REDUCING CLIMATE CHANGE IMPACTS AND PROMOTING FISH AND WILDLIFE: FINDINGS AND RECOMMENDATIONS FOR BIOLOGICAL CARBON STORAGE AND SEQUESTERING

Association of Fish and Wildlife Agencies and the Association of State Wetland Managers

Authors: Bill McGuire and the AFWA Forestry Working Group, Tim McCoy and the AFWA Biofuels Working Group, Jeanne Christie, and Jon Kusler (Association of State Wetland Managers)

Editors: Roger Griffis (NOAA), Chris Farley (USFS), Dean Smith (AFWA), and Arpita Choudhury (AFWA)

EXECUTIVE SUMMARY

This white paper is intended to reflect the current thinking of the Association of Fish and Wildlife Agencies (AFWA) and the Association of State Wetland Managers (ASWM) membership in regard to how carbon sequestration can proceed in ways that are most compatible with the conservation of fish and wildlife and their habitats. The paper will provide an overview of how biological carbon storage[1] and sequestration can proceed in concert with fish and wildlife sustainability in forests, wetlands, and grasslands. It is a product of the AFWA Forestry Working Group, the AFWA Biofuels Working Group, the AFWA Climate Change Committee, and the ASWM, and is meant to provide a concise, easy to read briefing for AFWA members, ASWM members, legislators, and policy makers. It will describe the storage and sequestration ability of these habitats and how current practices such as wetland draining, afforestation of grasslands, and development of natural areas not only threaten existing carbon stores but also put pressure on the stability of fish and wildlife populations that are native to these habitats. Each section will also offer specific recommendations for science, management, and policy for carbon storage and sequestration. Literature that is cited is simply intended to provide some background for readers and is by no means an exhaustive resource list.

Increasingly, carbon sequestration discussions focus on approaches that maximize sequestration but, for the most part, disregard the benefits or unintended consequences carbon sequestration projects may have on fish and wildlife and their respective habitats. In addition, there has been little discussion of the importance of preventing the loss of the large amount of carbon currently stored in natural landscapes. To reduce the impacts of climate change, the appropriate management of carbon and other greenhouse gas emissions will be required. An appropriate management process will be a complex challenge that will require public support and thoughtful resolution by policy makers with the consideration of all sectors of the economy. Protection of existing carbon stored in the natural landscape in combination with biological carbon

[1] Biological carbon storage and sequestration is defined as the protection of existing carbon plus additional sequestering of carbon by soil and/or vegetation through specific management practices.

sequestration is a commonsense approach that benefits from existing natural processes while at the same time supporting biodiversity and other ecological services.

General Recommendations for Carbon Storage and Sequestration

Listed are some general recommendations to consider for policies and management plans for carbon storage and sequestration as well as the protection, management, and restoration of native fish, wildlife, and habitats:

- Protect the existing carbon stores and the carbon sequestering capabilities of forest lands, wetlands, grasslands, and other ecosystems while simultaneously protecting and restoring fish and wildlife habitat.
- Work with partners at the local, state, and federal level to sustainably manage land and water resources, including native habitats, to provide the diverse array of goods and services needed by society, including water, carbon storage, and sequestration benefits.
- Emphasize the use of native species in biological carbon storage and sequestration programs.
- Use a diverse array of native species and genotypes to maintain biodiverse habitats and provide resilience to uncertain future conditions.
- Maintain connectivity at a landscape level to not only protect fish and wildlife but to ensure the continuing capture of carbon within various habitats types.
- Incorporate habitat specific restoration/protection plans into existing programs such that they protect existing carbon stores and consider carbon sequestration capabilities.
- Create best management practices that address multiple functions (ex. fish and wildlife needs, carbon storage and sequestration, water resources, harvest production, etc.).
- Create carbon markets and carbon storage/sequestration programs that promote restoration, protection, and sustainable use.

General Resources on Carbon Storage and Sequestration

The Climate Action Reserve:
http://www.climateactionreserve.ort/how/protocols/adopted/forest/development/

The Climate Registry: http://www.climateregistry.org

Congressional Budget Office. 2007. The potential for carbon sequestration in the United States.

http://www.cbo.gov/ftpdocs/86xx/doc8624/09-12-CarbonSequestration.pdf

EPA. 2010. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.

http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

Post W.M. and K.C. Kwon. 2000. Soil carbon sequestration and land-use change: processes and potential. Global Change Biology. 6(3):317-327.

