to address the remaining research and policy gaps in such a way that CAR and other GHG offset registries will begin developing and/or adopting protocols for crediting GHG emission reductions from tidal wetlands projects.

Phase I - Synthesis and Planning

- Develop Issues Paper for CAR (February 2009)
- Convene Panel and hold public workshop (April 2010).
- Conduct ongoing outreach to agencies, the scientific community, and others.
- Complete Action Plan (this document, August 2010).
- Revise Issues Paper (Autumn 2010).

Phase II - Research and Implementation

- Address foundational challenges:
  - Establish working groups and research projects to develop recommendations concerning overarching protocol and policy issues.
- Conduct coordinated geographic case studies:
  - Provide proof of concept at three initial target sites.
  - Quantify GHG reductions and removals.
  - Test and refine methods.
  - Incorporate and test ideas and concepts from the working groups.
  - Determine applicability to other regions.

ACTION PLAN

Foundational Working Groups

The following plan outlines the recommended action items that should be undertaken in order to develop the necessary components of a wetlands offsets protocol. The Panel organized action items into two categories:

1. Overall foundational policy and protocol questions that can best be addressed through working groups and research projects.
2. Case studies to demonstrate GHG reduction methods and potential, quantification and measurement techniques, and monitoring technologies.

Foundational Working Group 1 (FWG1): Eligible Project Activities

The first foundational working group (FWG1) will focus on how to categorize project activities according to distinct functions that will be useful for the development of a GHG offset protocol. Typically, offsets registries categorize project activities according to common functions that lend themselves well to a standard additionality test and the development of streamlined procedures for quantifying baseline GHG emissions and flux. This working group will therefore work to define categories of eligible project activities based on common practices and functionalities related to the restoration and management of tidal wetlands.

The Panel defines a tidal wetlands GHG offset project as a planned set of activities to remove, reduce, or prevent GHGs in the atmosphere by conserving, and/or increasing, wetlands carbon stock, and/or lowering GHG emissions. Within this definition, the Panel discussed the following project activities that could be included in a protocol. These definitions were initially identified in the CAR Issues Paper and encompass four management approaches to wetlands:

- *Avoided Wetlands Loss* - Conserving and avoiding loss of existing wetlands carbon stocks that would otherwise be at risk of CO_2 release by erosion and/or human impacts.
- *Wetlands Restoration* - Actions taken in a converted former wetland or degraded natural wetland that result in the reestablishment of ecological processes, functions, and biotic and abiotic linkages, and lead to a persistent, resilient, integrated system.
- *Wetlands Management* - Manipulating one or more functions performed by an existing degraded wetland beyond baseline conditions of existing practice.
- *Wetlands Creation* - Conversion of a non-wetland (terrestrial upland or unvegetated water) to a vegetated wetland where no wetland previously existed.

Each of these project activities has parallels with principles of wetlands science and with principles established for existing national and international forestry GHG offset protocols and methodologies. If the CAR principles for protocol development are applied, each project activity would need a specific performance standard (i.e., eligibility criteria) and standardized requirements for quantification of baseline and project emissions. However, the Panel notes the likelihood that a single large wetlands project may include several of the above project activities, opening the possibility that it could be subject to several types of eligibility tests and baseline procedures. Because of this complexity of wetlands projects, it may be difficult to fit such projects within some offset program approaches, particularly those that rely on standardized eligibility tests. As a result, further work will be needed to better define and categorize relevant project activities in a way that best enables protocol standardization.

GHG emissions from tidal wetlands are strongly influenced by estuarine salinity gradients. Delineation of project activities may require field-based characterization of salinity-dependent below-ground processes. The CAR Issues Paper suggested such a simplified classification scheme for estuarine wetlands. The application of this scheme should be tested.

