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Second Draft

Recommendations for a National Wetlands and Climate Change Initiative

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INTRODUCTION

Although scientific uncertainties exist with regard to magnitude of climate change, there is ample scientific evidence to suggest that climate change is now having and will have significant impacts on millions of coastal, estuarine, and freshwater wetlands throughout the Nation. Wetlands serve a broad range of functions including flood loss reduction, pollution control, endangered species habitat and recreation. These functions will be diminished. Wetlands are also more sensitive to small changes in precipitation and temperature than other ecosystems and as a result many may be destroyed.

What actions could states, tribes, federal agencies and local governments cooperatively take to reduce the impact of climate change on wetlands? How can national resource managers “adjust” wetlands to climate change? What are the priority management-oriented research needs?

We believe that a cooperative national Wetlands and Climate Change Initiative is needed with action by all levels of government and the private sector.

The following recommendations for a National Wetlands and Climate Change Initiative are based upon speaker presentations at Wetlands 2008: Wetlands and Global Climate Change, conducted by the Association of State Wetland Managers and a broad range of cooperating parties in September 2008, Portland, Oregon. The recommendations also draw upon a series of earlier scientific workshops concerning wetlands and climate change conducted by the Association of State Wetland Managers.

We welcome your comments and suggestions. What has been left out? What should be emphasized?

The recommendations which follow begin with why we think that a National Wetlands and Climate Change Initiative is needed. Suggested actions by states and tribes, federal agencies and local governments are next considered. More specific measures to reduce the impacts of climate change on wetlands and to adjust wetlands to climate change are then listed separately for coastal/estuarine wetlands and then for freshwater wetlands. The recommendations conclude with collaborative research needs.

WHY IS A NATIONAL WETLANDS AND CLIMATE CHANGE INITIATIVE NEEDED?

A National Wetlands and Climate Change Initiative involving all levels of government and the private sector is needed for a number of reasons:

- **Severe climate change impacts to wetlands.** Increased temperatures, increase or decrease in precipitation, and sea level rise will have severe impacts on wetland ecosystems. Impacts will be particularly great for coastal and estuarine wetlands, which cannot migrate inland due to steep topography, levees, sea walls, or other development. They will also be great for small, shallow wetlands such as vernal pools and prairie potholes, where temperatures and evaporation rates may substantially increase without

corresponding increases in precipitation. They will be great for montane wetlands with temperature-sensitive plant and animal species and little opportunity for such species to migrate. They will be great for permafrost wetlands due to melting.

- **Release of stored carbon, methane.** Much of the carbon stored in wetland soils in the U.S. and world will be released if wetlands are drained or if permafrost wetlands melt. Bacteria which live in aerated conditions will oxidize much of the carbon and return it to the atmosphere. Fires will add to releases. Peatlands in the Northern U.S. (e.g., Minnesota, Maine) and Alaska and some other types of wetlands continue to sequester small quantities of carbon. The release of carbon will exceed sequestering if temperatures rise, precipitation levels fall, or if wetlands are drained.

Wetlands globally emit significant amounts of methane. This total has been estimated to be in the 15-22% range of total global methane emissions. Most of these emissions are at lower latitudes rather than in the U.S., for example the Amazon floodplain. However, because methane is a very active greenhouse gas, the climate change “forcing” function of methane may exceed the gains from carbon sequestering, particularly on short term basis. In the long term (500-1000 years), methane has a decreasing effect.

- **Reducing the impacts of climate change on wetlands and “adjusting” wetlands to climate change will require an effort by all levels of government and the private sector.** No single action or measure will be sufficient to reduce the impact of climate change on wetlands or to adjust wetlands to climate change. Many actions will be needed. See recommendations below.
- **Lack of coordination between programs, efforts.** At the present time there is a great deal of interest at all levels of government concerning the impacts of climate change on wetlands and measures which might be taken to better protect wetlands from impacts and adjust wetlands to climate change. There is also a fair amount of management-oriented wetland and climate change research taking place in universities, agencies, and nonprofit organizations in the U.S. and abroad. However, federal, state, tribal, local government and private sector efforts are not coordinated. One state does not know what another state is doing. Little research is taking place with regard to some of the most critical management-related issues such as evaluation of carbon storage and methane generation in wetland sediments and the implications of various management practices upon carbon stores, sequestering and methane generation.

WHAT SHOULD A NATIONAL WETLANDS AND CLIMATE CHANGE INITIATIVE INCLUDE?

