Plains CO_2 Reduction (PCOR) Partnership

Practical, Environmentally Sound CO_2 Sequestration

Best Management Practices for Terrestrial Carbon Sequestration on Private Lands in the Prairie Pothole Region

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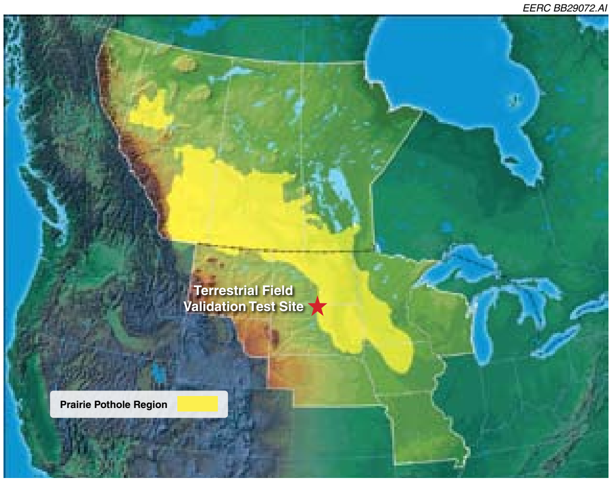

Figure 1. Prairie Pothole Region.

The diversity of landscapes and land uses in the Plains CO_2 Reduction (PCOR) Partnership region offers many opportunities for terrestrial carbon sequestration on private lands. Terrestrial sequestration involves the removal of CO_2 from the atmosphere via natural CO_2 sinks, such as plants and soils. To achieve maximum sequestration results, it is important that best management practices be implemented. The most effective management strategies focus on increasing sequestration rates and storage capacity (carbon inputs) and minimizing carbon loss from disturbances.[1] Successful management plans require shifting land uses from those with low or negative sequestering capabilities to those with large sequestering and storage capabilities (e.g., grassland protection and restoration, wetland restoration and enhancement, or afforestation), as shown in Table 1. However, a portfolio of more incremental management practices (e.g., conservation tillage) is available that, when aggregated over the hundreds of millions of private hectares in the PCOR Partnership region, has significant carbon-sequestering potential.

Ducks Unlimited, Inc.; the U.S. Geological Survey Northern Prairie Wildlife Research Center; and North Dakota State University, under the direction of the Energy & Environmental Research Center (EERC), are conducting ongoing research on the effects of various land management practices on carbon sequestration and storage in different wetland and grassland communities and cropland in the Prairie Pothole Region (PPR) (see Figure 1).

This fact sheet presents results from ongoing and past research conducted to examine the methods and benefits of terrestrial carbon sequestration that may be applicable to managed lands within the PPR. Managed lands in the PPR include those that are used for agriculture, grazing, forests, and wetlands. The PCOR Partnership is conducting a Terrestrial Field Validation Test to address data gaps that exist in carbon storage and greenhouse gas (GHG) emission estimates for native, restored, and cropped wetland catchments and native and restored grasslands in the PPR. Preliminary results from the field validation test will be available in 2008.

How Can Cropland Be Managed to Sequester Additional Carbon?

Croplands can be maintained as net carbon sinks by minimizing soil disturbances and improving the efficiency of soil water and nutrient use. An effective means to reduce soil disturbances on annual croplands is the adoption of conservation tillage, also known as no-till, partial-till, or mulch-till. Conservation tillage minimizes soil disturbance and provides a shield of crop residue that prevents loss of soil moisture and inhibits the breakdown of soil organic carbon (SOC).[2] When SOC breaks down, carbon dioxide (CO_2) is rereleased to the atmosphere. Conservation tillage is most effective when used in conjunction with crop rotation with no, or limited, fallow periods. Historically, seasonal fallow periods have been used to conserve water and mineral content for future crops. This is typically accomplished with the application of herbicides or repeated cultivation. The repeated