Zhu, Zhiliang, et.al. 2010. A method for assessing carbon stocks, carbon sequestration, and greenhouse-gas fluxes in ecosystems of the United States under present conditions and future scenarios: U.S. Geological Survey Scientific Investigations Report 2010–5233. http://pubs.usgs.gov/sir/2010/5233/

Forests and Carbon Storage and Sequestration by Bill McGuire and the AFWA Forestry Working Group

In pre-settlement times, forest land constituted about one billion acres (~45 %) of the United States. Approximately 300 million acres of forest land were converted to agriculture and other uses by the end of the 19th century. At present, the United States is about one-third (~30 %) forested, with 747 million acres, an amount that has been fairly stable during the last 100 years. Of these forested acres, approximately 422 million acres (~60 %) are in private ownership with the remainder publicly owned by such agencies as the United States Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS), and United States Fish and Wildlife Service (USFWS) as well as state, county and local government entities.

Forest lands are of strategic importance to the Nation and its citizens. Forested watersheds provide clean water supplies by filtering and improving water quality and recharging groundwater and protecting communities by slowing runoff and lessening flood frequency and severity. Forests provide important habitat for a variety of wildlife that could not survive otherwise. Forest lands have long been an important source of construction materials, pulp and fiber, and wood to provide heating, but there is increasing interest in forests as a source of feedstock that could be burned to generate electricity or converted to biofuels. Forests supply many other valuable ecological services as well as other services such as oxygen production, moderating temperatures, nutrient cycling, etc. Increasingly, interest is building in regard to the role of forest lands in sequestering carbon to mitigate climate change and setting up carbon markets. Finally, each of these uses and functions of forest land has social and economic impacts on jobs (i.e. the forest products industry, recreation/tourism, agriculture, energy production, etc.), revenues, and communities that need to be carefully considered when evaluating if and how to implement carbon sequestration projects.

Forests have always sequestered carbon dioxide from the atmosphere but the amounts have only been measured in recent decades. Forests are net sinks for carbon dioxide, sequestering 791.9 Teragrams (1 Tg = 1 million tons of carbon dioxide) of carbon dioxide equivalent in 2008 across the United States. With financial motivation to increase sequestration, the EPA has modeled that new forestry projects could sequester an additional 356 Tg of CO2 eq per year at a moderate $15/ton trading price. By comparison, 1,785 Teragrams of carbon dioxide were emitted by the entire United States transportation sector in the same year, meaning that forests are a substantial buffer to fossil fuel emissions.

As societal demand on forest land continues to increase, it becomes more and more important to optimize and deliver a variety of products as opposed to maximizing one or two. Native forests comprise of diverse native species that are ecologically appropriate to the site on which they are growing. These lands, by way of species and structural diversity, offer considerable potential and flexibility to help meet multiple societal needs on the same land. Forest soils have the capacity to store a great deal of carbon. The rate of storage as well as the amount of carbon stored can also be enhanced while benefiting wildlife through effective management of native forest lands. It is important that programs and opportunities intended to support and stimulate carbon sequestration and carbon markets be designed and implemented to sustain native forest land in ways that perpetuate native plant and animal diversity consistent with the ecosystem in which the forest land is located. Plantation forests and agroforestry may also help sequester carbon as well as provide additional benefits such as soil conservation, groundwater recharge, increased water quality, and, with management and/or innovation, improved wildlife habitat. As environmental markets continue to develop, the stackability of benefits such as carbon sequestration, water quality, wildlife habitat, etc. could result in bundles of compensation that shift economic advantage toward forest land that delivers a variety of products and benefits.

Regarding carbon sequestration and forests, it is important to note that different species (whether native or exotic) can exhibit significantly different growth responses and lifespan on the same site. There are some short-lived trees that can be planted that will out-sequester longer lived species over short time frames, but over time the longer-lived species will sequester more carbon. For example, loblolly pine will out-sequester longleaf pine in the first 30 years but longleaf sequesters beyond 30 years and keeps sequestering carbon long after loblolly stops growing. In addition, loblolly is often used for pulpwood which has a relatively short use life after harvest whereas longleaf is often used for poles, furniture, or other wood products that tie carbon up much longer. Sustainable management strategies that focus on native species and ecosystem health can provide fish and wildlife benefits while also providing carbon sequestration benefits. The use of harvest best management practices (BMP's) designed to sustain native forest land and that incorporate wildlife needs (specific to the region and site) would help ensure that societal needs and expectations regarding an array of products and benefits are met.