FWG1 Tasks

The tasks of this working group are to:

1. Refine the definitions of the four proposed categories of project activities.
2. Clarify associated performance standards requirements.
3. Confirm that such activities would be appropriate in landscape settings where project spatial migration may be required to accommodate sea level rise.
4. Evaluate classification and mapping schemes.
5. Evaluate how to address projects with more than one baseline (may involve splitting one project into multiple projects).
6. Address ownership and geographic boundary issues.

Foundational Working Group 2 (FWG2): Eligibility

The second foundational working group (FWG2) will develop guidelines for how to establish eligibility criteria for tidal wetlands projects. Because GHG offset projects are used for offsetting someone else's emissions, it is important that the credits generated go beyond common practice in terms of reducing or sequestering emissions, otherwise the offset project would actually lead to an overall increase in GHG emissions. GHG offset registries have developed eligibility rules for determining whether a project is truly additional. This includes a requirement that a tidal wetlands project must not already be required by existing laws and regulations. Additional eligibility tests may also be established to ensure that the offset project activity would not have occurred in the absence of the offset program. CAR, for example, uses standardized performance tests and eligibility thresholds to distinguish between common and better-than-average practices.

FWG2 will analyze the types of laws and regulations governing the management of tidal wetlands and will review options, data, and background information that will help CAR and other offsets programs develop credible and practical additionality tests for screening out business-as-usual projects.

Where wetlands projects are required by laws or regulations, opportunities may exist to enhance the project scale or carbon sequestration potential beyond what is required. In these cases, there may be an opportunity to create offset credits through the additional carbon sequestration generated by the project. A framework for addressing this challenge is needed.

There are several key issues that remain to be addressed in order to determine if a project, or class of projects, is truly additional. Establishing what is business-as-usual for tidal wetlands raises fundamental questions. How much tidal wetlands restoration and management occurs already, nationally and in different geographic regions? What is the overall opportunity for tidal wetlands restoration and management nationally? Where restoration is occurring, how is it funded? A rigorous approach and data are needed to answer these questions.

Tidal wetlands restoration and management projects are complex ecologically and economically. A typical restoration project has many partners who work together to identify, fund, plan, and implement the project. Partners include non-profit organizations, government agencies (state, local, and federal), businesses, scientists, individuals, and others. Very few, if any, of these partners have a restoration mandate and dedicated funding that require projects to occur. On the contrary, many restoration projects occur as a result of voluntary action and funding. Many agencies have restoration and coastal management goals that guide their actions and could be supportive of offset project development. Guidance is needed to determine if the sources of funding and how funds are utilized in a project should determine offset eligibility.

Underlying ownership of the project property also raises important questions. Many tidal wetlands restoration projects occur on publicly owned lands

and waters. In these cases, guidance is needed regarding project eligibility. The Panel recommends that projects on publicly owned lands not be ruled ineligible.

The environmental impacts, positive and negative, must also be weighed in considering the net benefits of tidal wetlands restoration and sequestration projects. Some projects may have direct or indirect environmental impacts, such as mercury methylation and increased mosquito populations. Before a project can be considered for offset credits, it must be able to demonstrate compliance with local, state, and federal environmental permitting and review requirements. The working group will outline the range of such environmental considerations that should be addressed in a protocol, including whether certain practices should be excluded on the grounds that they could otherwise threaten local biodiversity or ecosystem sustainability.

Tidal wetlands restoration projects have multiple ecosystem benefits, including habitat for plants, fish, and wildlife; improved water quality; and increased protection from storms and flooding. Efforts are underway to develop ecosystem services markets. This raises a key question about the possibility of a single project creating both GHG credits and ecosystem services credits for sale in the markets. Generating multiple credit types through one project is called "stacking." A protocol should address when stacking is appropriate and when it is not. The working group will monitor other ongoing efforts to consider stacking of ecosystem credits in the context of developing additionality tests for GHG offset projects.