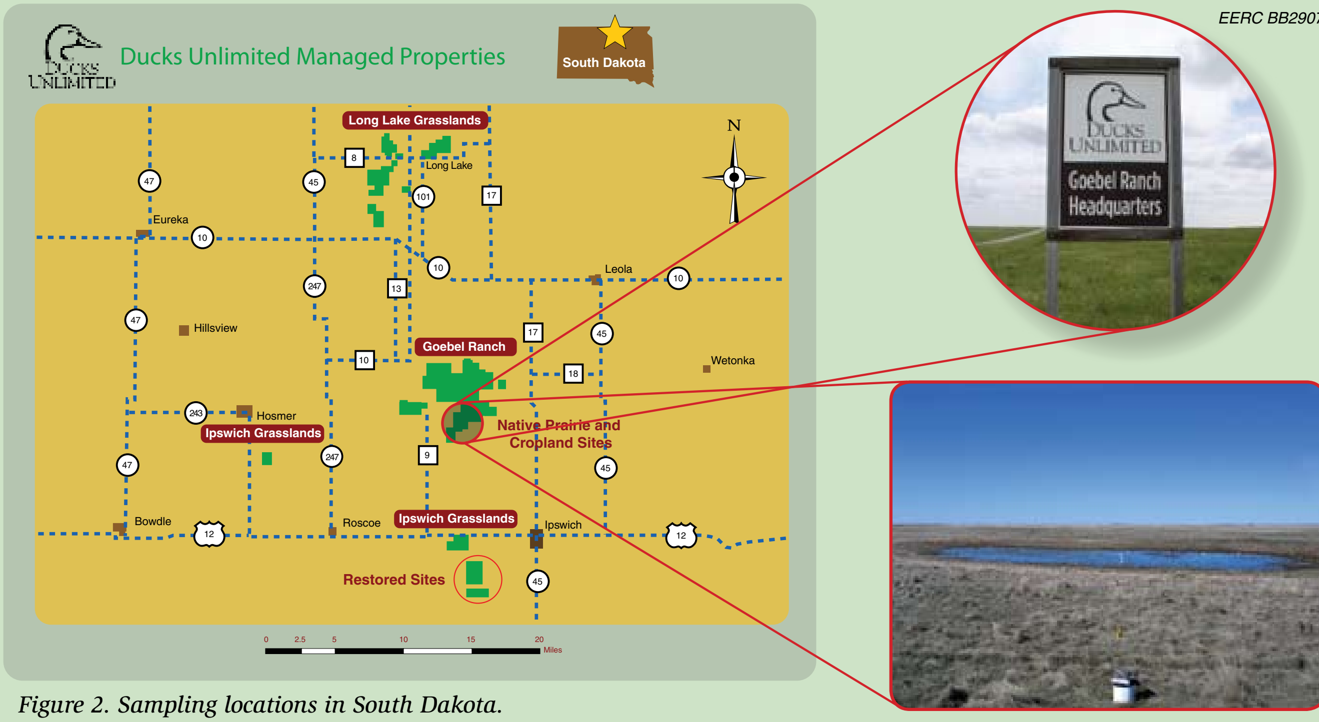

Figure 2. Sampling locations in South Dakota.

tillage of crop residue into the soil enhances the release of CO_2 into the atmosphere, thereby reducing the amount of carbon stored in the soil.[3] The desired soil quality benefits of a seasonal fallow period can be achieved by rotating crops and implementing conservation tillage practices, which will enhance the ability of the soil to store carbon.[4]

Do Different Crops Have Different Carbon Sequestration Capabilities?

Perennials, high-residue crops, and legumes have favorable carbon sequestration properties that can be utilized to enhance terrestrial sequestration on cultivated lands. Perennial grasses (switchgrass) and perennial forage legumes (alfalfa) are desirable sequestration crops since they can be harvested and regrown in multiple growing seasons without being replanted, avoiding the associated soil disturbances of annual cultivation. Also, the extensive root systems of perennials are well suited to store carbon since a relatively low proportion of the plant is lost to harvest. The roots also contribute to the addition of carbon into the soil, enhancing SOC.[1] Annual high-residue crops such as corn, sorghum, or wheat can enhance terrestrial sequestration as the organic matter left on the field after harvest is eventually incorporated into the soil as organic carbon.[5] The ability of legumes (annual or perennial) to regulate their nitrogen intake makes them highly efficient growers, maximizing plant productivity and carbon uptake while requiring fewer nitrogen-based fertilizer applications.

How Can Grazing Land Be Managed to Increase Soil Carbon?

The focus of any grazing land management plan is forage: the edible portion of plants that provide feed for grazing animals. Effective measures to increase carbon sequestration on grazing lands (rangeland and pastures) are those that increase forage availability. Forage production can be enhanced with additional but efficient applications of manure or the introduction of earthworms to the soil.[6] Planted pastures should be seeded as a mixture of perennial grasses and legumes (alfalfa) rather than as a single seed planting. A forage mixture better utilizes soil moisture and nutrients and is more resistant to insect and disease infestations.[7] When possible, grazing is preferable to mowing since more organic material (excreta and plant material) is returned to the soil.[8]

What Impact Does Grazing Have on Terrestrial Carbon Storage?

