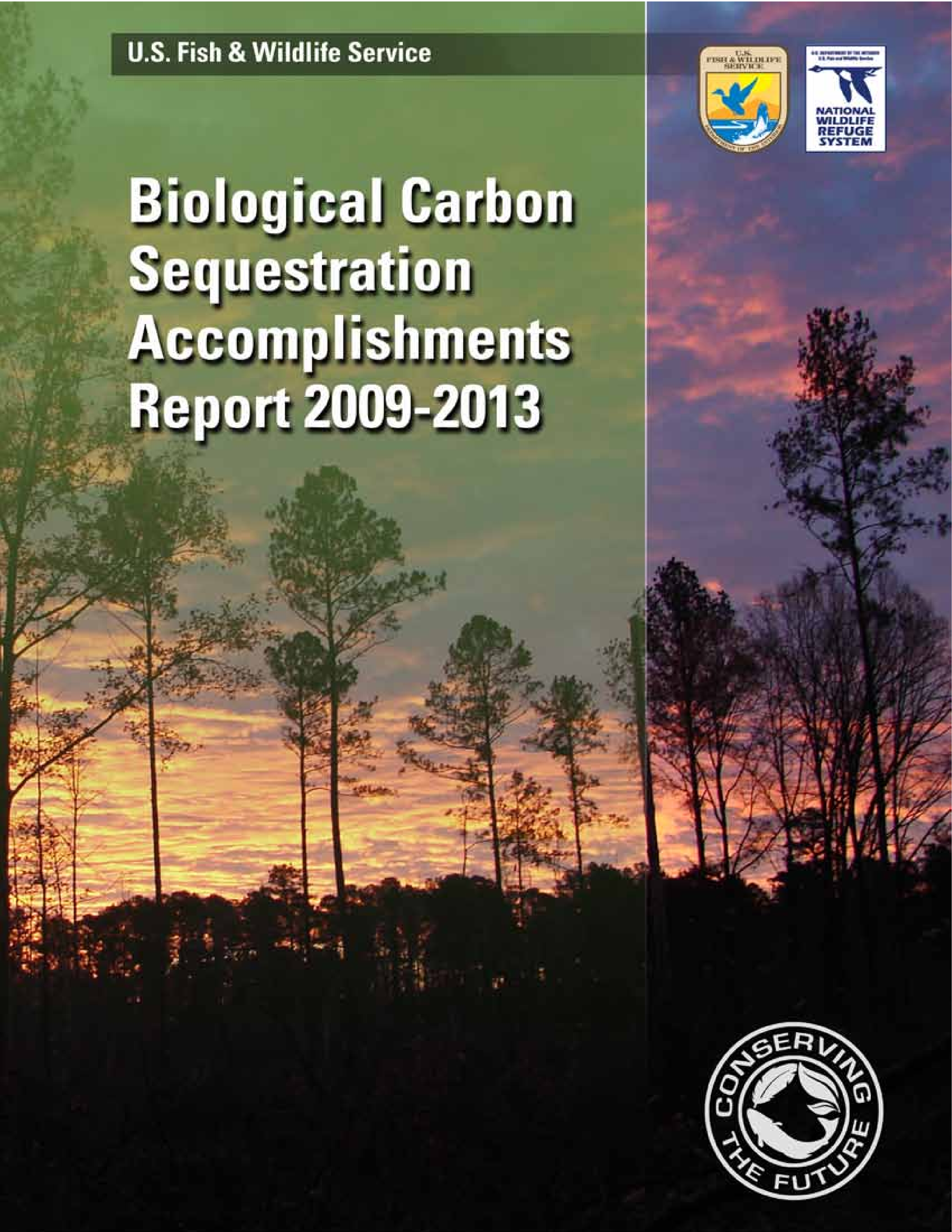
U.S. Fish & Wildlife Service

Biological Carbon Sequestration Accomplishments Report 2009-2013



NATIONAL WILDLIFE REFUGE SYSTEM

CONSERVING THE FUTURE

Biological Carbon Sequestration Accomplishments Report 2009-2013

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CONSERVING THE FUTURE

1. Introduction

Pete Jerome, Region 4 (retired)
Kurt Johnson, Science Applications

"Biological carbon sequestration (BCS) is the assimilation and storage of atmospheric carbon (in the form of carbon dioxide, CO_2) into vegetation, soils, woody products, and aquatic environments."

Biological carbon sequestration (BCS) is the assimilation and storage of atmospheric carbon (in the form of carbon dioxide, CO_2) into vegetation, soils, woody products, and aquatic environments[1]. The U.S. Fish and Wildlife Service (Service) recognized more than 15 years ago that BCS can be an important tool for wildlife habitat creation and restoration by capitalizing on the desire of governments and the private sector to mitigate (reduce) the concentration of greenhouse gases (GHGs) in the atmosphere. The Service has been actively involved in BCS management and research since the 1990s, starting first in the Southeast Region (Region 4) and expanding gradually to encompass all regions except Alaska.

The Service's involvement in BCS was initially directed toward the use of carbon credits and voluntary carbon markets to acquire land and restore habitats in Region 4. Early in the effort more than 40 corporations invested in the program, driven primarily by the desire to offset carbon emissions in anticipation of national climate change legislation that would provide incentives for companies to support ecosystem restoration partnerships that would result in quantifiable BCS benefits. These public/private sector partnerships, coupled with the Service's implementation of strategic habitat conservation, have attracted investment that has already led to considerable land acquisition and reforestation in the Lower Mississippi River Valley.

To date, the vast majority of Service BCS projects have occurred on lands within the National Wildlife Refuge System (Refuge System), which has served as the proving ground for testing the feasibility of using carbon credits and markets to foster habitat restoration and creation. There is now wide recognition that BCS conservation programs, if they are to make a true difference in GHG mitigation, will need to include all public lands as well as private lands.

The State of California, through association with the Climate Action Reserve (CAR), has developed an operational cap-and-trade and compliance carbon offsets program that is starting to provide incentives for BCS projects nationwide. The

Pocosin Lakes National Wildlife Refuge

Service has been working closely with CAR to help them develop carbon offset project protocols for several ecosystems such as forest, grasslands, wetlands and peatlands that will ensure projects have economic value through carbonoffsets while helping restore natural ecosystem functions. Active refuge-based research on carbon sequestration capabilities of various habitat types will help with protocol development.

In this report we present a compendium of BCS management and research activities on Refuge System lands and waters from 2009-2013 in order to illustrate the breadth of Service-supported BCS activities that are helping create and restore habitat while also mitigating GHGs.

[1] Definition from United States Geological Survey.

2. Land Acquisition and Habitat Restoration

"These restored forests act as a natural carbon sink while also providing key habitats for important wildlife species."

Reforestation - Planting trees after recent removal, for example a timber harvest.

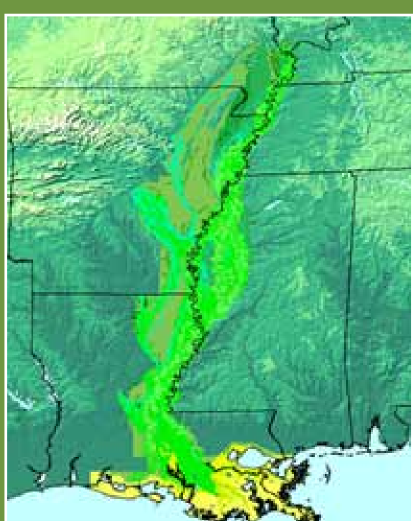
Aforestation - Planting trees on land which has never, or within recent past been a forest

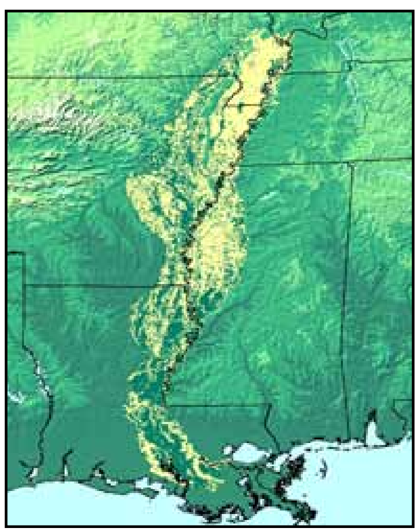
2.1 Bottomland Hardwoods

Ken Clough, Region 4 (USFWS)

Introduction

Decades of clearing for agriculture have reduced and fragmented the once expansive forests of the Lower Mississippi River Valley (LMRV). Today, the LMRV supports less than one quarter of its original 25 million acres of bottomland hardwood forest. Public and private partners are now working together to help protect and restore these lands through reforestation and afforestation on refuges in the LMRV. These restored forests act as a natural carbon sink while also providing key habitats for important wildlife species.





Forest cover in the Lower Mississippi River Valley (light green) pre-settlement (left) and 1992 (right).

Projects and Partnerships

Since 1998, the Service has participated in BCS land acquisition and reforestation projects in the Southeast, with an emphasis on the LMRV. Early projects involved reforestation of bottomland hardwood forests in the LMRV on agricultural lands owned by the Service. These early projects on refuge lands led to BCS projects involving the acquisition and reforestation of private lands within refuge acquisition boundaries. In these projects, private lands were reforested then donated or sold to the Service to be managed as part of the Refuge System. This type of BCS project involves partnerships among the Service, a nongovernmental organization (NGO) and a carbon partner, or carbon investor such as a private utility company. The carbon partner finances all or part of the land acquisition, restoration and long-term management of the project lands.

There are two types of carbon partners: (1) businesses or industries that invest in the carbon projects in order to obtain the rights to report the carbon credits or carbon offsets (compliance carbon market); and (2) businesses or individuals who invest in the carbon project to offset their own carbon footprint (voluntary carbon market). Subsequent conveyance of those lands to the Service to be managed as part of the Refuge System is accompanied by a transfer of funds to the Service for management. Each BCS project is governed by a Memorandum of Agreement (MOA) among the partners outlining each party's roles and responsibilities. In addition to project-specific MOA's, The Conservation Fund (TCF) and the Service are parties to a National Memorandum of Understanding (MOU) to work together on carbon offset projects on refuge lands through TCF's Go Zero® program. The Go Zero® program allows individuals and corporations to estimate their CO_2 emissions and then offset those emissions by planting trees. In partnership with the Service, TCF uses donations from Go Zero® to acquire and reforest lands within refuge acquisition boundaries and later donate or sell those lands to the Service for long-term management.

Biological Carbon Sequestration in Restored Forests

Healthy new forests are effective at naturally removing CO_2 from the atmosphere and storing the carbon in forest biomass. Environmental benefits of forest-based BCS sequestration projects include:

- Increased greenhouse gas mitigation
- Improved water quality
- Reduced soil erosion
- Connected forest fragments and wildlife corridors
- Restored critical habitat for threatened and endangered species
- Enhanced biodiversity
- Augmented floodwater storage
- Expanded public recreation opportunities.

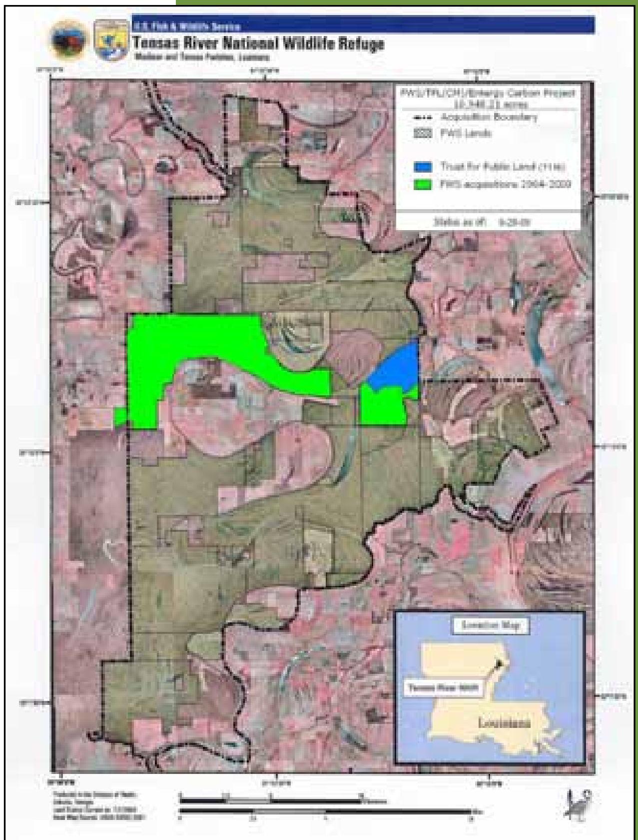
"Healthy new forests are effective at naturally removing CO_2 from the atmosphere and storing the carbon in forest biomass."