A national wetlands and climate change initiative should include the following elements. Note, this list is not exhaustive and would be revised by a National Wetlands and Climate Change Initiative coordinating committee. See discussion below.

- **Formation of a National Wetland and Climate Change Coordinating Committee.** The Council for Environmental Quality, U.S. Fish and Wildlife Service (FWS) and the

U.S. Environmental Protection Agency (EPA) should, in cooperation with other federal agencies, states, tribes, local governments and the private sector, convene a National Wetlands and Climate Change Coordinating Committee. Such a Coordinating Committee should build upon existing federal, state and local coordination efforts but should involve a broader range of partners. The goals of the committee should be to help protect wetlands from climate change including wetland functions and values and carbon stores and to evaluate how to help adjust wetlands to climate changes.

- **A survey of wetlands and climate change efforts underway including policies and programs, publications, webpages, and research.** The Committee should undertake a survey of wetland and aquatic ecosystem-related efforts underway throughout the nation. Such a survey should be a cooperative effort of all levels of government and the private sector. The results of this survey should be posted to the web.
- **Creation and updating of a national wetlands and climate change website.** The Committee should create a national website with links to other relevant sites, publications, reports and activities throughout the nation.
- **Creation of a coordinated wetlands and climate change research program.** The Committee should develop a priority list of wetland and climate change research needs and help fund priority studies. See list of priority research needs below.
- **Implementation of measures to protect and restore wetlands at all levels of government, the private sector.** Actions are needed by all levels of government including more specific measures for coastal/estuarine and freshwater wetlands (see below).

WHAT ROLES COULD FEDERAL AGENCIES AND CONGRESS, STATES AND LOCAL GOVERNMENTS PLAY IN IMPLEMENTING AN INITIATIVE?

Federal leadership is needed to implement a National Initiative. Suggested federal, state and local roles include the following items:

Federal Agencies

The Administration and federal agencies should take the following actions. (Note, agencies already have initiated some of these actions.)

- **The Council on Environmental Quality, U.S. Fish and Wildlife Service and U.S. Environmental Protection Agency should, in cooperation with the USDA Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, USDA Forest Service, Bureau of Land Management, U.S. Geological Survey, and National Science Foundation jointly form a federal, state, tribal and local Wetlands and Climate Change Initiative** building upon existing formal and informal coordinating mechanisms. See discussion of the Initiative above.

- **Adopt goals and plans.** All agencies should incorporate wetland and climate change protection and adaptation goals into agency missions, strategic plans.
- **Identify wetlands most threatened on public lands.** Land management agencies such as the U.S. Forest Service and Bureau of Land Management should devise protection and adaptation policies; implement policies.
- **Establish a coordinated system of reference sites.** Federal agencies should, in cooperation with the states/tribes and academic institutions, establish and operate a coordinated, national system of wetland and climate change reference sites including LTER sites, Estuarine Reserve Research Sites. These sites would be used to monitor climate change and development and test various protection and adaptation strategies. Agencies should make data widely available.
- **Incorporate adjustments to climate change in water projects, highway projects, other public works including added safety factors for floods and erosion and added ecosystem protection and adjustment goals.**
- **Survey state, tribal, federal, local climate change and wetland/water ecosystem programs; publish results.** EPA in cooperation with other agencies should survey federal, state, tribal, and local wetland ecosystem protection and adaptation efforts, post results to the web.
- **Prepare and widely distribute a wetlands and climate change best management practices handbook.** EPA and the FWS should in cooperation with other agencies, prepare or fund the preparation of a handbook or handbooks setting forth measures for protection of wetlands and adaptation of wetlands to climate change.
- **Carry out or fund demonstration projects** illustrating various measures to protect and adapt wetlands to climate change.
- **Add protection of wetland carbon stores as an explicit goal of the Section 404 permitting program;** require impact reduction and compensation.
- **Fund and/or carry out priority management-oriented research.** See below.

Congress

Congress should:

- **Establish a National Wetland Climate Initiative** as part of broader climate change legislation.
- **Fund wetland and climate change related research.**
- **Provide funding to support accurate wetland maps nationwide.** In most areas of the country wetlands maps are 20-30 years old.
- **Adopt the Clean Water Restoration Act or similar legislation** to clarify Clean Water Act jurisdiction to include all wetlands regulated before the SWANCC decision. This would provide additional agency protection for wetland ecosystems including those threatened by climate change.
- **Include protection and adjustment of wetlands** as part of national climate change legislation (e.g., the Lieberman/ McCain of 2003 or Lieberman/Warner bill of 2007).