Recommendations for Forests Carbon Storage, Sequestration, and Fish and Wildlife Sustainability

Management of forest land to achieve carbon sequestration generally refers to afforestation/reforestation, deforestation, and management. The following are the most wildlife compatible approaches to carbon storage and include examples of Farm Bill programs that could be used to meet this goal:

Afforestation/Reforestation

- Plant trees on woodland and transitional soils or on sites that do not result in conversion of native prairie or other natural communities and thereby, further fragmenting the habitat of species associated with non-forested communities and that are on long-term decline (Wetland Reserve Program (WRP)/Conservation Reserve Program (CRP) bottomland hardwood restorations, CRP riparian plantings).

- Take advantage of opportunities for large scale reforestation, as land use priorities change in regard to cropland or grassland that originally came from forest conversion- such restorations could help restore important ecosystems and associated functions as well as provide society with carbon storage, biomass for energy and other benefits. Use only native species for plantings (WRP/CRP bottomland hardwood restorations, CRP longleaf pine natural community restorations; Healthy Forest Reserve Program (HFRP).

- Incorporate multiple species, suited to the site and of differing growth rates and heights in plantings (WRP/CRP bottomland hardwood restorations, Environmental Quality Incentives Program (EQIP) tree plantings on upland sites).

- Encourage restoration of understory vegetation as well as native tree species in reforestation efforts (EQIP, Wildlife Habitat Incentive Program (WHIP)) – longleaf pine restoration in the Southeastern U.S. as an example)

Deforestation

- Strive for sustainability of native forest land (EQIP assistance in helping landowners pay for the cost of an inventory and plan will set the stage for enhanced productivity and economic return will encourage forest owners to manage forest sustainability).

- Seek out programs that provide some assurance (easements) that native forest land will endure (WRP, HFRP, Farm and Ranch Lands Protection Program (FRPP), etc.).

Management

- Develop management plans that sustain native forest land and/or incorporate wildlife considerations into forest plantations and agroforestry (HFRP, EQIP forest management plan development practice).

- Restore and manage for natural communities (HFRP, CRP longleaf pine restoration, WRP/CRP bottomland hardwood restorations).

- Exclude livestock exclusion and/or manage for sustainable grazing practices (CRP and EQIP).

- Employ harvest and forest management BMPs that address fish and wildlife considerations and needs (this can include forest management mosaics that include clear cuts and subsequent regeneration as well as initiatives like Emergency CRP to address extensive forest damage due to a natural disaster).

- Encourage timber stand improvement practices, consistent with wildlife needs, that help remove small diameter trees and other woody material that limit carbon sequestration and wildlife benefits (EQIP forest management practice).

- Apply prescribed fire and other management approaches to address deadfall and litter accumulation so as to minimize the risk of wildfires, catastrophic carbon loss and, as feasible, allow for nutrient recycling and habitat needs of wildlife associated with the forest floor (EQIP forest management practice).

- Maintain forest connectivity and minimize forest fragmentation (EQIP tree planting, WRP bottomland hardwood restoration, CRP riparian corridor plantings, and WRP, HFRP, and FRPP easements).

- Manage flexibly to best address the forest type (i.e. aspen and lodgepole pine need to be clearcut to regenerate, but clearcutting may not be the best approach for other forest communities). Use pre-commercial harvests to enhance wildlife habitat and accelerate growth/sequestration rates on remaining trees – for example, a stand of red pine in northern states will result in small trees and less than optimal growth after 40 years and no thinning (EQIP practice for forest stand improvement, CRP mid-contract management).

- Thin stands to open the canopy and restore the native grass component to a savanna (i.e. open a stand of shortleaf pine to stimulate suppressed native warm season grasses/forbs) where remaining trees and grass can sequester carbon and benefit wildlife (HFRP, EQIP natural community restoration practice, CRP mid-contract management – forest openings).

Resources on Forests and Carbon Storage and Sequestration

Birdsey, R.A. 1996. Regional Estimates of Timber Volume and Forest Carbon for Fully Stocked Timberland, Average Management After Final Clearcut Harvest. In Forests and Global Change: Volume 2, Forest Management Opportunities for Mitigating Carbon Emissions. eds. R.N. Sampson and D. Hair. American Forests. Washington, DC.

EPA. 2005. Greenhouse Gas Mitigation Potential in the US: Forestry and Agriculture. EPA 430 R 05-06.

Hamilton, K. et al. 2010. State of the Forest Carbon Markets 2009: Taking Root and Branching Out. Ecosystem Marketplace. 1-63.