Case Studies

Tensas River National Wildlife Refuge, Louisiana (Region 4)

prepared by Region 4 and The Trust for Public Land staff

In 2003, the Service partnered with the The Trust for Public Land (TPL) on a multi-year BCS project to acquire and reforest approximately 11,000 acres at Tensas River National Wildlife Refuge (NWR). Farmed since the mid-1940s, the property encompasses a large area between two



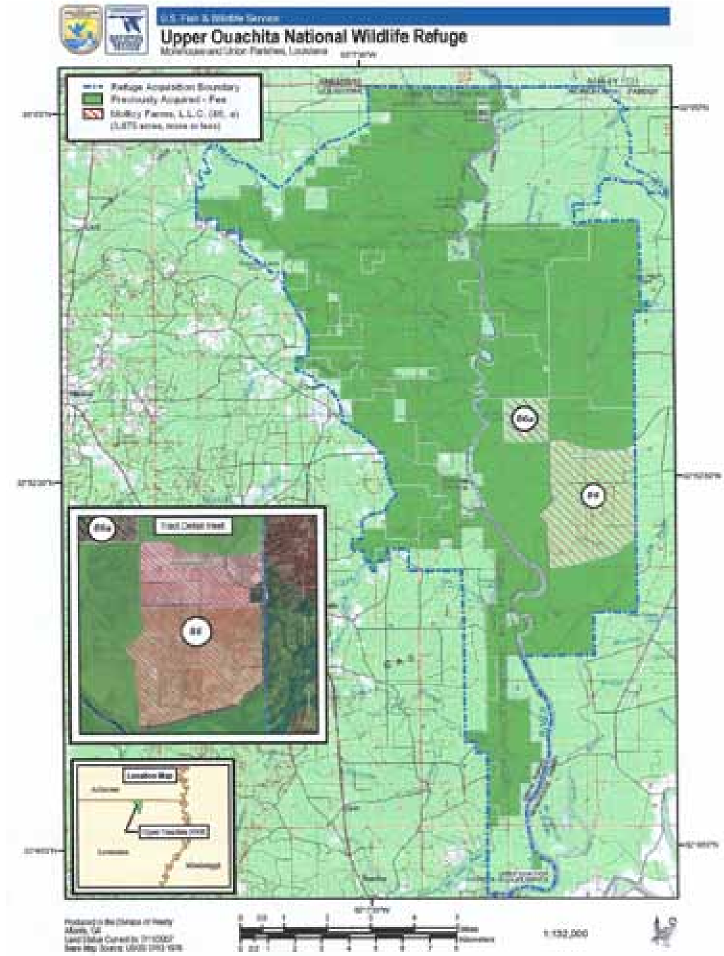
separate refuge units. As of 2012, thanks to the partnership with TPL and multiple corporate partners, the Service had acquired all but 1,200 acres of the property.

Now managed as part of the Refuge System, the acquired lands have been reforested. The final 1,200 acres, when acquired, will be reforested but will not include a BCS component. When the final acreage is acquired by the Service, the coordinated efforts of all partners involved will have added 11,000 acres of fish and wildlife habitat to the refuge. Acquisition and restoration of this property have reconnected the refuge units. As the restored forest matures, the resource benefits on all refuge lands will be enhanced further by the creation of a single forested block of more than 75,000 acres.

Upper Ouachita NWR, Louisiana (Region 4)

prepared by Region 4 and TCF staff

In 2010, the Service partnered with TCF on a multi-year carbon project to acquire 3,900 acres at Upper Ouachita NWR. The property lies adjacent to 13,000 acres of refuge lands within an approximately 30,000-acre flood zone along the Ouachita River. Viewed from the air, these 3,900 acres of agricultural land form a "hole in the doughnut" surrounded by forested or restored refuge lands. Through TCF's Go Zero® program, part of this property was restored to forest (refuge goals called for leaving part of the property to develop as open-water habitat). In order to complete the forest restoration project, additional restoration took place on lands already owned by the refuge; a total of 785,000 native oak, pecan and hickory trees were planted across 2,600 acres. A natural river levee break in 2010 flooded the entire area and provided a reminder of the multiple benefits realized by these forest restoration projects.

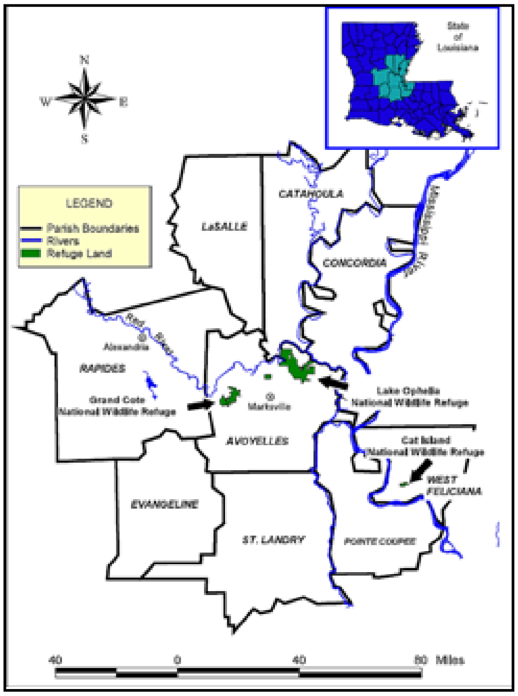


Lake Ophelia and Grand Cote NWRs, Louisiana (Region 4)

prepared by Region 4 and TCF staff

Grand Cote NWR and Lake Ophelia NWR near Marksville, Louisiana were once part of the vast bottomland hardwood forest characterizing the LMRV. The refuges and surrounding lands were cleared for agriculture in the 1960s and 1970s, leaving a highly fragmented forest landscape that was not conducive to the survival of many forest-dwelling species once found on or near the refuges.

Supported by donations from TCF's Go Zero® program, 245,000 oak, pecan and cypress trees were planted across 814 acres at Grand Cote and Lake Ophelia NWRs. The newly restored forests provide vital habitat for the federally threatened Louisiana black bear, as well as many bird species. Migratory waterfowl, songbirds and shorebirds all use the forested, moist soil and open-water wetland habitats



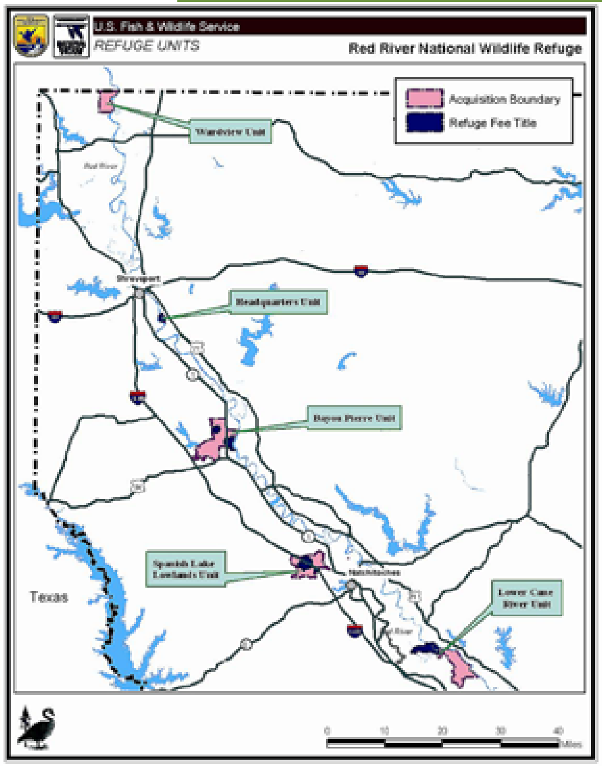
for nesting and foraging. According to planting and carbon monitoring partner, TerraCarbon, LLC, as the forests mature, they are expected to trap an estimated 240,000 metric tons of CO_2 from the atmosphere. In December 2010, the Lake Ophelia and Grand Cote NWR sites were validated by SCS Global Services at the Gold Level under the standards of the Climate, Community and Biodiversity Alliance (CCBA)[2].

[2] The Climate, Community & Biodiversity (CCB) Standards were created to foster the development and marketing of projects that deliver credible and significant climate, community and biodiversity benefits in an integrated, sustainable manner. Projects that meet the Standards adopt best practices to deliver net positive benefits for climate change mitigation, for local communities and for biodiversity.

Red River NWR, Louisiana (Region 4)

prepared by TCF staff

Originating in the Texas Panhandle, the two forks of the Red River merge at the Texas-Oklahoma border and flow 1,360 miles into Louisiana, draining into the Mississippi River and eventually the Gulf of Mexico. By the time the river reaches Natchitoches Parish in Louisiana, the damp and soggy riparian soils support cypress sloughs and hickory trees. Yet, today there are fewer trees flanking those banks than ever before—millions of trees fewer. Decades of conversion from forest to marginal farmland, and the myriad flood control measures that followed, resulted in a region that currently supports fewer than five million acres of bottomland hardwood forest.



TCF, supported by donations from its Go Zero® program and in partnership with the Service, bought and restored approximately 1,170 acres of marginal farmland within the boundary of Red River NWR. TCF restored the entire acreage to its native bottomland hardwood forest habitat and conveyed the restored acreage to the Service as an addition to the Red River NWR for permanent protection and long-term stewardship. TCF received Gold Level validation of the Red River NWR project against the standards of the CCBA.

Bottomland Oaks at Mingo NWR

"Although much of the native tallgrass prairie was cleared for agriculture, native habitats still occur in bottomland hardwood forests, tallgrass prairie, and gravel beds harboring freshwater mussels."

-Marais des Cygnes

Mingo NWR, Missouri (Region 3)

prepared by TCF staff

When settlers first came to Missouri's Bootheel region, lush bottomland hardwood forests, including giant cypress and tupelo trees, blanketed the southeastern corner of the state. Throughout the 20th century, the forests were cut for lumber; by the 1930s, most of the land was cleared and the swamplands were drained.

TCF, in partnership with the Service, and supported by donations from Go Zero®, restored 367 acres of walnut, hickory, oak and cypress trees at Mingo NWR near Puxico, Missouri. As the forest matures, it is expected to trap an estimated 100,000 metric tons of CO_2 from the atmosphere.

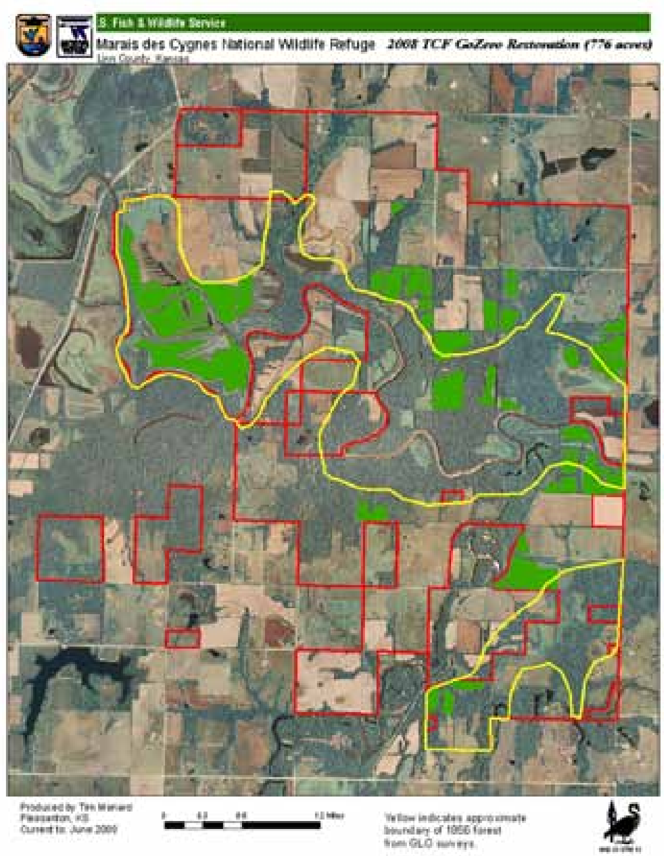
For its efforts, TCF's forest-based carbon sequestration project in southeastern Missouri received Gold Level validation, the highest level available, under the standards of the CCBA.