States, Tribes

States and tribes should:

- **Document threats to wetlands** and other ecosystems due to climate change and other stresses over time.
- **Document the successes or failures** of various protection and adjustment strategies and techniques.
- **Broaden state climate change programs beyond emission controls.** States and tribes should incorporate wetland and climate change protection and adjustment goals into climate change efforts.
- **Identify wetlands most threatened by climate change on state lands.** Develop protection and adjustment strategies.
- **Factor climate change into state wetland regulatory efforts; adopt remedial legislation where states have not adopted regulations.**
- **Require local governments to factor climate change into land use planning and regulatory efforts** where state statutes require state standard-setting for local planning and regulations (e.g., Washington State).
- **Integrate wetland protection and restoration into state flood hazard and climate change initiatives** such as protection of wetland flood storage and conveyance, increased freeboard in state floodplain and regulations, prohibition of fills in wetlands, adoption of zero rise floodways, and adoption of a no adverse impact standard for floodplain management.
- **Establish regulatory buffers for all wetlands and waters** to reduce stresses on wetlands, allow wetlands to migrate.
- **Create multiobjective corridors for migration of species** as part of state fish and game management efforts.
- **Work with partners such as land trusts, local governments and federal agencies to protect wetlands with significant carbon stores.**
- **Work with local governments and federal agencies to update wetland maps.**
- **Fund and/or carry out priority management-oriented research** in cooperation with the federal government, academic institutions and land trusts including the creation of systems of reference sites. See below.

Local Governments

Local governments should:

- **Adopt wetlands and climate change protection and adaptation goals as part of comprehensive land management and watershed management.** Adopt conservation zoning, sensitive lands, critical area ordinances to protect wetlands.
- **Identify wetlands most threatened by climate in a community;** devise protection and adjustment strategies
- **Factor climate change into “smart growth,” “sustainable cities,” similar land and water planning and management efforts.**

- **Factor climate change into infrastructure planning and plan implementation strategies** (e.g., “over-sizing culverts and other structures to better accommodate extreme events).
- **Better protect wetlands as part of flood hazard reduction efforts:** adopt increased freeboard in floodplain regulations, zero rise floodways, restrictions on fill in wetlands, and no adverse impact floodplain management policies.
- **Adopt wetland protection regulations** as separate regulations or include as part of zoning, subdivision controls, building codes.
- **Restore, create or enhance wetland types most threatened by climate change.**
- **Establish regulatory buffers to protect wetlands and other resources.**
- **Adopt “development rights” regulations to promote clustering of development on uplands and protection of wetlands.**
- **Tightly control drainage to prevent oxidation of wetland soils.**
- **Create multiobjective greenways** with wetlands as one component to provide corridors for migration of species.
- **Work with land trust, state, tribal and federal partners** to protect and manage wetlands and wetland carbon stores including establishment of wetland carbon banks.

WHAT SPECIFIC MEASURES ARE NEEDED TO BETTER PROTECT AND ADJUST COASTAL/ESTUARINE WETLANDS?

What, more specifically, may be done by states, tribes, local governments and federal agencies to protect and adjust coastal wetlands to climate change as part of a National Wetlands and Climate Change Initiative?

Climate Impacts on Coastal/Estuarine Wetlands

Projected sea level rises of 2/3 of a meter to 2 meters (reflecting, in part, assumptions concerning ice sheet melting) by 2100 combined with coastal subsidence will have severe impact coastal and estuarine wetlands, particularly on the Atlantic and Gulf coasts. There will be wetland losses, where there is insufficient plant growth and sediment deposition to equal sea level rise and coastal or estuarine wetlands cannot migrate inland. This is a particular problem for deltaic systems such as the Mississippi Delta, where sediment-trapping reservoirs have been constructed along inflowing rivers and subsidence is occurring due to compaction of sediments, oil and gas removal, and isostatic adjustments. Loss of many of these wetlands can be expected with release of the carbon contained the peats and soils to the atmosphere. In other instances, the carbon will be redeposited in new marshes or transported to the open ocean.

States, federal agencies, local governments and the private sector could take a variety of actions to reduce the impact of climate change on coastal and estuarine wetlands. These actions may be divided into two overlapping categories—protection and adjustment.