An economic and policy assessment is needed to address short-term and long-term costs and benefits of wetland carbon sequestration projects. The initial costs of restoration may be substantial, and additional expenses will occur during implementation and monitoring. However, wetlands carbon sequestration projects will likely result in long-term environmental co-benefits, some of which may be marketable. This type of assessment will help clarify which mechanisms are appropriate to foster project investment and how credit should be allocated to those who bear the costs.

FWG2 Tasks

The task of this working group is to recommend clear eligibility guidelines for project activities. Specific action items that will assist with this task are to:

1. Assist in data collection for the development of a standardized additionality test for offsets programs that could be applied to each project type at the national or regional scale. This would include:
    a. Collection of data on "business-as-usual" management practices and funding decisions which are relevant for each project type. This effort may involve collecting survey data on current tidal wetlands projects, typical restoration or management practices, the funding decisions that led to the implementation of the projects, and the level of participation by local, state, and federal agencies in the projects. In particular, data could be gathered in conjunction with the regional case studies recommended in this Action Plan.
    b. Collection of information that could be used to demonstrate and document what would constitute "better-than-average" wetlands practices, i.e., the types of projects that could be considered additional under a standardized additionality test. This could be based on anecdotal information, surveys, pilot carbon sequestration research projects, or other potential project examples and research.
2. Document the opportunities for tidal wetlands restoration and management nationally, with accessible regional and local data where available.
3. Develop a standardized framework for assessing additionality of each category of wetlands project activities.
4. Review environmental regulations, laws, ordinances, and other requirements that may already lead to implementation of wetlands projects. Such mandated projects should not

receive credit, or should receive only partial credit, under a GHG offset protocol.

5. Recommend guidance to determine the relevance of public ownership, management, and funding to project eligibility.
6. Propose guidance for stacking of multiple credit types, including the relationship between GHG offsets and ecosystem services.
7. Develop lists of potential environmental impacts—manageable and unmanageable, and beneficial and potentially harmful—for tidal wetlands projects for each of the four project activities.
8. Recommend or develop tools to assess the economic costs and benefits of creating carbon credits through tidal wetlands restoration.

Foundational Working Group 3 (FWG3): Permanence

The third foundational working group (FWG3) will examine issues related to ensuring the permanence of credits generated from tidal wetlands projects. Project failure or other interruptions may lead to intended or unintended releases of carbon stored in a wetland, thereby reversing some or all of the credits gained from the project. This working group will examine the potential for such reversals to occur as well as methods for managing risk and preventing this from happening.

Tidal wetlands have the capacity to sequester carbon and have done so continuously for thousands of years. In modern coastal settings, natural coastal wetlands and wetlands restoration projects are under pressure from sea level rise and local human impacts.

A landowner's decision to convert land back to wetlands is not trivial; laws protecting wetlands make such a decision near-irreversible. Landowners and project developers, as well as registries and agencies, will require a very high degree of confidence that a carbon offset project will be successful over a likely project life of at least 100 years.

Wetlands GHG offset projects may be at risk due to factors including: change of environmental policies, project manager financial failure, engineering failure (e.g., collapse of structures such as levees), vegetation eradication to manage invasive species, disruptive impacts of large natural events, progressive impacts of sea level rise and climate change, and human-induced disruption to upstream water and sediment supply. Assessment approaches will be required to account for these risks. Approaches developed for forestry protocols and methodologies include insurance to guarantee offsets, carbon buffer pools, and access to a secure source of replacement offsets.

Wetlands restoration projects are a central and valuable element of climate change adaptation and resource management planning as they create space and buffers for coastal landscapes to respond to sea level rise and other pressures. Wetlands projects built specifically for climate change mitigation add a layer of complexity because of the contractual requirements of offset projects. To avoid conflicts, the wetlands project should be planned to be consistent with the broader context of resource management and climate change adaptation plans that account for factors such as sea level rise, coastal erosion, changes in salinity, migration of wetland types, and management of non-carbon resources.