2.2 Riparian Forests

Marais des Cygnes NWR, Kansas (Region 6)

prepared by Tim Menard, Region 6

The Marais des Cygnes NWR in Kansas consists of 7,350 acres of wetlands, riparian forests, tallgrass prairie, and agricultural lands. Established in 1992, the refuge is owned in fee title by the Service as part of the Refuge System. Prior to refuge establishment,



Reforestation at Marais des Cygnes NWR.

significant alterations occurred to vegetation and hydrology. Although much of the native tallgrass prairie was cleared for agriculture, native habitats still occur in bottomland hardwood forests, tallgrass prairie, and gravel beds harboring freshwater mussels. Within the context of the watershed, Marais des Cygnes NWR contributes two unique biological communities – bottomland hardwoods and freshwater mussels – and serves an important role as an anchor for biodiversity including 31 species of freshwater mussels and the federally-threatened Mead's milkweed.

Former agricultural fields provide sites for restoration of forests and tallgrass prairie, and the creation of moist soil impoundments, while above the floodplain there are opportunities for restoration of tallgrass prairie and shrublands. Given its location at the interface of tallgrass prairie and central hardwood forest, restoration of bottomland hardwoods and tallgrass prairie has emerged as a priority for the refuge.

In early 2008, TCF and Environmental Synergy Inc. worked with the Service to plant native seedlings across 35 non-contiguous parcels, consisting of 776 acres, within the refuge (the "Go Zero® Tracts") using donations from the TCF Go Zero® program. This restoration project will be managed by the refuge as forested habitat for wildlife, including waterfowl and neotropical migrant songbirds. Over their lifetime, these newly restored forests are expected to sequester thousands of tons of carbon dioxide equivalent from the atmosphere.

In addition to the benefits to biodiversity and climate, restoring lands to their native habitats will help stabilize the top soil and slow the rate of erosion, thereby reducing the sediment load into the Marais des Cygnes River. These restored lands will also provide new recreational areas for public enjoyment. The Marais des Cygnes NWR received CCBA Gold Level validation in July 2009.

"Former agricultural fields provide sites for restoration of forests and tallgrass prairie, and the creation of moist soil impoundments, while above the floodplain there are opportunities for restoration of tallgrass prairie and shrublands."

San Joaquin River NWR, California (Region 8)

prepared by Kurt Johnson, Science Applications based on information provided by Region 8

The San Joaquin River in California's Central Valley

provides a conveyance channel for massive floods that occur when the San Joaquin Valley's network of dams and bypasses is overwhelmed by unusual storms. Dos Rios Ranch and the adjacent San Joaquin River NWR (SJRNWR) stand as a landscape-scale model of a strategic and multi-benefit flood-control project. By repurposing the flood-prone lands behind the levees as high-quality floodplain habitat for threatened and endangered wildlife and transient floodwater storage basins during massive flood years, these projects find a good balance between two historically competing land uses.

Since 2002, River Partners, the Service, California's Department of Water Resources, and a host of other technical experts, engineers and conservation partners have designed and installed levee breaches, constructed wetland basins, developed elevated refugia for terrestrial species and restored vegetation patterns that safely convey floodwaters in a strategic way to optimize the flood protection benefits of the largest contiguous riparian habitat restoration initiative in California at the confluence of the San Joaquin River and its largest tributary. More than 2,000 acres have been put into restoration since 2002.

The most recent effort, completed in 2009-10, was River Partners restoration of approximately 53 acres of riparian habitat on the Buffington unit of the SJRNWR along the Stanislaus River. A detailed site evaluation examined soil texture, structure, stratification, and depth to water table, as well as past land use and current conditions. Based upon the site evaluation, five woody plant communities and a native herbaceous layer were planted on the project site. Work conducted by Winrock International indicates that the 53 acres will likely sequester about 15,000 tons of CO_2 over an 80 year period.

2.3 Thorn Scrub Woodlands

South Texas Refuge Complex, Texas (Region 2)

prepared by Bob Barry and Chris Hathcock, Region 2

Much of the lower Rio Grande Valley has been altered by agricultural and urban development, with more than 95% of the native vegetation impacted. Since the mid-1980s, the South Texas Refuge Complex (STRC) has been actively restoring Tamaulipan thornscrub habitat through a variety of methods such as direct seeding and planting seedling trees and shrubs. Working with partners such as the Valley Nature Center, Friends of the Wildlife Corridor, cooperating farmers, and grant funding from American Forests' Global ReLeaf program, the STRC planted more than 1.1 million seedlings on more than 1,640 acres in the five years through 2011. The Refuge Complex added 310,085 plants over 367 acres in 2012, and anticipated planting 216,539 seedlings over 361 acres in Fall 2013.

Based on an estimate of carbon sequestration rates for this type of vegetation, the seedlings planted in the five years prior to 2011 will have sequestered more than 91,000 tons of carbon by the time they reach 20 years of age and 128,000 tons by the time they reach age 40. The 2012 plantings will result in 20,500 tons of carbon sequestered in 20 years and 28,600 in 40 years.

La Casita East tract, Garciasville, Starr County, TX, five years post-planting. Photo: Bob Barry, USFWS

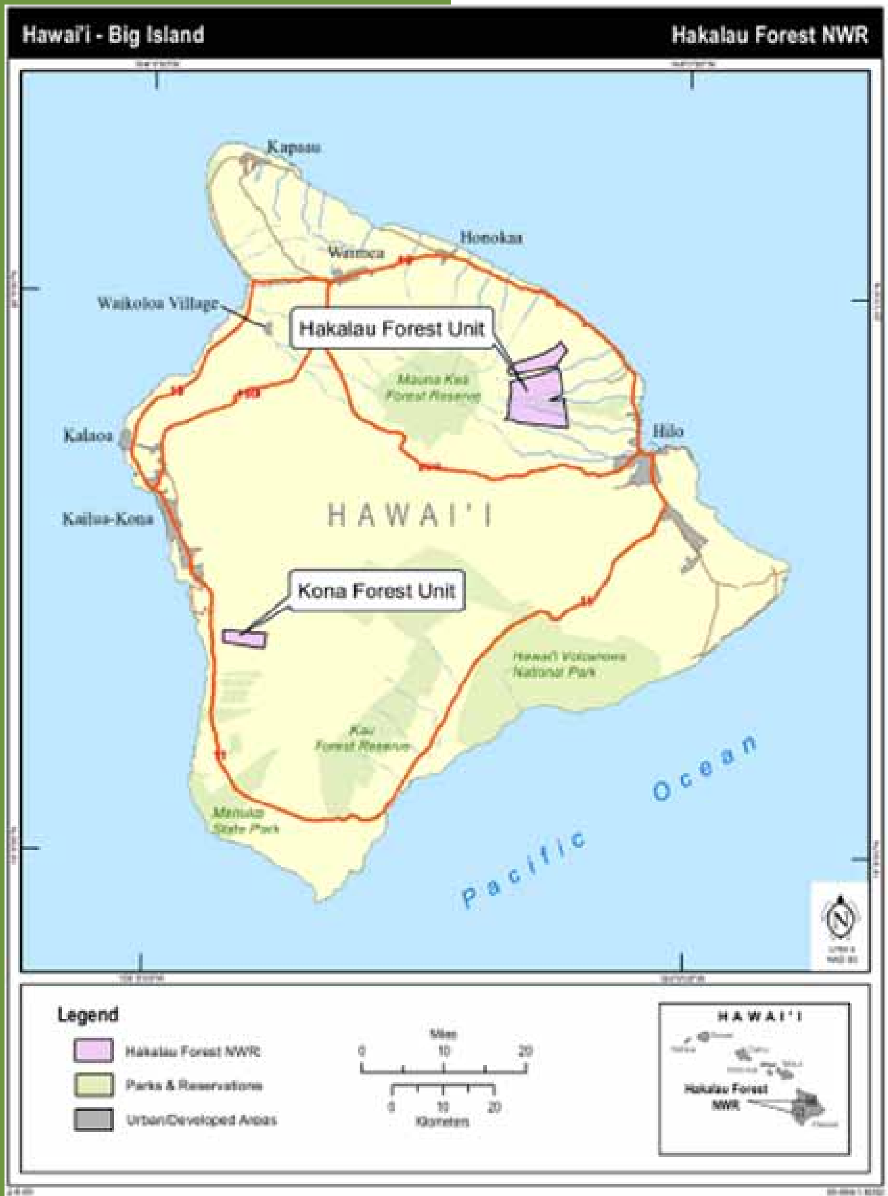
The STRC currently has approximately 7,000 acres of cropland to restore and continues to plant some 250,000 seedlings each year. As more sites are planted and existing sites mature, new trees and shrubs will grow and the amount of carbon removed from the atmosphere will increase. The STRC is conducting research on building a better model of carbon sequestration for this vegetation type. When the model is completed the STRC should be able to project the carbon sequestration rate of these restored lands with greater precision.

2.4 Hawaiian Koa Forest

Hakalau Forest NWR, Hawaii (Region 1)

prepared by Christian P. Giardina, Institute of Pacific Islands Forestry, USDA Forest Service

The Service acquired lands that comprise the Hakalau Forest National Wildlife Refuge (HFNWR) on the



Island of Hawaii in the 1980s. Located on the windward slope of Mauna Kea, the 32,733-acre refuge supports a significant diversity of native birds and plants. The HFNWR contains extensive areas of intact native montane rain forest, primarily below 5,000 feet of elevation, where rainfall can exceed 250 inches annually. Above 6,000 feet, rainfall decreases to 100 inches or less, and much of this area was converted to cattle pasture in the early 1900s. Today, these abandoned pasturelands are dominated by exotic grasses and problem weeds, such as gorse, which has led to an introduced fire cycle. These factors prevent the regeneration of native forest species.

For 22 years efforts have been underway to restore degraded pastures to native forest, with the goal of creating habitat for endangered wildlife. Management has included removal of feral pigs and cattle and planting of the endemic A. koa tree, an economically and ecologically important nitrogen-fixing tree species. Since 1987, 329,000 *A. koa* seedlings have been planted into corridors spanning ~1000 ft. elevation and 3°Farenheit. Trees are planted at a density of ~200 trees per acre. The Service is interested in converting these remaining 4,000 acres of degraded pasture to native dominated forest with both much higher conservation value and a much higher capacity to sequester atmospheric CO_2.

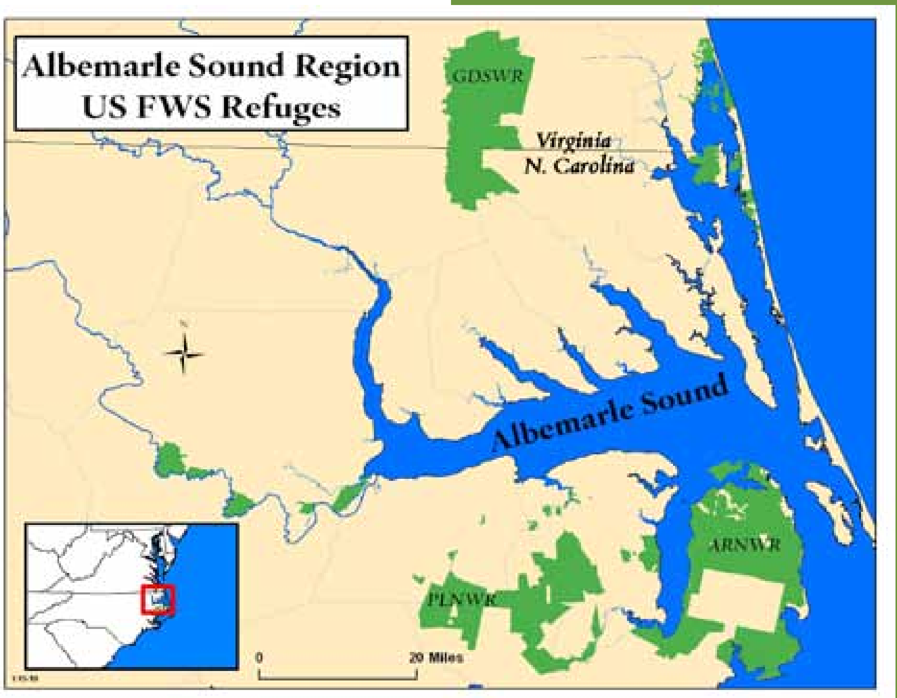
The Service's projection is that total carbon stocks in the project area will increase by 101 metric tons of carbon per hectare (ha) over 100 years. For the total project area, this change in carbon stocks translates into a net project carbon flow from the atmosphere into the 200 ha of native forest of 50,500 metric tons of carbon. This estimate would be spread over 110 years as the Service plans to plant 20 ha per year for 10 years.