Protection Strategies for Coastal/Estuarine Wetlands

- **Incorporate wetland and climate change ecosystem protection and adjustment goals into coastal zone regulatory, infrastructure development, watershed**

management and land planning management programs. Coastal/estuarine protection and management programs need to take place at greater spatial and temporal scales than they have to date.

- **Implement “low risk” protection options.** Implementation of a variety of “low risk” management options is justified now despite uncertainties in climate change because options can serve a broad range of independent objectives in protecting and restoring wetland functions and values (e.g., flood storage, erosion control, pollution control) even if climate change does not occur at the projected rates. Examples of options include building setbacks for coastal/estuarine wetlands, more stringent control of drainage, the attachment of conditions to permits to help protect carbon stores, and government acquisition of wetlands with the largest carbon stores to protect them from drainage and filling.
- **Implement “resilient” wetland strategies as part of “resilient estuary” and other protection efforts.**
- **Develop and document coastal/estuarine protection and adjustment tools through the use of demonstration “pilots.”** Monitor success and failures. Make the results of studies broadly available.
- **Identify (map, identify through GIS) coastal and estuarine wetlands and wetland species most at risk from climate change within a locality, state, or particular region.** This will require identification of plant and animal species with greatest vulnerability such as species with poor distribution and limited range.
- **Establish on the ground priorities for protection and adjustment.** For example wetlands best able to keep up with sea level rise could be identified and targeted for acquisition or more stringent regulations. Similarly, wetlands with strong restoration potential should be identified.
- **Establish buffers for coastal/estuarine and freshwater wetlands.** Buffers will allow coastal/estuarine wetlands to migrate as sea level rises. Buffers will also reduce stresses and make more coastal and estuarine wetlands.
- **Consider the impact of proposed activities on carbon stores in regulatory permitting.** Regulatory agencies at all levels of government should amend regulations to better protect wetland carbon stores. Permittees should be required to estimate carbon impacts in seeking permits. Mitigation and compensation measures should be required.
- **Strengthen control of drainage.** Control of drainage of wetlands is a particularly high priority to protect carbon stores and carbon sequestering. It is also a high priority to better protect wetland functions and values since drainage is only partially regulated at federal, state and local levels.

Adjustment Strategies for Coastal/Estuarine Wetlands

- **Control invasive species in climate-stressed wetlands.** This will require the ability to distinguish between range shifts and species invasions.
- **Acquire upland buffers to permit coastal/estuarine wetlands to migrate when sea level rise occurs.**
- **Divert sediments (e.g., the Davis diversion in Louisiana) to nourish wetlands.**
- **Undertake restoration, creation, enhancement for wetland types most threatened by climate change.** Wetland restoration, creation and enhancement including the establishment of mitigation banks or more specific, multiobjective “wetland carbon banks” may help reduce the impact of climate change on wetlands, protect existing carbon stores and carbon sequestering, and reduce methane emissions.
- **Establish wetland reference sites (see above) to monitor the impact of climate change and determine the effectiveness of management and adjustment strategies.**
- **Undertake long term planning with the goal of protecting and increasing the resiliency and adaptability of wetland ecosystems in the face of climate change.**
- **Undertake priority research. See discussion below.**

Some management options to enhance carbon sequestering and storage such as stabilization of water levels, control of fires and replanting wetlands may be inconsistent with broader ecosystems goals, depending how they are carried out. They should be approached with caution.

WHAT SPECIFIC MEASURES ARE NEEDED TO BETTER PROTECT/ADJUST FRESHWATER WETLANDS?

Climate Impacts on Freshwater Wetlands

Climate change will also seriously affect freshwater wetlands due, principally, to temperature rise, increased evaporation, and reduced precipitation (for some areas). Projected temperature rise of 2-8 degrees F by the end of the century without comparable increases in precipitation will dry out or lower water levels in wetlands in many areas of the nation. Northerly shifts in vegetation and animal species will take place where migration pathways are adequate and there is sufficient time for such migration. Otherwise, temperature sensitive species will be destroyed or their numbers seriously reduced by shifts in temperature and/or shifts in precipitation.

Impacts will be particularly great where precipitation decreases. Increases in temperatures and evapotranspiration combined with reductions in precipitation will likely reduce surface and ground water levels in northern latitude wetlands, destroying or reducing in the size many wetlands.