FWG3 Tasks

The overall task of this working group is to identify, recommend, and establish where necessary, approaches for assessing, accounting for, documenting, and preventing risks of reversal to carbon sequestration projects in coastal settings. Specific working group tasks are:

1. Identify and establish guidelines for risk of reversal, including: project risks (e.g., transfer of ownership), economic risks, regulatory risks, resource management risks, natural disturbance risks, and long-term landscape change risks.
2. Develop decision trees, models, or other tools for helping project developers evaluate and assess the risk of project reversal through a standardized and transparent process.
3. Develop guidelines to integrate planning for wetlands offsets projects into regional climate adaptation and resource management plans.
4. Develop approaches for assessing and managing uncertainty.
5. Identify existing resources and develop methods to respond to the risk of project reversal. Risk management approaches should be assessed for coastal response to sea level rise as well as other risks, such as invasive species management.
6. Address how legal protections affect permanence.

Foundational Working Group 4 (FWG4): GHG Quantification

The fourth foundational working group (FWG4) will coordinate and help advance research and analysis related to the quantification of carbon storage and GHG flux from tidal wetlands. In particular, FWG4 will focus on ways that GHG quantification can be standardized for use in protocols that rely on standardized procedures for crediting projects. It will also work on issues related to the development of accurate, effective, and practical measurement and monitoring techniques.

While measurement technologies are available to quantify carbon storage and GHG emissions, the scientific utilization of these technologies has not been focused on building datasets to support detailed and cost-effective GHG budgeting for tidal wetlands projects. There is a need to establish cost-effective, rigorous, and replicable standardized approaches for quantifying baseline and project GHG benefits.

Models are required to improve our understanding of biogeochemical processes, to anticipate future changes in processes that control carbon storage, and to support project planning and monitoring. Currently, a scientific working group sponsored by the National Center for Ecological Analysis and Synthesis (NCEAS) is developing a carbon sequestration and GHG emissions model for salt marshes.[6] This approach builds on models developed for projecting rates of soil elevation change in tidal wetlands.[7] Adapting such models for a carbon offset protocol will require fairly routine studies of carbon storage as a function of depth and related parameters. Modeling the processes that produce methane (CH_4) and nitrous oxide (N_2O) is more challenging. Therefore, the NCEAS working group is exploring adapting the soil elevation change model for this purpose and adapting a process model developed for agricultural soils to quantify N_2O emissions. The de-nitrification decomposition model is being tested on rice fields and is proposed as a leading candidate for detailed simulation of GHG (CO_2, CH_4, and N_2O) emissions for agricultural baseline conditions,[8,9] as well as mangrove systems.[10] This

[6] http://www.nceas.ucsb.edu/featured/callaway

[7] Morris, J.T., Sundareshwar, P.V., Nietch, C.T., Kjerfve, B., and Cahoon, D.R. "Responses of Coastal Wetlands to Rising Sea Level." *Ecology* 83 (2002): 2869-2877.

[8] Fumoto, T., Kobayashi, K., Li, C., Gi, K., and Hasegawa, T. "Revising a Process-Based Biogeochemistry Model (DNDC) to Simulate Methane Emission from Rice Paddy Fields under Various Residue Management and Fertilizer Regimes." *Global Change Biology* 14 (2008), 382-402.

[9] Qui, J., Li, C., Wang, L., Tang, H., and Van Ranst, E. "Modeling Impacts of Carbon Sequestration on Net Greenhouse Gas Emissions from Agricultural Soils in China." *Global Biogeochemical Cycles* 23 (2009), GB1007.

[10] World Bank. *Trinidad and Tobago: Nariva Wetland Restoration and Carbon Sequestration Project. Project Appraisal Document on a Proposed Purchase of Emission Reductions by the Biocarbon Fund and Other Carbon Funds.* Report No. 45642-TT, 2008.

approach may potentially extend to simulating restoration of managed tidal freshwater wetlands and salt marshes.