2.5 Eastern Peatlands

Introduction

Sara Ward, Region 4

As highly concentrated sinks of carbon storage, peatland forests are gaining global recognition for their tremendous carbon sequestration potential. The 425,000 acres of refuge land in northeastern North Carolina and southeastern Virginia, comprised of Alligator River NWR, Pocosin Lakes NWR and Great Dismal Swamp NWR, represent the largest ownerships of peat-based forested wetlands in the eastern United States. The National Wildlife Refuge System and Ecological Services programs are collaborating with an array of stakeholders from various State and Federal agencies, universities, conservation organizations, and corporations to develop long-term management strategies that contribute to ecosystem resiliency and prevent degradation of carbon-rich peat deposits through hydrologic restoration and adaptation to sea level rise.



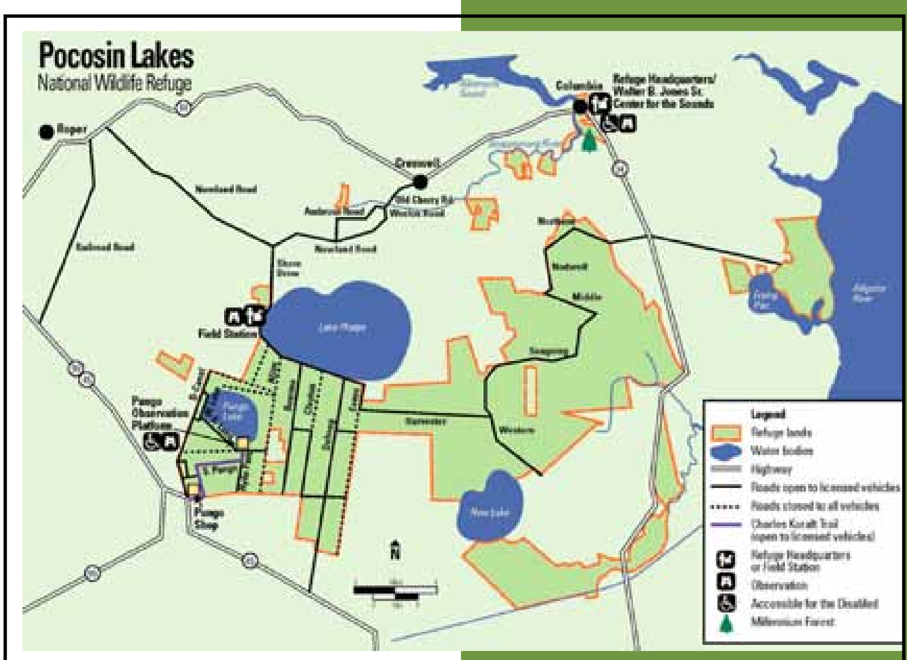
Case Studies

Pocosin Lakes NWR, North Carolina (Region 4)

prepared by Sara Ward, Region 4

Pocosins are unique wetlands characterized by a very dense growth of mostly broadleaf evergreen shrubs with scattered pond pine. The typically thick layer of peat soils underlying pocosins is a chemical sponge, locking-up metals, carbon, and nitrogen in vegetation and the deepening soil layer. Under normal conditions, these soils are saturated with water and decomposition is minimized due to a lack of oxygen, allowing for accumulation of organic carbon in peatlands.

As pocosins of the Albermarle Peninsula of North Carolina were drained for now defunct farming and peat mining



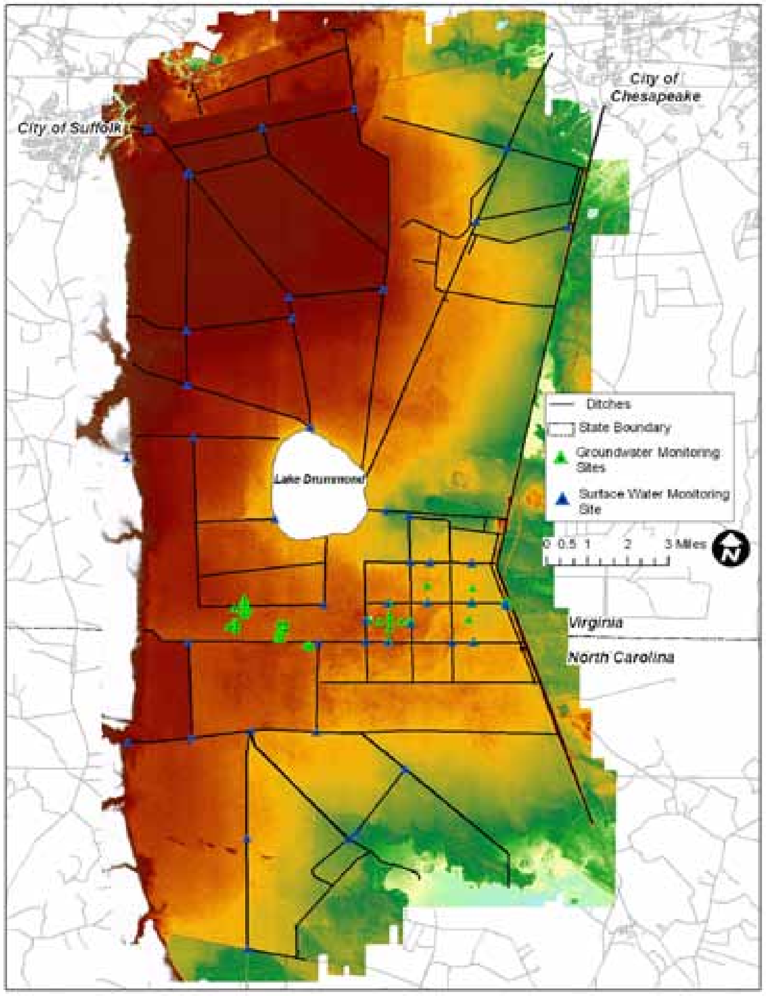
Hardwood removal to enhance pine-pocosin habitat for reintroduction of endangered red-cockaded woodpecker.

operations, their ability to retain carbon was diminished, resulting in releases of carbon to the atmosphere and adjacent waters. When these lands became part of Pocosin Lakes NWR in 1990, managers began restoring water levels. The refuge has restored nearly 20,000 acres of peatland by installing water control structures and raising roads (dikes) along canals, both of which raise water levels and promote sheet flow through water level management. The restored hydrology is expected to slow the loss of carbon from soil oxidation and create conditions suitable for peat accumulation, resulting in retention of an estimated 130 million pounds of carbon per year. Restoration of an additional 6,640 acres is planned and will render refuge and surrounding private lands more resilient to climate-driven stressors (such as large storms, catastrophic fire and droughts). When complete, improved water management capability over 30,000 acres will ultimately leverage additional restoration via private carbon-based financing on strategic parcels selected by stakeholders to enhance resiliency and provide wildlife retreat corridors to adapt to climate-driven habitat change. A study (click here to link) is underway to measure changes in carbon and nitrogen dynamics in response to restoration/water level management, which will document the carbon benefits of pocosin restoration. These data can be used in other peatland hydrology restoration efforts.

Great Dismal Swamp NWR, Virginia (Region 5)

prepared by Chris Lowie, Region 5

Great Dismal Swamp NWR has been installing water control structures and manipulating water levels in ditches since the refuge was established in 1974. Recent research has confirmed that maintaining higher water levels in ditches can indeed slow drainage and hold groundwater levels higher across the refuge, creating conditions more suitable for peat accumulation. In addition, the refuge is modeling groundwater flow to help verify and further understand the hydrology. The model will provide a management tool for evaluating the effects of different water levels in the ditches on the rates of groundwater flow, and can be used to evaluate effects of installing new water-control structures. Recent partnership projects secured funding to install five water control structures in 2012, and monitor the effects on water levels and changes in vegetative communities. The project is estimated to restore 10,000 acres of wetland habitat. Using the same carbon sequestration estimates of Pocosin Lakes NWR, approximately 97 million pounds of carbon can be sequestered per year.



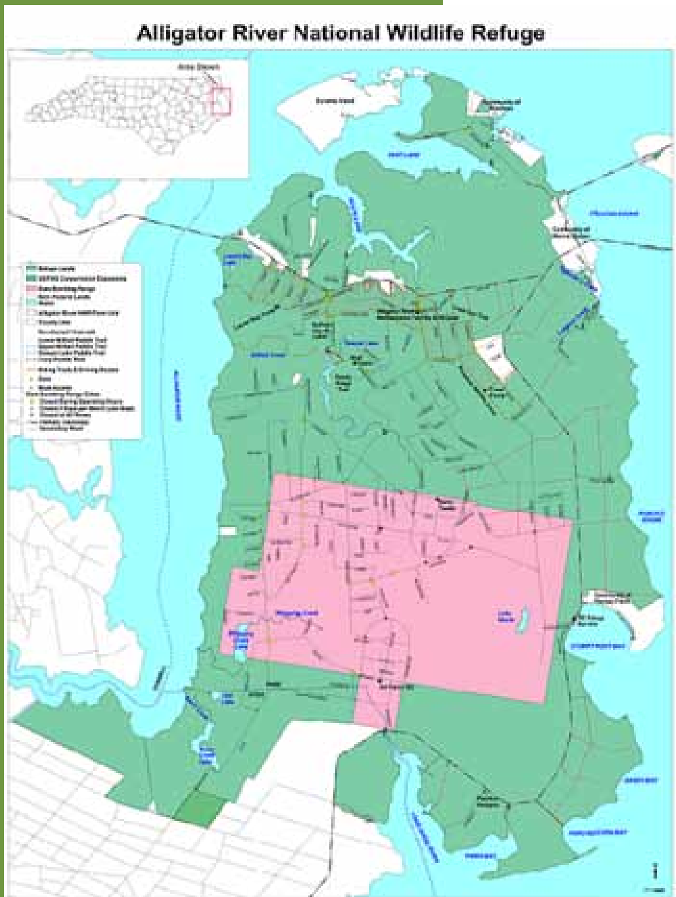
Great Dismal Swamp NWR

Water control structure at Great Dismal Swamp NWR.

Alligator River NWR, North Carolina (Region 4)

prepared by Sara Ward, Region 4

Alligator River NWR partnered with The Nature Conservancy (TNC) to evaluate and implement a range of strategies to increase the resiliency of refuge habitats to sea level rise impacts. Saltwater intrusion through the network of drainage ditches kills freshwater wetland vegetation and expedites the breakdown of peat soils, while intense wave action along the exposed



Oyster Reef at
Alligator River NWR.

estuarine shoreline erodes the brackish marsh buffer, leaving peatlands vulnerable. Strategies to address these impacts include: creating oyster reefs to reduce erosion along peat shorelines, filter water, sequester carbon and enhance aquatic habitat; installing water control structures to prevent salt water intrusion, slow drainage of freshwater wetlands and manage water levels; and, planting vegetation that is more tolerant of salt intrusion in areas likely to be inundated.

Monitoring and research will provide more detailed information regarding the carbon sequestration potential of the project. In addition, separate research is using several different methodologies to measure spatial and temporal variability of carbon and nitrogen within the refuge to help compare data across the landscape.

Peatland Summary

Sara Ward, Region 4

Restoring drained peatlands is proving to be a quantifiable approach to sequestering carbon. The refuge land in the Albemarle Sound watershed represents a nationally-significant peatland restoration and carbon sequestration opportunity for the Service and its partners.

Another significant benefit to peatland restoration is reducing the impacts of severe ground fires, which emit millions of metric tons of carbon with each incident. Recent wildfires at these refuges resulted in three to six feet of peat loss and an estimated 20 million metric tons of carbon released into the atmosphere. Restoring the hydrology can raise the water table and re-wet the peat, reducing the catastrophic peat loss during wildfires. Pocosin Lakes and Great Dismal Swamp NWRs are working to quantify peat and carbon loss from recent wildfires, which can provide better estimates of the acute effect wildfires have on GHG emissions.