McCarl, B. and U. Schneider. 2001. Greenhouse Gas Mitigation in U.S. Agriculture and Forestry. Science. 294:2481-2482.

Oren, R. et al. 2001. Soil fertility limits carbon sequestration by forest ecosystems in a CO_2-enriched atmosphere. Nature. 411:469-472.

Ryan, M.G. et. al. 2010. A Synthesis of the Science on Forests and Carbon for U.S. Forests, Ecological Society of America, Issues in Ecology #13, Washington, DC. 13p. http://esa.org/science_resources/issues/FileEnglish/issue13.pdf

Smith, W.B. et al. 2000. Forest Resources of the United States, 1997: St. Paul, MN, U.S. Department of Agriculture Forest Service.

Smith, J. E. et al. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. Gen. Tech. Rep. NE-343. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 216 p. http://www.fs.fed.us/ecosystemservices/pdf/estimates-forest-types.pdf

Smith, W.B. et. al. 2009. Forest Resources of the United States 2007. Gen. Tech. Rep. WO-78. Washington, DC: Us Department of Agriculture, Forest Service, Washington Office. 336p. http://www.treesearch.fs.fed.us/pubs/17334

Unger, K. and D. Abhat. 2010. New Focus on Forests. The Wildlife Professional. 4 (1): 24-29.

Wetlands and Carbon Storage and Carbon Sequestration by Jeanne Christie and Jon Kusler (Association of State Wetland Managers)

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands constitute approximately 4% of the surface area of the contiguous United States (excluding Alaska and Hawaii). In the last 200 years, this area of the 48 states lost an estimated 53 % of their original wetlands. Wetlands are havens of biodiversity and serve as habitat for much of the nation's wildlife including birds, fish, mammals, amphibians, and reptiles, including 35% of all rare and endangered plant and animal species. Wetlands provide a broad range of additional goods and services such as producing vital water supplies through groundwater recharge, water quality improvement, and protecting communities through flood storage, storm tide buffering, flood conveyance, erosion control, and pollution control.

Wetlands have stored a large amount of soil carbon throughout geologic history. Subjected to heat and pressure, plant and soil carbons deposited in wetlands during the Mississippian, Pennsylvanian, and Tertiary period are now major United States coal deposits. Wetlands contain a significant amount of carbon stored in wetland soils, peats, litter, and vegetation (global estimate of 500-700 GT), which is similar in magnitude to the total amount of atmospheric carbon. The total amount of carbon currently stored in United States wetland soils, peat, litter and vegetation in the United States is undetermined. No comprehensive inventory of soil carbon has been completed in the United States. Most quantitative measurements of soil, peat carbon, carbon, and methane fluxes to date have focused on peat lands and rice paddies. Most measurements have been in the upper meter of soil or peat and few studies have considered buried horizons in wetland soil carbon layers, especially in wetlands and floodplain soils. Peat lands are found in several areas of the United States (e.g., Minnesota and Alaska). There is also a relatively small acreage of rice paddies (around 3,000,000 acres), mainly in Arkansas, Texas, and California. But most United States wetlands are of other types: slope wetlands, depressional wetlands, coastal and estuarine salt marshes, lake fringe wetlands, and riverine wetlands. Large amounts of carbon are broadly dispersed in the thick sediments of deltaic and riverine wetlands, in swamps, subaqueous soils, and tidal marshes.

Wetlands are also sinks of carbon produced from upland agriculture, forestry, and other land uses and not simply carbon fixed by photosynthesis in wetland plants. Carbon from watershed sources in the form of soil organic carbon, dissolved organic carbon, leaves, tree trunks and woody debris from floods, and other organic materials are washed into low lying wetland areas from upland landscapes. It is deposited in stream valley sides (slope wetlands), in depressions in agricultural landscapes (depressional wetlands like the Prairie Potholes), in lake fringe wetlands along the Great Lakes and smaller lakes, in riverine and floodplain wetlands, in river oxbows and abandoned meanders and clayey back swamps, Yazoo streams, floodplains and terraces, and in coastal and estuarine wetlands like the Mississippi Delta. In the Delta and all along the east coast Coastal Plain margin the total sedimentary deposition has been enormous (tens of thousands of feet). Decomposition of the carbon deposited in wetlands is slowed by prolonged water saturated, anaerobic conditions. Some of the carbon deposited in these wetlands is recycled to the atmosphere by aerobic and anaerobic decomposition as carbon dioxide or methane. But even this decomposition takes considerable time and a portion is stored for hundreds to thousands of years, especially in Histosols, Spodosols and Vertisols.