Monitoring, particularly of GHG emissions and below-ground carbon stocks, can be expensive. Cost-effective monitoring approaches to track and verify project progress are required to support a protocol. Modeling will provide essential guidance for monitoring across the landscape as well as support development and use of simple and low cost indicators (e.g., water table depth, pH, salinity, temperature, and redox) that may provide indirect proxies for GHG emissions.

Quantifying baseline conditions for wetlands restoration projects on agricultural land can be accomplished using established scientific techniques. In addition to the increased carbon storage associated with restoration, a recognized and creditable benefit may include halting of ongoing carbon losses from drained organic-rich former wetland soils. This credit for avoided loss may be additive to carbon sequestration from the wetland restoration project. For projects that avoid wetlands loss with sea level rise, a significant challenge is quantifying the fate of carbon released from eroding salt marshes. Issues include determining the percentages of carbon that are permanently buried, released into the atmosphere, support CH_4 production, and re-sequestered elsewhere.

For high-salinity salt marshes (salinity >18 ppt), emissions of CH_4 are typically negligible. In certain managed freshwater tidal settings, CH_4 is produced, but offset projects would result in positive net GHG sequestration due to the high level of soil carbon production. The potential for other wetlands types (brackish wetlands, forested tidal wetlands, natural freshwater tidal wetlands) is poorly quantified and requires additional analysis. Emissions of N_2O also require study, especially in wetlands systems that receive nitrogen loading from agricultural activities.

For each project type, it is necessary to list relevant and significant sources of GHG flux. Protocols distinguish between primary and secondary sources of GHG flux. Primary sources occur as a direct result of project activities, such as the release of CH_4 and N_2O during anaerobic organic matter decomposition in wetlands or the release of CO_2 from the combustion of fuel for transporting sediments to a restoration site. Secondary sources occur as a subsequent effect of project activities. For example, taking agricultural land out of production for a tidal wetlands project may result in land elsewhere being put into agricultural production. The secondary sources of GHG flux are those that are a result of the shift in land use. These are sometimes referred to as "leakage."

FWG4 Tasks

The overall task of this working group is to establish standard methodologies for monitoring and modeling for baseline and project soil carbon sequestration and GHG emissions.

1. Quantify baseline conditions for project activities. Coordinate and share data with agricultural protocol development efforts.
2. Develop and refine models of wetlands ecosystems, soil and sediment biogeochemistry, sediment dynamics, carbon sequestration, and GHG flux for project activities. Incorporate the findings of NCEAS scientific working group into this effort.
3. Develop information to address issues of scale and accuracy related to use of integrated biogeochemical models and field sampling, including coordinating and sharing data with other related protocols under development.
4. Establish and test cost-effective and statistically appropriate field sampling procedures to characterize heterogeneous carbon sequestration and GHG emissions across a wetlands project.
5. Synthesize existing data and identify critical information gaps to support baseline land-use 'look-up' tables for carbon sequestration and GHG emissions.
6. Develop an approach to quantify secondary sources of GHG flux, i.e., leakage, and the adjustments in landscapes associated with project activities.

Geographic Working Groups

Geographic Case Studies and Working Groups

Geographic case studies will provide quantifiable proof-of-concept and address information gaps for relevant activities and specific wetlands classes. The Panel recommends case studies to address specific issues that will be encountered in protocol development. In particular, the case studies should consider environments where emissions of CH_4, and possibly N_2O, are naturally high or low, and case studies with different degrees of complexity in terms of the baseline condition due to their spatial scale. For each case study, the Panel is aware that carbon sequestration could be achieved through one or more of the four project activities, and recommends that the group of case studies collectively address the full range of project activities.

