

FACT SHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Midwest Regional Carbon Sequestration Partnership (MRCSP)

NETL Cooperative Agreement DE-FC26-05NT42589

DOE/NETL Project Manager: Traci Rodosta,
Traci.Rodosta@NETL.DOE.GOV

Submitted by Battelle

November 2009



Terrestrial Sequestration Field Test: Croplands

Test Locations:

2006: Thirteen cropland plots within the MRCSP region, primarily Ohio, Indiana, and Michigan

2007: Eleven paired cropland fields across Ohio, Kentucky, and Pennsylvania.

2008: Five paired cropland fields across Michigan, Ohio, and Pennsylvania.

2009: Ten paired croplands fields across Michigan, Indiana, and Ohio.

Amount and Source of CO₂: Not applicable – this is a terrestrial field test to determine and validate rates of sequestration using different agricultural methods.

Field Test Partners: The Ohio State University
Ohio Corn Marketing Program
Ohio Soybean Council

Summary of Field Test Site and Operations:

Multiple test sites located within different Major Land Resource Areas (MLRA's) have been selected to collect soil samples from three predominant land uses, namely till, no till and woodlot (Figure 1). Soil samples were collected from five different depths (i.e., 0-5 cm, 5-10 cm, 10-30 cm, 30-50 cm, and >50 cm) in four replications 100 m apart. These samples were analyzed for total soil organic carbon (SOC) and total nitrogen concentrations (N) and various soil physical quality parameters, including soil moisture content, soil bulk density, aggregate size distribution and stability, plant available water, texture, shrinkage, soil compaction, and soil hydraulic properties. A complete range of

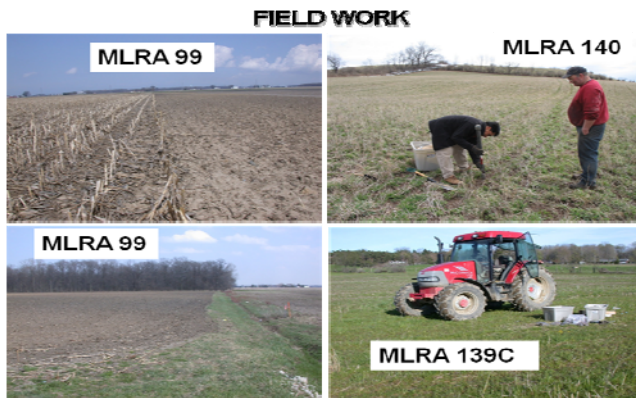


Figure 1. Field work on MLRA Sites

analysis and pedometrics are being conducted with the aim to predict soil carbon stock in relation to readily available data, such as land use (woodlot, no till, and conventional till), digital elevation model, soil reflectance, and weather data (temperature and precipitation) for the whole MRCSP region.

Research Objectives:

- Demonstrate terrestrial carbon (C) sink capacity for predominant land use systems.
- Develop a credible measuring, monitoring, and modeling protocol to evaluate C sink capacity in biota and soil at different scales.
- Determine how C sequestration from MRCSP activities could be incorporated into existing schemes of trading C credits.
- Assess mechanisms of C sequestration with regards to land use and soil management.
- Assess the soil-profile C distribution to determine C storage within the topsoil and subsoil, and relate it to soil components (particle and aggregate size fractions).
- Evaluate historic C loss and assess the old vs. new C in soil.
- Establish relationships between soil C and soil physical quality, and agronomic production.

field and laboratory studies have been conducted to assess the impact of soil C pool on soil quality and the attendant co-benefits (Figure 2).

Three sites based on different parent material: Glacial Till (Coshocton), Till plain (Delaware), and Glacial Lake Plain (Henry county) located in Ohio, were selected to assess the historic carbon loss by cultivation. An additional 144 soil samples and 24 plant residue samples were also collected for measuring additional soil physical properties. Geospatial



Figure 2. CN analyzer, for analyzing soil organic carbon and total nitrogen (left); Wet sieving apparatus for analyzing aggregate (right).