States, tribes, federal agencies, local governments and the private sector could take a variety of actions to reduce the impact of climate change on wetlands. Recommendations for actions to be taken for freshwater wetlands are in many respects similar to those for coastal and estuarine wetlands:

Protection Strategies for Freshwater Wetlands

- **Identify (map, identify through GIS) wetlands and wetland species most at risk from climate change within a locality, state, or particular region.** This will require identification of plant and animal species with greatest vulnerability such as species with poor distribution and limited range. Formulate protection plans and strategies for these wetlands or classes of wetlands.
- **Incorporate wetland and climate change ecosystem protection goals into watershed management, water planning, comprehensive land planning including smart growth, and infrastructure development programs.**
- **Increase regulatory protection for wetlands most threatened by climate change to reduce stresses and provide opportunity for wetlands to migrate:**
 - More stringently control of drainage
 - Consider the impact of activities on wetland carbon stores in regulatory permitting; require impact minimization and compensation measures; attach conditions to permits, and
 - Prevent fragmentation of wetland/aquatic ecosystems; more fully protect migration corridors.
- **Adopt buffers to reduce potential stresses, allow migration of plants and animals.**
- **Establish wetland reference sites to track changes in wetlands due to climate change, determine the effectiveness of management and adjustment strategies.**
- **Acquire and protect wetlands with the largest carbon stores.**

Adjustment Strategies for Freshwater Wetlands

- **Prioritize wetlands with regard to management and adaptation.** Establish “on the ground” priorities for the most cost effective application of protection and adaptation strategies. For example wetlands with deep carbon deposits could be identified and targeted for acquisition or more stringent regulations. Similarly, wetlands with strong restoration potential should be identified.
- **Control invasive species.** This will require deciding whether plant or animal species migrating into an area due to increased temperatures, sea level rise or other climate change factors are to be considered “invasive.”

- **Install water control structures at the outlets of freshwater wetlands.** Such structures can, in some instances, help maintain water levels during dry periods. However, structures may be quite expensive and require maintenance.
- **Re-establish and maintain corridors.** Re-establishment and management of wildlife corridors is needed to permit plant and animal species to migrate. This is particularly important for river corridors which permit, under natural conditions, the migration of fish, reptiles, birds, and other animals and plants.
- **Divert sediments (e.g., the Davis diversion in Louisiana) to nourish wetlands.**
- **Undertake restoration, creation, enhancement.** Wetland restoration, creation and enhancement including the establishment of mitigation banks or more specific, multi-objective “wetland carbon banks” may, under certain conditions, help reduce the impact of climate change on wetlands, protect existing carbon stores and carbon sequestering, and reduce methane emissions.
- **Establish wetland reference sites to document the impacts of climate change and to determine the effectiveness of management and adjustment strategies.**
- **Undertake long-term as well as short-term planning and watershed/ecosystem scale as well as site-specific scale planning with the goal of protecting and increasing the resiliency and adaptability of wetland ecosystems in the face of climate change.**
- **Develop protection and adjustment tools through the use of “pilots.”** Monitor success and failures. Make the results of studies broadly available.
- **Consider the impact of proposed activities on carbon stores in regulatory permitting.** Regulatory agencies at all levels of government should amend regulations to better protect wetland carbon stores. Permittees should be required to estimate carbon impacts in seeking permits. Mitigation and compensation measures should be required.
- **Strengthen control of drainage.** Control of drainage of wetlands is a particularly high priority to protect carbon stores and carbon sequestering. It is also a high priority to better protect wetland functions and values since drainage is only partially regulated at federal, state and local levels.
- **Prevent fragmentation of wetlands, reestablish corridors.** Prevention of fragmentation in wetlands and reestablishment of corridors is needed to permit migration of plant and animal species.
- **Better address invasive species in climate-stressed wetlands.** This will require the ability to distinguish between range shifts and species invasions.
- **Undertake priority research. See discussion below.**

As with coastal/estuarine wetlands, some management options to enhance carbon sequestering and storage in freshwater wetlands such as stabilization of water levels, control of fires and replanting wetlands may be inconsistent with broader ecosystems goals, depending how they are carried out. They also should be approached with caution.

WHAT ARE PRIORITY MANAGEMENT-ORIENTED AND BASIC RESEARCH NEEDS?