3.0 Biological Carbon Sequestration Research

3.1 Tidal Marshes

Introduction

Sara Ward, Region 4

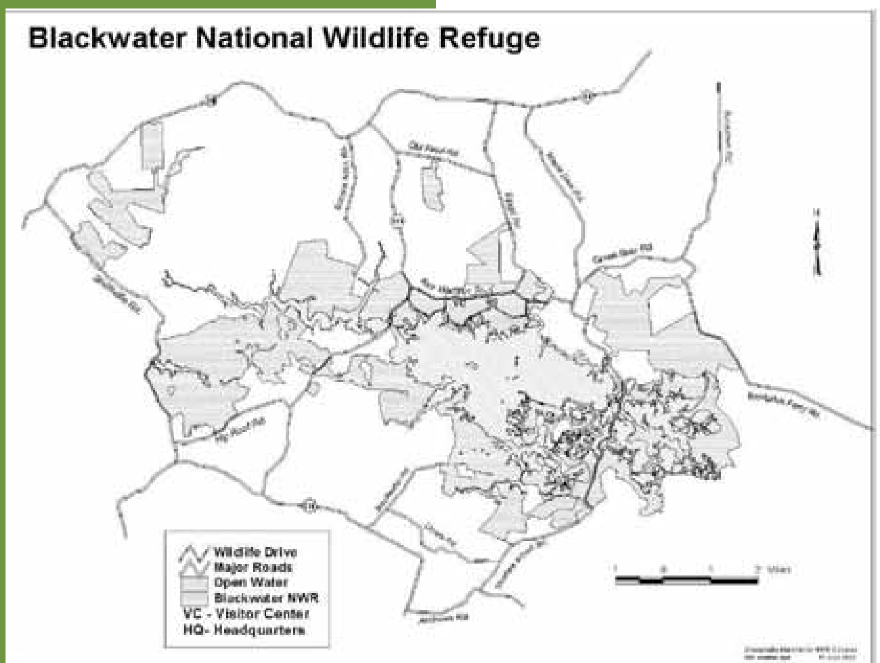
The restoration and avoided loss of tidal wetlands and coastal habitats offers significant potential for the sequestration of carbon, simultaneously restoring ecosystem health while reducing GHG emissions. Wetlands restoration and other management projects could be used as GHG offsets while meeting other ecosystem restoration and climate adaptation objectives. According to Restore America's Estuaries (REA), wetlands sequester carbon by not only supporting a standing biomass of plant material but, more importantly, by continuously burying a portion of this carbon within soils. Expansive areas of once existing wetlands have been drained, filled, and converted to other uses. Once 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-induced 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 CO_2.

Sifleet *et al.* (2011) provided carbon estimates for salt marsh habitats as follows: annual carbon sequestration ranges from 0.01 to 62.81 metric tons of CO_2 equivalent per hectare per year (n = 22); soil carbon stock range from 0.009 to 0.190 grams of carbon per cubic centimeter (n=126), though most estimates are found in the lower end of that range. Bridgham *et al.* (2006) estimate a loss of 0.4 million ha of North American salt marsh area over the last 200 years.

An important objective of the Refuge System is to protect and restore healthy coastal marsh habitats. In addition to providing positive climate benefits, tidal wetland conservation and restoration also improves water quality, provides important nursery habitat for fish and shellfish, and benefits human

"Remaining coastal wetlands are under threat from rising sea level and other human-induced impacts."

communities via flood and storm reduction attenuation. In low-elevation coastal areas, tidal wetland restoration also buffers important interior habitats from the impacts of sea level rise by promoting soil formation and solidifying shorelines from erosion.



"...the CH_4 emissions are offsetting approximately half of the carbon sequestration benefit at the two marsh islands."

Case Studies

Carbon Sequestration and Methane Emissions in Tidal Marshes at the Blackwater NWR, Maryland (Region 5)

prepared by Brian A. Needelman et al., University of Maryland, College Park

Since 2006 the University of Maryland has been conducting carbon sequestration research at Blackwater NWR in order to quantify and better understand carbon sequestration and methane (CH_4) emissions in restored and natural tidal marshes at the refuge. In order to test and develop restoration methods using dredged material, a tidal marsh restoration project was undertaken in 2003. Collaborating scientists are currently monitoring these sites for elevation changes and vegetation status.

The study is being conducted at one of the restored tidal marsh cells created in 2003 and one natural marsh cell. In 2006, 45 plots were established in each cell and feldspar marker horizons were laid down in order to estimate accretion rates. The plots are sampled annually for soil and vegetation data. Upon collection, soils are divided into horizons and analyzed for bulk density and carbon. In 2007 and 2008, CH_4 emissions were collected and flux rates were estimated at three sites per marsh cell in collaboration with P. Megonigal from the Smithsonian Environmental Research Center.

Carbon sequestration research at Blackwater NWR.

Researchers found that the marshes at the study sites are sequestering carbon at rates of 16.1 and 12.5 metric tons of CO_2 per hectare per year, which is within the normal range for brackish coastal marshes. Authors estimated that the annual daily average

CH_4 flux from these marshes were 94 and 90 milligrams of mg CH_4 per square meter per day for the natural and restored marsh cells. This converts to a carbon dioxide-equivalent flux of 7.2 and 6.9 metric tons of CO_2 per hectare per year. Therefore, the CH_4 emissions are offsetting approximately half of the carbon sequestration benefit at the two marsh islands.

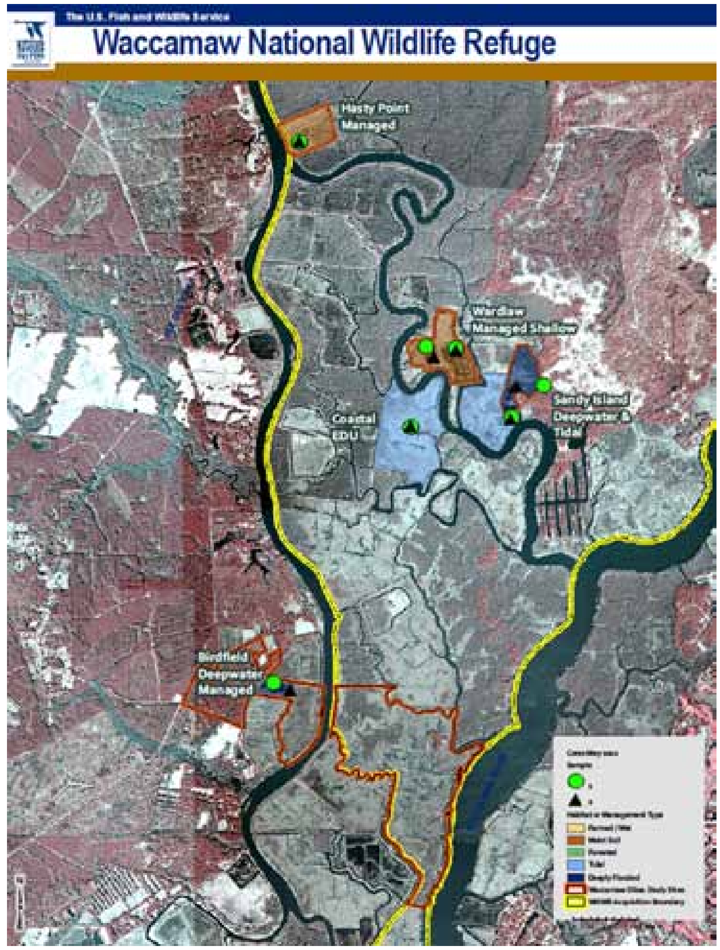
Two publications have resulted from the work thus far: Wills *et al.* (2008) and Poffenbarger *et al.* (2011).

Carbon Storage at Managed and Natural Marshes in and Adjacent to the Waccamaw NWR, South Carolina (Region 4)

prepared by Judith Z. Drexler, USGS California Water Science Center et al.

Although tidal freshwater marshes are known to have high rates of carbon sequestration, it is unknown whether impounded (managed) freshwater marshes store carbon at similar rates.

In order to address this question, carbon storage was compared between impounded and naturally tidal freshwater marshes in and adjacent to the Waccamaw NWR near Georgetown, South Carolina. Soil cores were collected in (1) naturally tidal, (2) moist soil (impounded, seasonally drained since ~1970), and (3) deeply flooded "treatments" (impounded, flooded to ~90 centimeters since ~2002). Cores were analyzed for percent organic carbon, percent total carbon, bulk density, and ^{210}Pb and ^{137}Cs for dating purposes. Carbon sequestration rates ranged from 25 – 200 grams of carbon per square meter per year (moist soil), 80 – 435 grams of carbon per square meter per year (naturally tidal), and 100 – 250 grams of carbon per square meter per year (deeply flooded).



The moist soil and naturally tidal treatments were compared over a period of 40 years. The naturally tidal treatment had significantly higher carbon storage (mean = 219 grams of carbon per square meter per year vs. mean = 91 grams of carbon per square meter per year) and four times the vertical accretion rate (mean = 0.84 centimeters per year vs. mean = 0.21 centimeters per year) of the moist soil treatment. The results strongly suggest that the long drainage period in moist soil management limits carbon storage over time.

Overall, the study revealed that managers across the Refuge System have an opportunity to increase carbon storage by minimizing drainage in impoundments as much as practicable. Further research on how small management changes can change carbon storage would be instrumental in increasing carbon sequestration rates at refuge wetlands.

Carbon Sequestration Potential of Natural and Managed Tidal Salt Marshes of the Northeast Coast (Region 5)

prepared by Susan C. Adamowicz, Region 5

Indiana University has undertaken a project whose overall goal is to develop a better understanding of biological carbon sequestration potential on refuge salt marshes and the effects certain management activities might have. Researchers want to identify human-induced stressors that impair marsh ecosystem services in order to take management action that puts Service assets in the best position to deal with climate change. This project was developed with an SSP grant in FY10 and funds from the Region 5 salt marsh LMRD (Land Management Research and Demonstration) program, and implemented with a Wildlife and Habitat grant awarded in FY11 and again supported by LMRD funds. Activities to date include:

- Collection of 60 cm-long peat cores from eight tidal salt marshes in the Service Region 5 (Rachel Carson NWR, Parker River NWR, Wertheim NWR, Forsythe NWR);

- Analysis of core sections for bulk density, organic C (carbon) and total N (nitrogen); and

- Conducting 50 and 100 year vertical accretion rates using ^{210}Pb gamma radiation analysis;

Future plans include calculating rates of carbon sequestration and comparing characteristics of managed versus "natural" salt marshes.

3.2 Peatlands

Carbon Cycling and Storage in Forested Wetlands of the Alligator River NWR, North Carolina (Region 4)

prepared by John King, Asko Noormets, and Jean-Christophe Domec, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh

The forested wetlands of the Alligator River NWR are extremely valuable for biodiversity as they comprise one of the last expansive tracts of unbroken habitat for black bears in the eastern U.S., and are the site of the successful reintroduction of the eastern red wolf. In addition, the complex terrestrial-aquatic interface of

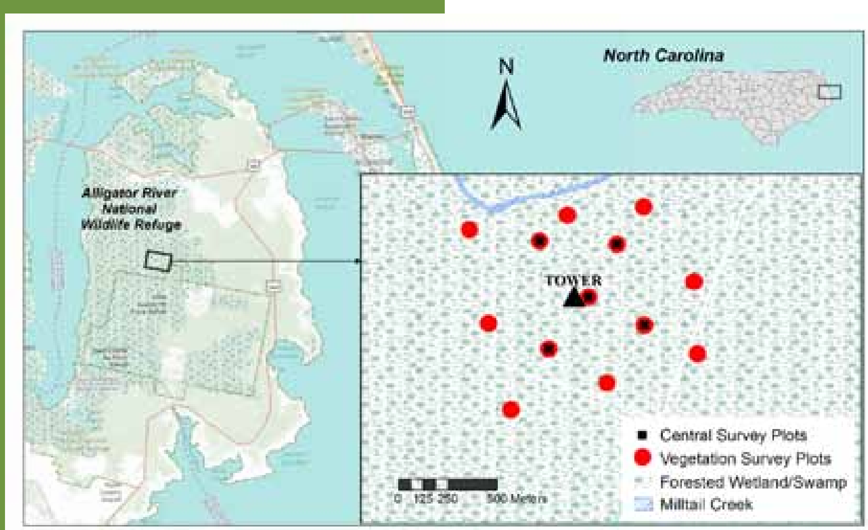


Figure 1. Location of the forest carbon cycling study at Alligator River National Wildlife Refuge in Dare County, NC. The study site consists of an eddy covariance tower to measure the land-atmoshere exchange of carbon, surrounded by thirteen plots to characterize carbon pools and fluxes in plant biomass and soils.

this refuge provides a nursery for commercially important marine fish and shellfish species and helps protect coastal communities from flooding due to storm surges associated with hurricanes and tropical storms. Finally, the deep organic soils and extensive forests of Alligator River NWR represent regionally significant stocks of stored carbon that are vulnerable to release to the atmosphere if the forests are disturbed by the rising sea, extreme storms, and forest fires. Accordingly, it is important to gain a better scientific understanding of the ecological, climatic, and land use controls of carbon accumulation and storage in these forests to guide the development of refuge management plans that will protect their ecological function and biodiversity in the face of a rapidly changing environment.