Summary of Modeling and MMV Efforts:

Measurement Technique	Measurement Parameters	Application	Reference
Dry combustion method (900°C) - CN analyzer (Vario Max, Elementar Americas)	Total Organic Carbon (%) and Total Nitrogen (%)	Measure soil organic carbon and nitrogen content in all samples.	Nelson and Sommers (1996)
Dry combustion and isotopic separation	Total carbon (%) and $\delta^{13}\text{C}$	Measure soil carbon and $\delta^{13}\text{C}$ as well as plan residue carbon and $\delta^{13}\text{C}$	Boutton (1991) and O'Leary (1993)
Core method	Bulk density	Determine the density of the bulk soil	Grossman and Reinsch (2002)
Static hand cone penetrometer (Eijkelkamp, Giesbeek, The Netherlands)	Cone index	Determine the resistance of the soil to cone penetration as a means to evaluate soil compaction	Lowery and Morrison (2002)
Crushing method	Tensile strength of aggregates	Determine the tensile strength of individual soil (5-8 mm, 2-5 mm, and <2 mm diameter) aggregates	Dexter and Watts (2001)
Clod method	Aggregate density	Determine the density of discrete (5-8 and 2-5 mm diameter) aggregates	Grossman and Reinsch (2002)
Tension table and pressure plate apparatus	Moisture retention of aggregates	Determine the capacity of aggregates (5-8 mm, 2-5 mm, and <2 mm diameter) to retain water	Dane and Hopmans (2002)
Wet-sieving method	Aggregate stability	Quantify the percentage and mean weight diameter of water-stable aggregates	Nimmo and Perkins (2002)
Hydrometer method	Soil texture	Determine the particle size distribution	Gee and Or (2002)

Accomplishments to Date:

The Phase II studies on terrestrial carbon sequestration in cropland have resulted in the following research findings:

- Residue retention as surface mulch is essential for soil carbon sequestration and soil quality improvement in no-till system.
- Rates of soil C sequestration, 250-1000 Kg C/ha/yr, depend on soil properties, crop rotations, residue management, soil fertility management, and the duration since conversion from plow tillage to no-till. Residual removal adversely impacts soil quality.
- Rather than assessment for the plow depth only, soil carbon pool in relation to land-use and management must be measured to 1-m or at least 0.5 m depth.
- Complete life cycle analysis of production system (i.e., no-till, plow tillage, manuring) must be conducted to assess management-induced changes in ecosystem carbon pool. The data on changes in ecosystem carbon pool are essential to developing an effective mechanism for trading carbon credits.

- Residence time of carbon sequestered in soil depends on soil properties (more for clayey than sandy soils), depth (longer for sub-soil than surface soil), land use (longer for perennials than annuals), and management. The soil carbon pool is maintained or enhanced as long as no-till system and other best management practices are used.
- Soil quality is improved with increase in soil organic carbon pool, and increase in agronomic productivity is attributed to improvement in use efficiency of inputs (fertilizers) and decrease in losses (e.g., runoff, erosion, mineralization).
- The soil carbon pool at regional scale can be reliably predicted by using GIS and terrain characteristics, and other modeling techniques. The upscaling of soil C pool is extremely useful in assessing carbon credits for trading purposes.

Peer reviewed publications:

- Blanco-Canqui, H. and Lal, R., 2008. No-tillage and soil-profile carbon sequestration: an on-farm assessment. *Soil Science Society of America Journal*, 72:693-701.
- Chatterjee, A., Lal, R., 2009. On farm assessment of tillage impact on soil carbon and associated soil quality parameters. *Soil Till. Res.* 104, 270-277.
- Christopher, S., Lal, R. and Mishra, U., 2009. Regional Study of No-Till Effects on Carbon Sequestration in the Midwestern United States. *Soil Science Society of America Journal*, 73(1): 207-216.
- Mishra, U., Lal, R., Slater, B., Calhoun, F., Liu, D. and Meirvenne, M. V., 2009. Predicting Soil Organic Carbon Stock Using Profile Depth Distribution Functions and Ordinary Kriging. *Soil Science Society of America Journal*, 73(2): 614-621.

Target Sink Storage Opportunities and Benefits to the Region:

- There is an estimated 10.7 million hectares of prime non-eroded cropland in the MRCSP region. It is estimated that 22.5% of that land area is already practicing no till and will likely remain in that mode. The remaining 77.5% or 8.3 million hectares is potentially amenable to adopting no till or reduced tillage practices, which, if adopted on these lands, would result in an estimated 55 to 74 million additional tons of carbon sequestered over a 20 year period for the MRCSP region. This is equivalent to 200 to 270 million metric tons of CO₂.
- Conversion of cropland to no till and reduced tillage practices also yields benefits of placing land use in more sustainable agricultural practice.
- When carbon markets become more fully developed, the stored carbon may be sold as a carbon dioxide offset, which will earn additional income for landowners. This Phase II research will lay valuable groundwork for helping to quantify the amount of carbon stored in soils typical of the MRCSP region.

Cost*:

Total Project Cost: \$26,320

DOE Share: \$20,033 (76%)

Non-Doe Share: \$6,287 (24%)

(*) Costs are for overall MRCSP Phase II project, reported in thousands.