Environmental conditions affect wetland carbon storage and sequestration, so both climate change and management can influence these processes. The effect of climate change on wetland stores and sequestering depends upon atmospheric CO_2 levels, temperature, water levels, fires, tree harvesting, and land management practices. The release of carbon from wetlands may exceed the amount being sequestered if temperatures rise due to atmospheric warming. This is particularly true if water levels also fall due to increased evapotranspiration. In addition, even more of the carbon stored in wetlands will be released if wetlands continue be drained. Upon drainage, fungi and bacteria which thrive in the newly aerated conditions will oxidize much of the carbon stored previously, and return it to the atmosphere. Fires can accelerate carbon release and serious subsidence may occur in some areas (e.g., the Sacramento Delta, the Everglades, New Orleans and the Mississippi Delta) exacerbating the impacts of sea level rise.

Increased CO_2 and increased temperatures may increase photosynthesis and carbon sequestration in some circumstances. However, increased temperatures and evapotranspiration will also lead to lowered water levels and increase decomposition in some wetland types such as tundra and prairie potholes. Increased temperatures may also increase the generation of methane in soils that remain waterlogged. However, increase in sea level may offset these accelerated losses by keeping tidal marsh soils saturated longer and cooler, with lower fungal activity and decrease of decomposition by salt-intolerant bacteria.

Recommendations for Wetland Carbon Storage, Sequestration, and Fish and Wildlife Sustainability

Protection of wetland carbon stores and sequestration will also protect wetland habitat for a broad range of waterfowl, fish, moose, otter, crustaceans, mollusks, and other species including many endangered species. Restoration of drained and partially drained wetlands will "stop the bleeding" of carbon from partially drained organic soils as well as restore habitat and wetland functions. Federal agencies, states, tribes, local government, nongovernmental organizations, and others should act cooperatively to increase protection and restoration of the nation's wetlands to promote carbon storage, sequestration, and other valuable services. Measures needed at federal, state, and local levels to help protect existing carbon stores and the ability of wetlands to sequester carbon include the following:

- Complete a national research assessment of all soil carbon with wetlands as an important component.

- Complete identification of wetlands throughout the nation with the greatest carbon stores and restoration potential. Explore policy mechanisms to provide greater protection of these areas (e.g. National Ocean Policy Marine Protected Areas).
- Include wetland carbon credits for protection and restoration of wetland carbon stores and wetland carbon sequestering in any carbon market system. This would go beyond the Kyoto Protocol limited options to provide credits for protecting and restoring existing carbon stores under certain conditions.
- Work with partners such as land trusts, local governments, and federal agencies to protect wetlands with significant carbon stores and sequestration abilities.
- Include protection, adaptation, and restoration of wetlands as part of national farm policy and national climate change legislation.
- Establish a coordinated system of reference sites for wetlands with significant carbon stores and carbon sequestration.
- Increase funding and incentives for wetland protection and restoration
- Eliminate policies/regulations that promote wetland drainage and degradation.

Best Management Practices for Protecting Carbon Stores and Sequestering Carbon

All levels of government should also adopt management practices that simultaneously protect wetland carbon and the broader range of other wetland goods and services, including biodiversity. The following are approaches to carbon storage and sequestration that are most compatible with fish and wildlife conservation.

- Add protection and restoration of wetland carbon stores and carbon sequestering as an explicit goal of federal, state, tribal, and local land use and natural resource planning, consistent with fish and wildlife needs. Planning should avoid wetland management practices for storing and sequestering carbon that adversely impact wildlife and plant diversity.
- Add protection of wetland carbon stores and carbon sequestering as an explicit goal of federal, state and local regulatory programs. Impact reduction and mitigation should be required.
- Identify, protect, and restore wetlands with significant carbon stores and sequestration ability as an important wetland value in selecting lands for enrollment in the Wetland Reserve Program and other USDA agriculturally-related wetland programs.
- Halt or reduce wetland drainage and other land and water management practices that lead to dewatering of wetlands and oxidation of carbon.
- Control fires in wetlands, including deep burns and hot burns.

- Allow natural revegetation to occur in wetlands or undertake replanting to prevent proliferation of invasive species due to climate change. Control invasive species where economically feasible.

- Control peat harvesting and other removal of carbon from wetlands.