The Panel recommends investigating a freshwater wetland where emissions of CH_4 can be high. To offset relatively high rates of CH_4 emissions, such a site will need to have high rates of carbon sequestration, most likely achieved through hydrologic management and enhanced organic soil building on subsided lands. Tidal freshwater wetlands, such as those in Sacramento-San Joaquin Delta and coastal North Carolina, are ideal case studies because the hydrology can be managed to rebuild and store carbon much faster than they emit CH_4. The Panel recommends a case study in a highly saline marsh where sea level rise drives continual sequestration of soil carbon through burial, and the high sulfate content of seawater suppresses CH_4 emissions, but where approaches for assessing risks to permanence are needed. Finally, the Panel recommends considering a large deltaic coastal wetland system (e.g., the Mississippi Delta) in which several different baseline conditions may exist, but where restoration or management would need to be highly coordinated.

Results from these case studies will be coordinated and integrated with the foundational working group activities to support a draft protocol that can be expanded to other coastal settings.

These case studies, in some cases, are already underway or being developed, led by regional teams. Regional teams are coordinating with this national protocol development effort to ensure sharing of information and consistency of approaches when possible. Ongoing coordination is essential.

While the Panel's recommendations focus on case studies with high offset potential and readily available information, it is hoped that case studies for additional wetland classes will be established as supporting information becomes available (e.g., mangroves, seagrass beds, forested tidal wetlands, and seasonal floodplains). Geographic working groups (GWG) will be established for each primary case study and are described in more detail below. As with the FWGs, the GWGs will be coordinated by the national project team to provide for continuity of concepts and methods.

Geographic Working Group 1 (GWG1): Managed Freshwater Tidal Wetlands

Managed freshwater tidal wetlands offer very high potential for net carbon sequestration per unit area as part of a multi-decadal, but interim, phase to restore natural resilient freshwater tidal marsh. Experimental subsidence reversal and carbon sequestration through vegetation growth and soil rebuilding in deeply subsided lands in the Sacramento-San Joaquin Delta has yielded positive results. Potential avoided loss due to carbon respiration from drained organic-rich soils, plus rebuilding of organic soils, could sequester more than ten tons CO_2e/acre/year,[11] after accounting for CH_4 emissions.[12] It is estimated that in the Sacramento-San Joaquin Delta, approximately two billion tons of CO_2 has been released due to soil management practices over the past 100-150 years.[13] Because soils surfaces would need to be raised by up to 25 feet to reestablish and

[11] Carbon dioxide equivalent.

[12] Miller, R., Fram, M., Fujii, R., and Wheeler, G. "Subsidence Reversal in a Re-Established Wetland in the Sacramento-San Joaquin Delta, California, USA." *San Francisco Estuary and Watershed Science,* 6(3) (2008). Retrieved from: http://escholarship.org/uc/item/5j76502x.

[13] Crooks, S. "The Impacts of Sea Level Rise on Tidal Wetlands: Implications for Carbon Sequestration and Estuarine Management." White Paper by Philip Williams & Associates, Ltd. to the Resources Legacy Fund, Feb. 9, 2009.

restore the natural marshes, there is potential to continuously sequester significant amounts of carbon in this delta for more than 100 years.

Next steps:

- Acquire additional resources to support an established community of experienced scientists, modelers, wetland managers, and economists who have been studying diverse aspects of wetlands restoration in the Sacramento-San Joaquin Delta. Carbon sequestration data have been collected over the past ten years on a demonstration project. Resources are required for coordination, quantification of baseline conditions, refinement of GHG models, and expansion of demonstration projects.

Geographic Working Group 2 (GWG2): Coastal Salt Marsh

Coastal salt marshes offer potential for significant carbon sequestration, especially where salinities are above 18 ppt and the presence of dissolved sulfate suppresses production of CH_4.[14] For salt marsh restoration projects, net carbon sequestration potential per acre may be equivalent to, or greater than, many reforestation projects.[15,16] In addition to creation and restoration, actions taken to reduce the rate of coastal salt marsh erosion or inundation from sea level rise have the potential to maintain and protect carbon accumulated over previous decades. The avoided loss of carbon stocks through restoration and management actions has significant GHG offset potential. Salt marsh carbon management should focus on both protection and enhanced resilience of existing wetlands resources as well as restoration of wetlands and carbon sinks.