The most effective practices for terrestrial carbon storage on Great Plains rangelands include grazing management strategies that minimize the risk of soil erosion and stress on perennial grasses. While most Great Plains rangelands have reached their carbon saturation limit, meaning that they have sequestered all of the CO_2 that they can; they continue to be valuable carbon sinks. In fact, a 1% loss of SOC from the surface 10 cm of private U.S. rangelands equals the entire amount of carbon lost annually from all U.S. croplands due to tillage.[9] The most likely cause of carbon loss on rangelands is through soil erosion by overgrazing. Overgrazing causes a myriad of negative effects on the composition of plant communities, plant regrowth in current and subsequent growing seasons, ground canopy cover, and soil temperature. Damage to rangelands can be reduced by monitoring the frequency, duration, and intensity of grazing. Attempts to measure the impact of light grazing on soil carbon have yielded contradictory results and are likely codependent upon several factors, such as soil type, site management history, plant species, and climate.[8] For the mixed-grass prairies of the PCOR Partnership region, improved stocking rates and grazing management will likely increase SOC.[10]

How Can Carbon Sequestration Be Maximized on Afforested Lands?

A forest management plan that minimizes disturbance impacts (fire, pests, disease, or harvest) also increases carbon sequestration potential. Tree selection is an important initial consideration on afforested or reforested lands. The tree species most compatible with long-term carbon storage in the PCOR Partnership region are the slower-growing hardwoods such as ash, fir, or spruce.[11] The likelihood of maintaining robust forest stands can be greatly increased by selecting trees from good genetic stock or those that are genetically engineered. Harvest impacts (carbon loss) can be mitigated with selective thinning or respacing as part of a sustainable forest management plan. Selective harvesting can improve forest structure by removing excess debris, lowering fire risk, and reducing nutrient and light competition among remaining trees. A simple measure to increase forest carbon uptake is to extend harvest rotations, allowing trees more time to accumulate biomass.

Can Fertilizer Management Affect Carbon Sequestration?

Management practices that produce emissions of more potent GHGs such as methane (CH_4) and nitrous oxide (N_2O) have the potential to negate any GHG gains achieved in terrestrial carbon sequestration and storage. For example, judicious applications of fertilizer are sometimes promoted to enhance biomass growth in grassland, forest, and cropland ecosystems, although the net effect of this practice is poorly understood.[12] In situations where fertilizer use is unavoidable, such as in conservation tillage, applications can be managed to better match plant nutrient needs. Fertilizer management applications that match plant growth requirements can be achieved by timing applications to coincide with plant needs and in quantities sufficient to enhance plant growth without oversaturation of the soil.[5] This means that postharvest applications in the fall should be excluded. Further, manure or fertilizer applications injected into the soil have a better absorption rate and lower risk of volatilization than surface applications.

Summary

The land use and management practices evaluated by the PCOR Partnership are well established. However, the exact carbon benefit of these practices is dependent upon many factors (e.g., cropland and grassland issues, fertilizer management), many of which have not been studied in the PCOR Partnership region. To provide answers to many of these questions, research is currently being conducted at over 300 sites in the PCOR Partnership region (Figure 2), with preliminary results expected in late 2007. This best management practices fact sheet is considered a “living document” and will be updated as results are available from current and future efforts during Phase II of this project.

Table 1. Potential CO_2 Sequestration from Various Management Practices Found Throughout the Prairie Pothole Region

Activity	Sequestration MT CO_2/ha/year	Years of Sequestration until New Equilibrium Reached	Accumulation Potential MT/Hectare	Reference
Annual Conventional Tillage Wheat/Fallow	–3.40	–	–	3
Conservation Tillage (no-till) from Continuous Cropping	1.17	20	–	13
Improved Grazing Management	1.06	–	–	10
Grazing Land Management–Interseeding Legumes	1.21–5.71	–	–	10
Restore Grassland on Cultivated Lands	0.29–6.59	20	–	10
Wetland Restoration	10.98	–	36.60	14
Afforestation with Elm/Ash/Cottonwood	7.47	125	935.50	15
One-Time Loss from Conversion of Native Prairie to Cropland	–75.54	–	–	10
One-Time Loss of Conversion of Wetland to Cropland	–36.60	–	–	14
Average Annual U.S. Passenger Car Emissions (12,500 miles)	–5.19	–	–	16

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The Plains CO_2 Reduction (PCOR) Partnership is a group of public and private sector stakeholders working together to better understand the technical and economic feasibility of sequestering CO_2 emissions from stationary sources in the central interior of North America. The PCOR Partnership is managed by the Energy & Environmental Research Center (EERC) at the University of North Dakota and is one of seven regional partnerships under the U.S. Department of Energy's National Energy Technology Laboratory Regional Carbon Sequestration Partnership Initiative. To learn more, contact:

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