- Prepare and widely distribute a wetlands and carbon best management practices handbook and develop/implement training for decision makers. EPA, NOAA, 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. The information should be made readily accessible online.

- Carry out or fund demonstration projects in saltwater and freshwater wetlands illustrating various measures to protect, restore, create, and manage habitats with carbon stores and carbon sequestering to reduce carbon dioxide and methane production while protecting wildlife and other wetland values.

Resources on Wetlands and Carbon Sequestration

Association of State Wetland Managers, Wetlands and Global Climate Change:

http://www.aswm.org/science/climate_change/climate_change.htm

Bridgham, S.D. et. al. 2006.The Carbon Balance of North American Wetlands. Wetlands. 26 (4): 889-916.

DANONE Fund for Nature, Achieving Carbon Offsets Through Mangroves and Other Wetlands:

http://www.ramsar.org/pdf/DFN_report_Final.pdf

Euliss, N.H. et. al. 1999. North American Prairie Wetlands Are Important Non-forested Land Based Carbon Wetland Sites. Science of the Total Environment. 36: 179-188.

Wetlands International, Wetlands and Climate Change:
http://www.wetlands.org/Whatwedo/Wetlandsandclimatechange/tabid/178/Default.aspx

Wylynco, D., Prairie Wetlands and Carbon Sequestration: Assessing Sinks Under the Kyoto Protocol:
http://www.iisd.org/wetlands/wrkshp_summ.pdf

Grasslands and Carbon Storage and Sequestration by Tim McCoy and the AFWA Biofuels Working Group

In the United States, grasslands cover over 30% of the land area (>760 million acres) and are the largest land cover type on private lands. Grasslands also represent the most common ecosystem across the North American Continent. From an economic standpoint, grasslands are critical to livestock production; are an important sector for the agricultural economy providing grass-based income and jobs, including the $70 billion beef industry in the United States, and diversify farm income sources. Healthy grasslands provide important soil carbon stores, storing as much carbon as pine-oak forests, and provide faster groundwater recharge than most forested areas. Grasslands characteristically have high natural soil fertility and organic matter content. Typical accounting for carbon in grassland primarily includes only carbon in the soil and roots; thus carbon sequestered in grasslands is considered relatively stable. However, these same soil characteristics make many types of grassland susceptible to conversion to cultivated agriculture, which typically results in substantial carbon losses. The central grasslands of North America represent one of the continent's largest biomes and harbor a rich biological diversity as well as many grassland endemic species. Human-dominated disturbances have converted this ecosystem across its entire range to the point of it currently being considered among North America's most endangered.

Since settlement, about half of all United States grasslands have been lost, with less than 1% of the historic tall grass prairies remaining in the eastern and central United States. Pressure continues for conversion of grasslands to cultivation and urban development, and, unlike forests, the decline of grasslands in the United States continues. The loss of grassland habitat, and continued degradation of existing grassland through intensified use and poor management, has led to wildlife declines and loss of biodiversity. Grassland birds for example, as a group, have undergone larger and more consistent population declines over the last 50 years than any other group of bird species monitored through the North American Breeding Bird Survey.

Grasslands, however, continue to be important for many wildlife species, including deer, pronghorn antelope, grouse, and other wildlife species that are adapted to open prairie conditions. Waterfowl such as northern pintails, mallards, canvasbacks, redheads, gadwall, and blue-winged teal need grasslands in association with wetlands for successful nesting. Grasslands provide biodiversity of plant and animal populations and play a key role in environmental quality on both public and private lands. Grasslands also improve the aesthetic character of the landscape, provide scenic vistas, create open spaces, and are valued for recreational opportunities.

Carbon sequestration rates for grasslands, on a per-acre basis, are often assumed to be lower than that of forestlands. However evaluations of cultivated soils restored to forests and grasslands indicate carbon sequestration rates are often similar. In both forests and grasslands, there is extensive variability related to productivity of restored vegetation, which is tied to the physical and biological conditions on specific sites. From a global standpoint, grasslands represent 26 % of the world's land area, 70 % of the world agricultural area, and grassland soils are estimated to hold 20 % of the world's carbon stores. Thus, the maintenance, management, and improvement of soil carbon stores is significant, and an important consideration in policy discussions.