Scientific techniques are available to systematically quantify and model carbon sequestration within coastal salt marshes. Standardized monitoring methodologies can be developed based on these techniques, and such efforts are underway, including that of the NCEAS working group. More significant challenges to establishing an offset protocol for salt marshes lie in addressing open and moving ecosystem and boundary issues and managing risk to permanence.

Next steps:

- Identify and support regional demonstration salt marsh restoration and creation projects to collect GHG sequestration and baseline data needed for protocol development. This will require coordinated action among the scientific community, government agencies, and other parties to improve our knowledge and methods.
- Support and expand upon the work of the NCEAS working group and similar efforts to quantify regional carbon sequestration in salt marshes and to develop predictive models.

Geographic Working Group 3 (GWG3): Large Deltaic System (Mississippi Delta)

Large deltaic systems are very complex both ecologically and politically. Deltas are one of the most concentrated sinks for coastal carbon. Attractive economies of scale may be possible for projects that halt and reverse ongoing losses of vegetated deltaic wetlands. Protecting and restoring carbon sequestration within deltas requires actions at the broader landscape level that will result in commensurately large carbon and ecosystem benefits.

Next steps:

- The Louisiana Office of Coastal Protection and Restoration is exploring options to bring coastal restoration into the carbon markets. As part of this effort, it will establish one or more demonstration projects. Coordination between the Louisiana effort and the national project will enhance the collective ability to develop a national protocol.

14 Poffenbarger, H.J., Needleman, B.A., and Megonigal, J.P. "Are Brackish Marshes Greenhouse Gas Sources or Sinks." Wetlands, in review.
15 Gorte, R.W. *Carbon Sequestration in Forests.* CRS Report to Congress, 2007. Order Code RL31432.
16 Laffoley, D.A. and Grimsditch, G., eds. *The Management of Natural Coastal Carbon Sinks.* Glands, Switzerland: IUCN, 2009.

ACTION PLAN

Additional Research

The action items in this report will provide the necessary information and context for full protocol development. Additionally, the Panel suggests several opportunities for additional research and development that would strengthen protocol development and implementation, and help integrate a protocol into broader climate change adaptation and resource management approaches. The Panel strongly encourages interested parties and partners to dedicate resources to these issues.

1. Research and Development Opportunities - Permanence

- Improve models of long-term, coastal geomorphic and habitat response to sea level rise to reduce uncertainties in assessments of wetlands erosion and permanence.
- Evaluate resource management and climate adaptation plans for coastal areas, and recommend ways to minimize potential conflicts with offset projects.
- Develop and evaluate predictive indicators of coastal ecosystem resilience, vulnerability, and sensitivity to climate change. Indicators should seek to provide enhanced predictions and early warning of potential risks to vegetated wetlands, in order to enhance predictions of risks to permanence of carbon storage in vegetated wetlands.
- Advance resource management and climate adaptation approaches that increase coastal wetlands resilience to sea level rise and reduce other risks to permanence.

2. Research and Development Opportunities - Quantification

- Advance technology to lower the cost of site-based monitoring of GHG flux.
- Evaluate the application of remote sensing technologies to characterize and differentiate GHG emissions across a landscape.
- Quantify the relative impacts of restoration projects on N_2O production within coastal landscapes.
- Determine and quantify the fate of carbon released from eroding wetlands.
- Improve the understanding of GHG budgets for wetlands across the estuarine salinity gradient. Beyond the recommended case studies there are major information gaps for highly productive brackish marshes, seasonally and occasionally flooded forested wetlands, mangroves, and subtidal habitats such as seagrass beds.

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