A National Wetlands and Climate Change Initiative should include a research agenda. Initiative members should define priority research needs and either help undertake or fund priority research. Some priority management-oriented research topics include the following items:

- **Document more fully the impacts of climate change on wetland ecosystems** through the use of reference sites and research projects. This should include but not be limited to the impacts of increased CO₂, increased temperatures, sea level rise, and increases or decreases in precipitation. How will climate change affect rates of photosynthesis, shifts in vegetation (e.g., what trees will grow where?), changing surface and ground water regimes, and other features? Field studies and experiments are particularly needed to document the sensitivity of specific wetland plants/animals and types of wetland ecosystems to small changes in temperature, precipitation patterns, changes in hydroperiod, changes and rates of change in CO₂, etc. Research projects need to investigate the impacts of rising sea levels upon coastal and estuarine wetlands including rates of sedimentation and other deposition, carbon sequestering and storage in sediments, and the pathways and fate of carbon in wetland sediments, which may be dislodged by sea level rise and flooding. Topics needing investigation include but are not limited to:
 - What is the relationship of in-situ wetland carbon storage and sequestering in wetlands to upland carbon fixing, erosion, runoff and wetland deposition by activities such as agriculture and forestry?
 - What are the methane fluxes in all types of wetlands and at various levels within wetland sediments?
 - What is the impact of fire upon carbon cycling in wetlands?
 - How significant are “catastrophic” events such as hurricanes and major rain storms to carbon sequestering and storage in wetlands?
- **Refine climate change models reflecting soils, geology and topography** to provide more accurate predictions regionally concerning changes in temperature, precipitation, extreme meteorological events, sea level rise and other aspects of climate change.
- **Investigate and quantify the impact of a wide range of land and water management practices upon carbon storage and sequestering and methane emissions** (and, in some instances, NO₂) including draining wetlands, water level manipulation, various forestry practices, various agricultural practices, burning and suppression of fire, plantings with various species, control of exotics, etc.

- **Investigate the compatibility of land and water management practices to sequester and store carbon and/or reduce methane emissions with broader biodiversity and other wetland functions and values; develop guidance.** What will be the impacts of various management techniques upon flood storage and conveyance, wave attenuation, erosion control, pollution control, food chain support, biodiversity, recreational values, other functions and values? How compatible will land and water management strategies to enhance wetland carbon sequestering and to reduce methane production (e.g., water level manipulation) be with protection of biodiversity and with protection and restoration of other wetland functions and values? More specifically:
 - a. Investigate the impacts of controlling fire upon habitat and ecosystems functions such as flood conveyance, biodiversity, and endangered species and upon long-term serious burns.
 - b. Investigate the impacts of controlling (stabilizing) water levels upon successional sequences and various wetland plant and animal species.
 - c. Investigate the impacts of using fertilization to increase carbon production and deposition upon eutrophication and wetland plant and animal species including accelerated demise of wetlands.
 - d. Investigate the impacts of diverting sediments into wetlands to increase carbon sequestration upon fisheries, waterfowl, and other plant and animal species and upon the accelerated demise of wetlands.

- **Investigate the use of various remote sensing techniques combined with field surveys to identify wetlands with significant carbon stores,** to calculate the amounts of wetland carbon stores and to determine methane emissions.

- **Develop model regulations and policies including monitoring protocols** to protect carbon stores, promote carbon sequestration, and reduce methane production.

- **Develop economic and other incentives** for land and water management practices for protecting carbon stores (e.g., peat lands), protecting and enhancing sequestering, and reducing methane production.

- **Investigate the roles wetland restoration, creation and enhancement can play in protecting wetland functions and values including protection of wetland carbon stores and the adjustment of wetlands to climate change.** What project designs will be most successful? What wetland management techniques should be used?

- **Investigate the dynamics of c-sequestration and storage and methane production in restored, created, and enhanced wetlands.** Investigate how various restoration, creation, and enhancement strategies (e.g., flooding, water level stabilization) affect c-sequestering and storage, and methane production. More specifically, can enhanced, restored or created wetlands sequester carbon at rates which exceed those of natural wetlands? release methane? If so, with what designs and management practices?
 - a. Rates vs. age
 - b. Rates vs. strategies
 - c. Rates vs. system types

d. Watershed interactions

- **Investigate approaches for creating wetland “carbon banks” to protect wetlands with large stores of carbon and (possibly) to sequester additional carbon.** What management practices are needed to not only protect existing stores but to enhance sequestering and reduce methane production? Are wetland “carbon farms” or “carbon banks” practical? If so, how might they be established? What sorts of management practices are needed? How are credits and debits to be calculated?