A detailed study of ecosystem carbon (C) storage pools and transfers (fluxes) was begun in 2009 to characterize mechanisms controlling the rate of soil and ecosystem carbon sequestration and loss (Figure 1). The immediate and cumulative influence of land use and management practices on the controls of ecosystem carbon pools is evaluated by comparing the C exchange rates to those at two instrumented loblolly pine plantations that have been cultivated for commercial timber production.

The study area was outfitted with a micrometeorological station and eddy covariance CO_2 profile system, followed by an automated soil respiration (SR) system (Figure 2). Tree sap flux systems were installed to estimate transpiration of

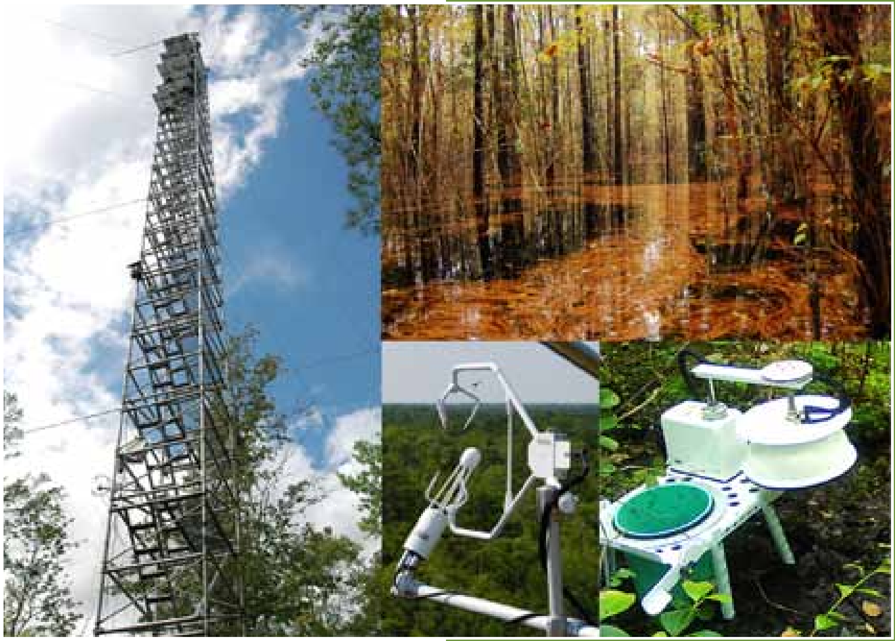


Figure 2. Advanced technology allows measurement of carbon moving into and out of the forest in air, soil and water

the five major over-story species (loblolly pine, red maple, red bay, swamp tupelo and bald cypress). Soil respiration measurements account for differences in micro-topography that have variation in flooding regimes and vegetation cover. Additional measurements include coarse woody debris biomass, coarse woody debris respiration, litter-fall, hemispheric analysis of canopy structure, litter decomposition, fine root production and carbon isotopic composition of soils and vegetation.

The ecosystem was a weak sink of CO_2 during 2009, accumulating about 56±35 grams of carbon per square meter per year, with gross ecosystem productivity of 1,453 grams of carbon per square meter per year and total ecosystem respiration of 1,396 grams of carbon per square meter per year, respectively. Gross ecosystem productivity peaked early in the growing season (May) and began to decline thereafter, whereas ecosystem respiration increased with temperature until late August, leading to near neutral carbon balance from July through December. The low net primary productivity was confirmed with biometric estimates of biomass increment. Soil respiration constituted about 30% of total ecosystem CO_2 efflux, estimated at 440±275 (mean ± SD, n=5 models) grams of carbon per square meter per year.

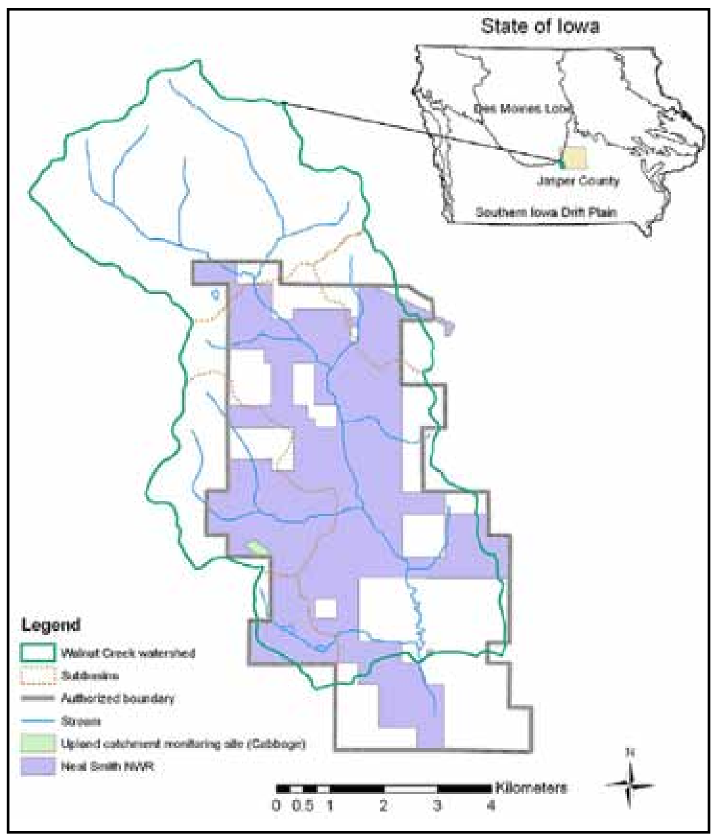
With strong in-kind support from the Alligator River NWR, significant progress has been made in characterizing carbon cycling responses of coastal forests to a rapidly changing climate and rising sea in the southeast U.S. Importantly, the natural forested wetland provides baseline data of ecosystem response at the land-ocean interface, which is among the most vulnerable physiographic regions due to its proximity to the ocean and intense pressure of economic development. Moving forward, we have begun to inventory the carbon stocks contained in the other predominant ecosystem types occurring on the refuge. Linking ground-based studies to remote sensing and GIS platforms will allow extrapolation of results to similar ecosystems across the region. The long-term data sets generated by this work will allow parameterization of ecosystem models to predict changes in ecosystem function before they occur, giving refuge managers a powerful decision support system to aid in the development of management plans that fulfill their mission to protect the nation's wildlife resources. Finally, linkage of the process-based ecosystem models to larger scale watershed and landscape scale models will assist in quantification of regional carbon balance as it is affected by changing climate, economic development, and changes in land use in the coming decades.

3.3 Prairies

Carbon Sequestration Research on Prairie Plantings on Neal Smith NWR, Iowa (Region 3)

prepared by Pauline Drobney, Region 3 and Cynthia Cambardella, USDA National Laboratory for Agriculture and the Environment

Scientists at Neal Smith NWR in south-central Iowa have been studying carbon sequestration on the prairie for more than 15 years. Carbon sequestration is the ability to contain, store or hold carbon through time. Living plants convert and store atmospheric carbon in their roots, stems, leaves, and wood. When a root, stem or leaf dies, microbes that live in the soil convert the plant carbon into soil carbon. In



undisturbed plant communities, the carbon remains sequestered in soil for thousands of years. Disturbing the plants and soil can release a large amount of that stored carbon to the atmosphere.

Most of the prairie's carbon sequestration happens below ground, where prairie roots can dig into the soil to depths up to 15 feet and

Soil Carbon Research at Neal Smith NWR

more. Prairies can store more carbon below ground than a forest can store above ground, according to Dr. Cynthia A. Cambardella, a research scientist with the U.S. Department of Agriculture's Agricultural Research Service National Laboratory for Agriculture and the Environment (USDA-ARS-NLAE). Dr. Cambardella leads a team of researchers from USDA-ARS-NLAE, Iowa State University, Iowa Department of Natural Resources Geological Survey Bureau, Grinnell College, and the Service. The team's research seeks to understand the carbon storage capabilities of reconstructed prairie on former cropland.

The team collected soil cores to a depth of 120 cm from each of 19 reconstructed prairies ranging in age from one to 17 years within the Neal Smith NWR in May of 2000, 2005, and 2010. Sampling locations were geo-located so the researchers could return to the same sampling locations every five years.

Tracts of cropped land have been restored to native prairie every year since 1992 at Neal Smith NWR, creating a sequence of landscapes defined by prairie age (chronosequence). The primary objective in 2000 was to use this chronosequence of prairie plantings to define the relationship between prairie age and the amount of carbon sequestered in prairie soil. The hypothesis was that soil carbon content would increase with prairie reconstruction age. A second hypothesis was that carbon change would occur more quickly at the soil surface than the deeper soil layers. This may be particularly evident in biologically-active forms of soil carbon, which is made up of fresh inputs of carbon from growing prairie plants. To test this theory, the team quantified biologically-active soil carbon for near-surface soils from the 2010 sampling. They found a consistent, positive relationship between prairie age and the amount of biologically-active carbon in the near-surface soil. Older prairies had more biologically-active carbon than younger prairies. The team also found that prairie age was not consistently related to the amount of total carbon stored in the soil at any depth, primarily due to high spatial variability in soil carbon content. Historical land management practices prior to prairie reconstruction contributed to this variability, limiting the ability to detect soil changes associated with contemporary land management practices.

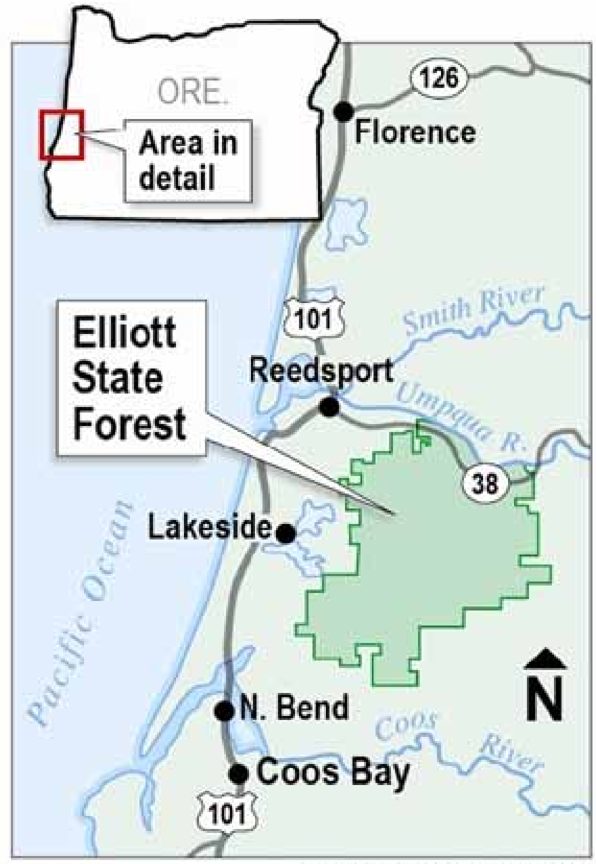
Publications resulting from this work include: Cambardella et al. (2004), Maher et al. (2004), and Tomer et al. (2010).

"The team also found that prairie age was not consistently related to the amount of total carbon stored in the soil at any depth, primarily due to high spatial variability in soil carbon content."