Grassland carbon sequestration faces similar challenges to those relating to forestry, wetland, and cultivated agriculture carbon sequestration. Because of the value of existing grasslands for soil carbon stores, conversion of grassland soils to cropland continues to be a concern. The largest challenge facing grassland carbon sequestration is the ability to measure soil carbon stores and to understand the spatial and temporal variability in sequestration rates related to management activities intended to increase soil carbon. Initial work has indicated that improved management of grasslands can improve carbon sequestration and organic matter accumulation in the soil. Improved grazing and haying management of grasslands enhances nutrient cycling, plant productivity, water filtration and retention, and enhances the conservation and sustainable use of habitat and improves species diversity. Thus, grassland management can serve to improve carbon sequestration as well as provide a key adaptation and mitigation strategy for both climate change and climate variability.

Grassland systems may be at risk from potential changes related to increased harvest and management pressure to produce biomass that can be processed into energy. Efforts to increase the use of biomass are focused on reducing the carbon footprint of fossil fuel energy. In doing so, biomass may be primarily viewed only as a crop. This is an issue of concern from the standpoint of wildlife and biodiversity, as efforts to produce better crops of biomass may disregard potential for carbon sequestration and may negatively impact wildlife habitat. Such efforts will provide little or no benefit to wildlife and biodiversity and in some cases may actually create new challenges.

Recommendations for Grassland Carbon Storage, Carbon Sequestration, and Fish and Wildlife Sustainability

Policies to encourage adoption of practices that sequester carbon in grasslands lag behind those for forest and agricultural lands. This is despite the fact that practices to improve carbon sequestration in grasslands are low cost, enhance productivity, and have substantial biological benefits. Practices that promote increased primary productivity on prairie grasslands and rangeland, particularly those that are used for producing livestock (or forage for livestock), could be poised to be an important and non-controversial avenue for addressing climate change. The following are approaches to carbon storage and sequestration that are most compatible with fish and wildlife conservation:

- Protect and restore native prairies and grasslands from conversion to agricultural lands, urban areas, or forests in order to increase carbon sequestration rates and biodiversity.
- Plant species that are ecologically appropriate in order for carbon sequestration activities to be ecologically sound (plant grassland species on grassland sites). There are ecological systems where restorations of both trees and grasslands on sites (e.g. savannahs) are appropriate, and will also provide key wildlife habitat and biodiversity benefits but trees should not be planted on grassland sites simply for the purpose of increasing carbon sequestration.
- Restore cultivated lands on grassland derived soils to grassland communities in ecologically important areas to fully meet the potential for sequestering carbon, providing wildlife habitat, and improving biodiversity. Plant multiple species to more closely mimic natural systems using local ecotypical seed sources where possible.
- Limit (where appropriate) monoculture plantings of grasses, which may negatively impact wildlife or biodiversity. Conversions of native or mixed grasslands to monocultures may result in further losses of wildlife habitat and biodiversity, as well as reduce carbon sequestration and should be avoided.
- Improve management of grassland and soil health in order to improve carbon sequestration. Many types of grassland are poorly managed and improved management could increase carbon sequestration and storage.

- Manage harvesting of grasslands in order to maintain plant health and species diversity and to maintain or increase carbon sequestration. In doing so, wildlife habitat and biodiversity is likely to be maximized.

- Manage the timing and extent of harvesting within grassland systems in order to maintain important wildlife habitat and biodiversity needs, especially during key periods of the year (providing adequate nesting habitat, thermal cover and refugia in winter, etc.).

- Manage invasive species, which may include harvest of invasive grasses, plants, shrubs, and trees, and incorporate this practice into grassland management plans.

- Support restoration of grassland systems that include forbs and legumes (that naturally provide nitrogen to soils) from a sustainability standpoint and incorporate this practice into grassland management plans.

- Conduct research on the impacts of prescribed fire on carbon sequestration in grasslands. Because carbon sequestration in grasslands is normally limited to carbon in the soil, losses of carbon from prescribed fire (which burns residual vegetation above the soil surface) used for managing grasslands are often assumed to be negligible, and in fact can increase plant vigor and health.

- Maintain and restore grassland connectivity and minimize fragmentation of existing grasslands landscapes.

Resources on Grasslands Carbon Storage and Sequestration

Barker, J.R. et al. 1995. Potential carbon benefits of the Conservation Reserve Program in the United States. Journal of Biogeography. 22: 743-751

Conant, R.T. (editor). 2010. Challenges and Opportunities for Carbon Sequestration in Grassland System – A Technical Report on Grassland Management and Climate Change Mitigation. Food and Agriculture Organization of the United Nations. http://www.fao.org/fileadmin/templates/agphome/documents/climate/AGPC_grassland_webversion_19.pdf

Fynn, A.J. et al. 2009. Soil carbon sequestration in U.S. rangelands: Issues paper for protocol development. Environmental Defense Fund, New York, NY, USA.