3.4 Western Conifer Forest

Carbon Analysis of Proposed Forest Management Regimes on the Elliott State Forest, Oregon (Region 1)

prepared by Kurt Johnson, Science Applications



Capital Press graphic

In 2010, the Service contracted with Ecotrust to provide a carbon analysis of proposed management regimes in the Elliott State Forest. These included specific management restrictions outlined in a Habitat Conservation Plan (HCP) proposed by the Oregon Department of Forestry (ODF) to meet Endangered Species Act (ESA) requirements and three different annual harvest volume targets. This is the first exercise of its kind to analyze the carbon sequestration effects of management options on state managed forestlands.

The Elliott State Forest (ESF) covers 93,282 acres of Oregon's coastal forest south of the Umpqua River. Located in Douglas and Coos Counties, it extends from within six miles of the ocean to the crest of the coast range. The ESF is comprised of a mix of native species, with a predominance of conifers such as Douglas fir, western hemlock, and Sitka spruce. Age classes reflect management categories, with approximately half the acreage managed as even-aged stands on shorter rotations, and the other half managed for older-stand structure.

Working closely with Service and ODF staff, Ecotrust utilized the latest forest inventory data from the ESF to model carbon sequestration potential of the proposed HCP-associated management prescriptions and three different annual harvest volumes: 30, 35, and 40 million board feet. In addition, three data sets were evaluated for comparison: a maximum storage scenario, in which all ESF lands are managed for maximum standing forest biomass; a minimum storage scenario, in which all ESF lands are managed for timber production, while meeting the legal requirements of both the Oregon Forest Practices

Act and the ESA; and a regional average provided by U.S. Forest Service inventory data.

3.5 Emissions from Fires

Mike Broughton, Branch of Air Quality (USFWS/HQ)

The Service's Branch of Fire Management contracted with Sonoma Technology, Inc. (STI) to conduct an inventory of GHGs emitted from all wildland fires that occurred on Service lands in federal FY 2006-2010. Analysis of the results was conducted by Mike Broughton, Smoke Management Specialist, Branch of Air Quality.

Estimated GHG emissions (CO_2 and CH_4) were modeled for each fire during the five-year period. The BlueSky Framework, a suite of independent computer models, was used to determine the emissions. Inputs included areal size of each fire as well as detailed fuel loading and fuel moisture data. Once emissions of CO_2 and CH_4 were modeled for each fire, they were then combined to obtain "CO_2 equivalent (CO_2e)," a more useful and globally-accepted quantity.

Significant study results

(see figures on page 27)

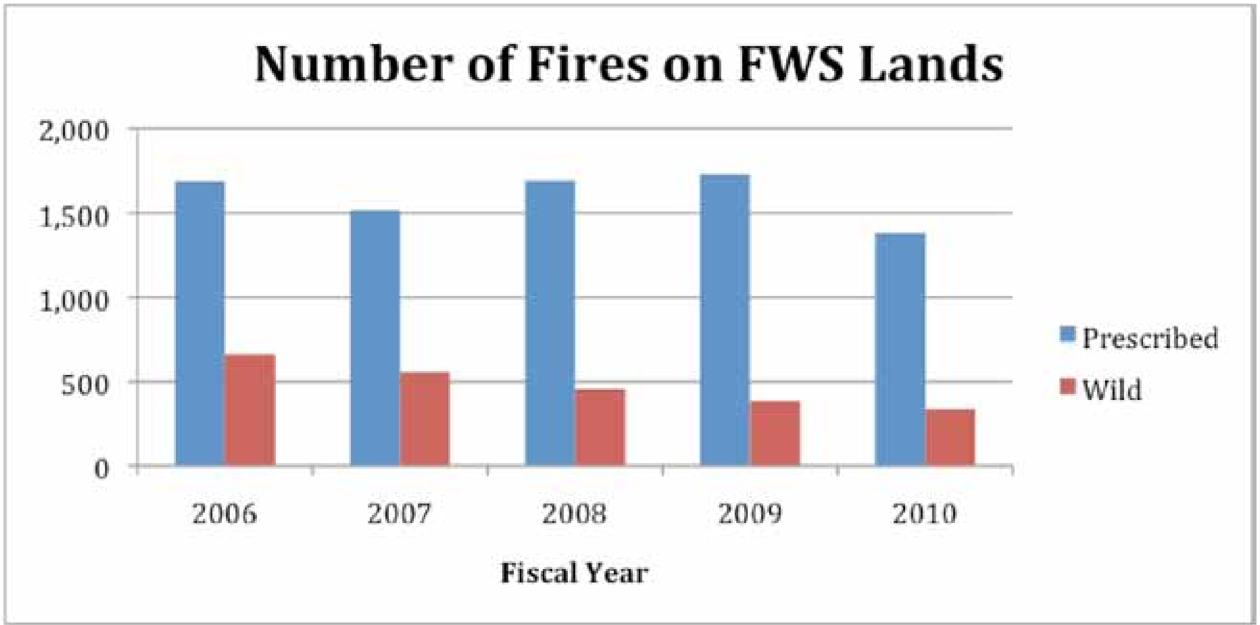
- Annual GHG emissions from wildland fires on Service lands averaged 39 million tons of CO_2e with great variation among the years, ranging from 15 million tons to 92 million tons.

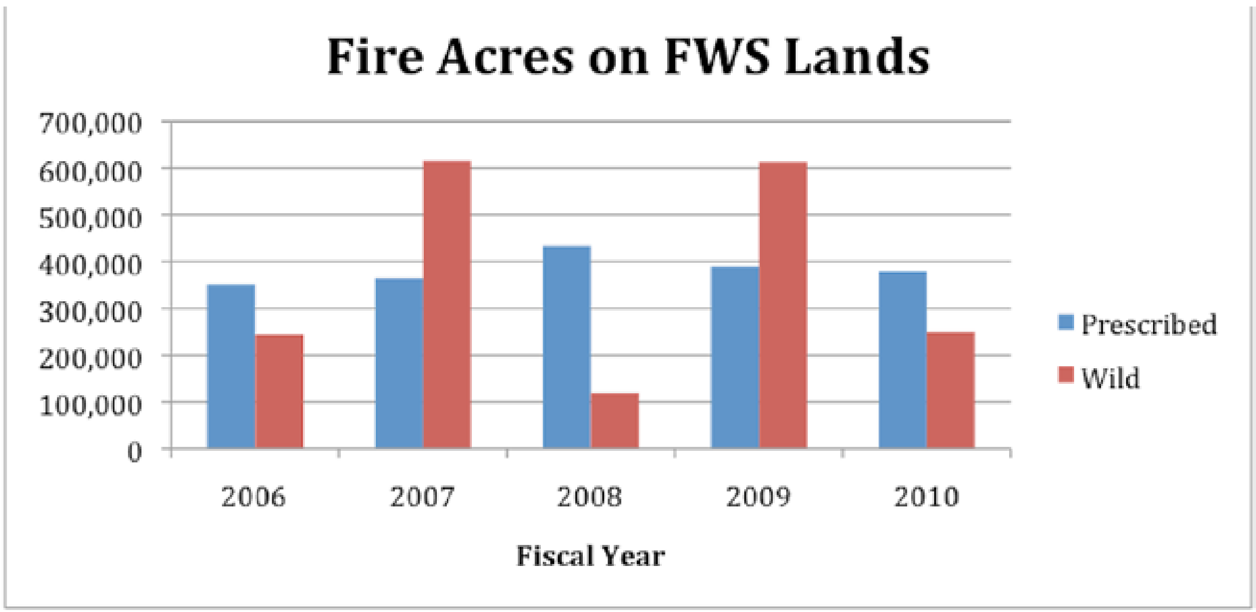
- While there were more than three times as many prescribed fires as wildfires on Service lands, acres burned from the wildfires were three times as high as those burned in prescribed fires. More significantly, average GHG emissions from wildfires were more than eight times greater than the GHG emissions from prescribed fires.

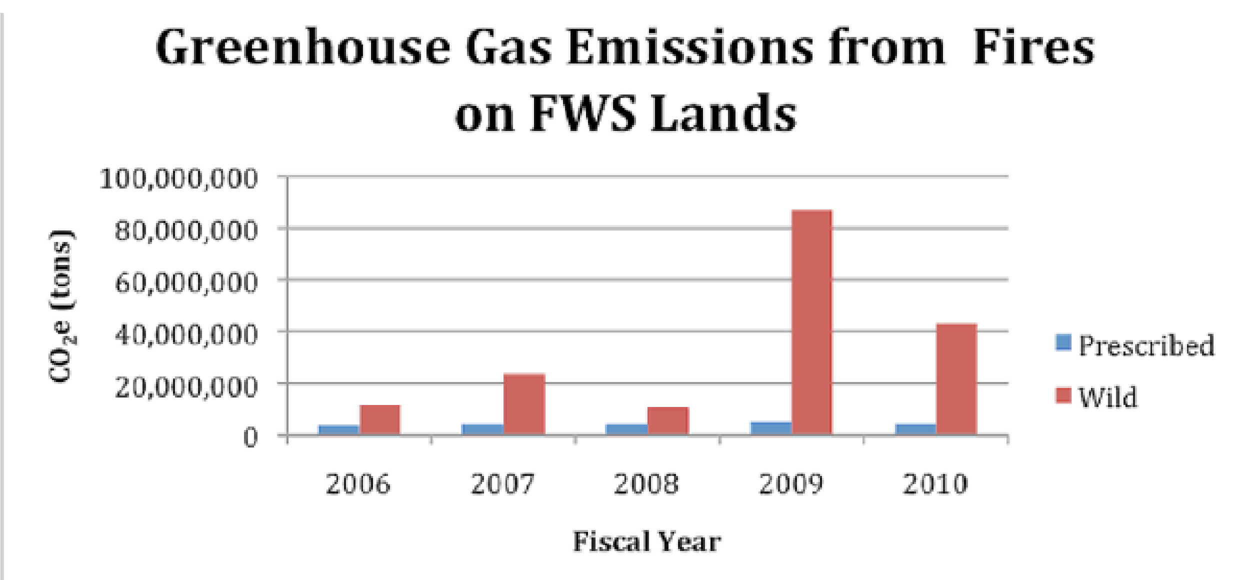
- The number of prescribed fires on Service lands was reasonably constant over the five-year study period, while the number of wildfires occurring varied dramatically. Similarly, the number of acres burned in prescribed fires also showed low variability, while acres burned in wildfires again showed high variability. Neither of these results is particularly surprising, however, since prescribed fires are planned and wildfires are, by definition, unplanned.

- Assuming that wildfires tend to be less severe and less intense in areas recently burned in prescribed fires, it is reasonable to assume that overall GHG emissions can be reduced significantly if prescribed fires can be increased.

It is important to note that currently accepted emissions factors for surface fires do not handle ground fires well. Ground fires are those that burn below ground, as in peat and other organic soils. To estimate GHG emissions from these types of fires, the depth of the burn and the organic content of the soil must be known to determine the amount of carbon lost, from which the emissions can then be estimated. In one of the few situations where this information has been collected extensively (Evans Road Fire, North Carolina 2008), it was found that the estimated GHG emissions were higher by a factor of 35 when compared to emissions estimates using accepted calculation factors (22 million tons vs. 650,000 tons). When these emissions are taken into account, they exceeded the GHG emissions from all other Service fires in that year, which totaled approximately 15 million tons. Additional studies are planned for similar fires (Pains Bay Fire - Alligator River NWR 2011; Dismal Swamp Fire – Great Dismal Swamp NWR 2011; and the Bugaboo Scrub Fire in 2007 and Honey Prairie Complex in 2012, both in the Okeefenokee Swamp NWR).


Number of Fires on FWS Lands
2,000
1,500
1,000
500
0
2006
2007
2008
2009
2010
Fiscal Year
Prescribed
Wild


Fire Acres on FWS Lands
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
2006
2007
2008
2009
2010
Fiscal Year
Prescribed
Wild


Greenhouse Gas Emissions from Fires on FWS Lands
CO_2e (tons)
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
2006
2007
2008
2009
2010
Fiscal Year
Prescribed
Wild

4.0 Recent Initiatives

4.1 Collaboration with United States Geological Survey LandCarbon Activities

Kurt Johnson, Science Applications

One key component of the Service's mission is to protect, restore, and manage highly diverse lands that support a broad array of habitats and species. The Service recognizes the importance of considering carbon sequestration values in the protection and management of its lands, and is continually looking for data and tools to assist its land acquisition, management, and restoration practices. The USGS Biologic Carbon Sequestration Assessment (LandCarbon Project) has identified lands with high carbon sequestration capacity and the potential for future climate change, wildfire, land use change, and land management activities to modify that capacity. The Service can apply LandCarbon products such as specialized maps to identify lands where protection and restoration would yield benefits of increased biological carbon storage together with other management objectives. Use and promotion of carbon sequestration management techniques within the Service would provide land management leadership by demonstrating the link between protecting and increasing biological carbon storage and other land management objectives.