Jzaurralde, R.C. et al. 2006. Simulating soil C dynamics with EPIC: Model description and testing against long-term data. Ecol. Model. 192: 362–384.

Lewandrowski, J. et al. 2004. Economics of Sequestering Carbon in the U.S. Agricultural Sector, Technical Bulletin No. (TB1909) of USDA Economic Research Service. http://www.ers.usda.gov/Publications/tb1909/tb1909fm.pdf

Liebig, M.A. et al. 2010. Grazing Management Contributions to Net Global Warming Potential: A Long-Term Evaluation in the Northern Great Plains. J. Environ. Qual. 39(3):799-809.

Manomet Center for Conservation Sciences. 2010. Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources. Walker, T. (Ed.).

Contributors: Cardellichio, P., Colnes, A., Gunn, J., Kittler, B., Perschel, R., Recchia, C., Saah, D., and Walker, T. Natural Capital Initiative Report NCI-2010-03. Brunswick, Maine.

Peterjohn, B. G. and J.R. Sauer. 1999. Population status of North American grassland birds from the North American breeding bird survey. Studies in Avian Biology. 19:27–44.

Piñeiro, G. et al. 2009. Set-asides can be better climate investment than corn ethanol. Ecological Applications. 19:277–282.

Sauer, J. R. et al. 2008. The North American Breeding Bird Survey, Results and Analysis 1966–2007, version 5.15.2008. U.S. Geological Survey Pautxent Wildlife Research Center, Laurel, Maryland. http://www.mbr-pwrc.usgs.gov/bbs/

Schuman, G.E. et al. 1999. Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland. Ecological Applications.9: 65–71.

Soussana, J. et al. 2004. Carbon cycling and sequestration opportunities in temperate grasslands. 20(2): 219-230.

http://www.ingentaselect.com/rpsv/cgi-bin/cgi?ini=xref&body=linker&reqdoi=10.1079/SUM2003234

CONCLUDING REMARKS

For increased carbon sequestration and longer term storage to take place, improved management of land is required. As noted throughout this document, best practices for carbon storage/sequestration and best practices for wildlife management are not necessarily at odds with each other. In order to continuously store and capture carbon, landscape connectivity is required as it is for habitats and the wildlife that they support. Destruction of habitat through urban sprawl, the conversion of grasslands, the draining of wetlands, or other similar actions will not only release carbon stores, it will also reduce the ability of these habitats to provide valuable services including sustaining fish and wildlife populations. Increased habitat protection and restoration can increase carbon storage and sequestration and have multiple other social, economic, and environmental benefits. Smart growth policies provide social and economic benefits, while at the same time protecting and maintaining natural systems that can continue to store and sequester carbon in habitats that support fish and wildlife resources, which provide corresponding social, economic, and ecological benefits. Future policy should recognize the tie between healthy ecosystems and productive carbon storage/sequestration projects by requiring the use of diverse, preferably native species, in the restoration of existing communities, the protection of ecosystem services, and the maintenance of connectivity. The use of non-native or potentially invasive species must be regulated as it could encroach on native species and create imbalance within a habitat. This includes genetically-modified trees or plants that may spread across a landscape. Monocultures should also be used cautiously within diverse landscapes, as they lack the diversity required to sustain a variety of animals that help maintain a healthy ecosystem. Although the replacement of annual crops with perennial monocultures may provide carbon sequestration and water quality benefits, they will provide minimal benefits to wildlife and biodiversity and must be balanced accordingly.

At the same time, little is known of just how much carbon is stored in deep soils and how much additional carbon can be sequestered by certain landscapes. This information could be used to more efficiently manage resources for carbon storage and sequestration as well as wildlife conservation. Studies may also help us understand how native ecosystems protect existing carbon stores and how they can sequester additional carbon; which could provide further support for ecosystem conservation. State and federal programs, such as the Farm Bill, could use information on carbon stores and sequestration to adapt and ensure that improved practices are actually implemented. As carbon markets begin to be set up across the country and storage and sequestration projects are implemented, we must keep in mind that how we sequester carbon could also have an adverse effect on the fish and wildlife populations that we cherish. Sustainable methods must be applied.

This white paper was adopted at the AFWA Business meeting at the North American Wildlife and Natural Resources Conference on March 18, 2011 in Kansas City, MO.