Service application of LandCarbon assessment products to conservation and restoration actions could significantly assist in identifying priority lands for acquisition and/or restoration, but will require decision support tools incorporating biological carbon sequestration considerations into resource planning strategies applicable in ecosystems across the United States. The goal of this project is to develop and test tools and guidelines that can be used to identify lands with the greatest current or potential carbon stocks and/or sequestration values for application in two key areas of Service interest: (1) Refuge System's land protection and acquisition activities, and (2) ecological restorations associated with Natural Resource Damage Assessment settlements and Partners for Fish and Wildlife restoration work. In both cases, LandCarbon results may be extremely useful in

"One key component of the Service's mission is to protect, restore, and manage highly diverse lands that support a broad array of habitats and species."

helping prioritize lands for acquisition and/or restoration.

4.2 Engagement with the Climate Action Reserve (CAR), California

Sara Ward, Region 4

Landscape level restoration can be advanced by seeking nontraditional funding sources such as carbon market investments. Although success has been had with bottomland hardwoods, peatlands are new to carbon investors and we have worked to address science, policy, and legal issues associated with these cutting edge projects. Accordingly, the Service is currently discussing opportunities to engage carbon markets in peatland restoration with the CAR. Recently, our engagement with CAR has focused on (1) mechanisms to advance crediting of carbon sequestration projects on federal lands and (2) development of peatlands carbon sequestration verification methods for validation and crediting purposes.

In June 2012, CAR released the final white paper, "Forest Offset Projects on Federal Lands", concerning eligibility of forest carbon projects on federal lands. The Service provided a response (August 22, 2012 Letter from Dan Ashe, Service Director, to Mr. Gary Gero, CAR President) to assure continued qualification of projects initiated in partnership with the Service for compliance credits on private lands per CAR standards and to advance a dialog about potential mechanisms to address CAR's crediting concerns on NWRs in the future. During our ongoing dialog with CAR, we have encouraged them to evaluate emerging protocols, such as those for tidal wetlands and peatlands, and have provided: (1) the technical basis for expanded focus on peatlands via a webinar to CAR staff highlighting collaborative landscape scale peatland rewetting efforts at Pocosin Lakes NWR; (2) technical input during the development of CAR's issue paper regarding crediting of peatland soil carbon, Peatlands Research Brief; and (3) participation in a CAR public workshop in February 2013 regarding potential peatland protocol development.

Recently, CAR committed to advancing a grassland carbon sequestration protocol and has expressed willingness to continue to discuss mechanisms to advance peatland carbon verification approaches, with particular interest in using a proposed Service pilot carbon verification project at an Albemarle-Pamlico Region NWR to address remaining science and policy issues of mutual interest.

4.3 Blue Carbon Efforts

Bret Wolfe, National Wildlife Refuge System and Kurt Johnson, Science Applications

Coastal blue carbon is the carbon captured by living coastal and marine organisms and stored in coastal ecosystems, most significantly healthy salt marshes, mangroves, and seagrass beds. These ecosystems play two important roles—carbon sequestration and carbon storage (the long-term confinement of carbon in plant materials or sediment). The Service has become increasingly active in recent efforts to encourage blue carbon conservation initiatives.

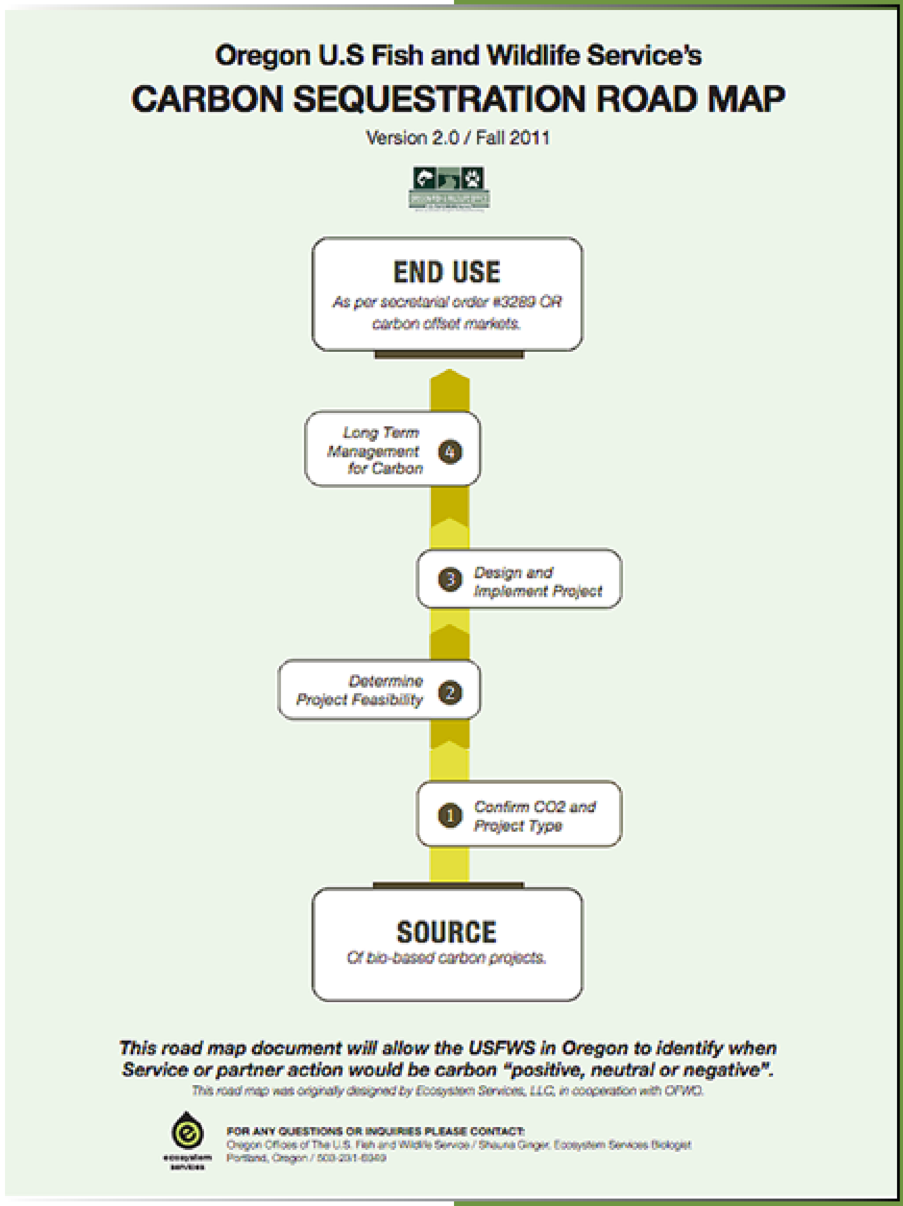
The Service is participating in the Interagency Working Group (IWG) on Coastal Blue Carbon being chaired by the National Oceanic and Atmospheric Administration. The Service has a strong nexus and overlap with this issue through coastal wetland conservation projects, terrestrial carbon sequestration through reforestation partnership projects, and the vast coastal wetlands protected within the Refuge System. The goals of the IWG are to improve understanding for assessing carbon services of coastal habitats, incorporate carbon services as part of federal agency policies and practices concerning coastal habitats, and increase awareness and consideration of coastal habitat carbon services within international policies and programs.

The Service has partnered with RAE to foster blue carbon conservation by providing funding to RAE to facilitate development of a protocol for tidal wetland GHG offsets. A protocol will provide the necessary guidance to calculate, report, and verify GHG emission reductions associated with offset projects. The Service also funded RAE to conduct a blue carbon workshop for state and federal agencies, tribes, non-profit organizations, and consulting firms in the Puget Sound region in February 2014. The workshop succeeded in substantially increasing local knowledge of blue carbon concepts and their potential application in the region.

4.4 Carbon Sequestration Road Map

Shauna Ginger, Region 1

The Service's Oregon Fish & Wildlife Office (Oregon FWO) has developed a rapid assessment tool for methods and techniques to enhance the use of carbon sequestration market and non-market opportunities through its programs and practices with partners (e.g., the Partners program, endangered species recovery, energy and ecosystems markets, etc.). This Carbon Sequestration Road Map is designed to enable Service staff in the Oregon FWO to identify and act upon biologically-based carbon sequestration opportunities in daily application of their authorities. It also serves as a tool for determining whether an agency or partner action will be carbon "Positive, Neutral or Negative" and if a partner can monetize its carbon sequestration opportunities. The guide starts from initial identification of a bio-based carbon project and continues through the various project stages. At each step it provides questions to ask and critical resources staff will need along the way. The document also includes estimated minimum acreage for projects throughout the various ecosystem types in the State of Oregon.



4.5 International Carbon Sequestration Efforts – REDD+

Brian Hayum,
Division of International Conservation

In FY 2010, the Service's Wildlife Without Borders – Great Apes Conservation Fund supported the Wildlife Conservation Society (WCS) efforts to advance REDD+ (Reducing Emissions from Deforestation and Forest Degradation) activities in the Nam Et-Phou Louey National Protected Area (NEPL) in northern Lao PDR. NEPL ranks high in the national protected area system and may contain one of the most important remaining populations of Northern White-cheeked Crested Gibbon *Nomascus leucogenys* in the country (Duckworth 2008). *N. leucogenys* is Red Listed as Critically Endangered (Bleisch et al. 2008) and Laos is believed to contain the largest remaining populations.

With Service support, the WCS conducted a feasibility assessment for a REDD+ project under the Verified Carbon Standard (VCS) in the NEPL. The assessment included analysis of the causes and rates of deforestation and forest degradation in the NEPL landscape; recommendations on appropriate methodologies, based on forest carbon project activities and carbon accounting methods being applied in Laos; and an analysis of emissions reductions that could be achieved. The approximate value of the reductions in CO_2 emissions was estimated based on available market prices and compared with the long-term management costs for the NEPL.

The analysis demonstrated that, due to low emission reduction potential and therefore low credit potential, a REDD+ project under the VCS in the NEPL is not financially feasible under current or anticipated carbon credit prices in the voluntary carbon market. Ten different scenarios were assessed, incorporating different areas of the NEPL to try and find a combination of size and emission reduction potential that would demonstrate financial feasibility. None of these scenarios proved to be financially feasible.

This case study illustrates a critically important issue for global conservation: efforts must be made to ensure that REDD+ enhances in situ conservation, particularly in protected areas. The low rates of deforestation in protected areas should be a strong incentive for carbon market investments, rather than a risk or an opportunity cost.

5.0 Conclusion

John Schmerfeld,
National Wildlife Refuge System, Region 9

The BCS accomplishments outlined in this report are astounding, given that a formal program does not exist within the Service, that there is no formal leadership structure, and there has been no congressionally-allocated funding that has been budgeted specifically for any of these activities. This fact is testament to the importance of the work documented here. Clearly, climate change is the most pressing conservation issue we, and future generations will face. It is, therefore, vitally important for the Service to continue to support and enhance efforts such as those highlighted here. The Service must continue to participate with its BCS partners in efforts such as these if the agency expects to remain relevant in national efforts that seek to mitigate our carbon footprint, attain carbon neutrality by 2020, and to design landscapes that are resilient, connected, and redundant.

"Clearly, climate change is the most pressing conservation issue we, and future generations will face."

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U.S. Fish and Wildlife Service
National Wildlife Refuge System

www.fws.gov/refuges

May 2014

Recommendation 2: *Develop a climate change implementation plan for the National Wildlife Refuge System that dovetails with other conservation partners' climate change action plans and specifically provides guidance for conducting vulnerability assessments of climate change impacts to refuge habitats and species as well as direction for innovation in the reduction of emissions and improved energy efficiency on federal lands.*