MRCSP Phase II
Terrestrial carbon sequestration in the MRCSP region

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Objectives

I. Identify processes and quantify rate of carbon sequestration in minesoils, wetlands, and croplands.

II. Predict soil carbon stock in the MRCSP region under different landuses.

III. Quantify historic carbon loss and estimate C sink capacity.

IV. Relate C stock to soil quality.

V. Estimate the economic consequences of activities adopted to enhance carbon sequestration on all MRCSP region land uses.

C sequestration, reclaimed mine sites

Reclaimed Mine Site Descriptions

Site Name	Mylan Park	Skousen	Dent's Run	New Hill
Owner Name	Mon County School Board	Jeff Skousen		Patriot
Pre Mine Land use	Forest	Forest/pasture	Forest	Ag, pasture, and forest
Mining Began	1982	1996	1999 (June)	2003 (Spring)
Mining Ended	1990	1998 (January)	2000 (October)	2005(Fall)
Coal Seam	Waynesburg	Waynesburg	Waynesburg	Waynesburg
Method of Mining	Contour Mining, Front end loaders	Contour Mining, Front end loaders	Contour Mining, Front end loaders	Contour Mining, Front end loaders
Type of Overburden	70-80% Sandstone, rest is shale	~80% Sandstone, rest is shale	70-80% Sandstone, rest is shale	70-80% Sandstone, rest is shale
Reclamation Method	Backfilled, 3“[a] topsoil, grass and legumes	Backfilled, 8" topsoil, grass and legumes	Backfilled, 3"[a] topsoil, grass and legumes	Backfilled, 3"[a] topsoil, grass and legumes

[a] Original backfill was likely deeper, but measured backfill at sample sites was shallow.

Soil Sample Collection

- All 4 sites have been visited and samples collected between 1st week of June to 1st week of July 2006.
- Number of samples collected from each site:
  - Samples were collected along a diagonal transect for each terrain from two different depths: 0-6 cm and 6-12 cm.
  - **Mylan Park:** 60 points (locations)
    - a total of ~115 samples (for some there was only rocks for 6-12 cm depth)
    - ideally it should have been 120 samples for 60 locations
  - **New Hill**: ~110 samples
  - **Dent's Run**: ~120 samples
  - **Skousen**: ~60 samples (30 points, 2 for each depth)

Accomplishments

- Collected soil samples from four reclaimed mine sites.
  - A total of 405 soil samples have been collected from 205 sampling points at four locations.
- Estimated the Total Organic Matter (TOM) content from 153 soil samples from two separate reclaimed mine sites at two depths.
  - A total of 450 soil samples have been analyzed for TOM when all three replications from each sampling site are included.
- Estimated the Total Organic Carbon (TOC) content (%) from 153 soil samples from two separate reclaimed mine sites.
  - A total of 450 soil samples have been analyzed for TOC when all three replications from each sampling site are included.
- Estimated nitrate (NO_3) content of 24 soil samples from two depths
  - Total of 48 samples estimated when two of the three replications from each sampling site are included.
- Estimated the carbon value that would be required to encourage landowners to adopt the practices (no-till, afforestation, etc.) that enhance carbon sequestration in the MRCSP region.

Preliminary Results – Mine Soil C

	Mylan Park	Skousen
	TOM (Total Organic Matter) (%)	
0 – 6 cm	**4.5** 3.2 – 7.0	**3.0** 2.3 – 4.2
0 – 12 cm	**2.6** 1.9 – 4.0	**2.7** 1.9 – 3.9
	TOC (Total Organic Carbon) (%)	
0 – 6 cm	**3.5** 2.0 – 5.7	**1.7** 1.4 – 2.4
0 – 12 cm	**2.0** 1.2 – 3.3	**1.6** 1.1 – 2.3

Preliminary Results – Economic Value of Stored Carbon

($/Mg)

State	Non-eroded Cropland CT to NT C Value	Eroded Cropland CT to NT C Value	Afforested Eroded Cropland C Value	Afforested Marginal Land C Value	Afforested Reclaimed Mine Land C Value
IN	40.53	78.55	272.86	44.29	78.85
KY	59.10	79.67	139.40	NA	70.87
MD	101.82	148.87	120.25	36.33	70.22
MI	126.54	159.60	255.15	39.16	72.11
OH	145.47	177.58	183.08	38.96	66.18
PA	100.04	155.49	52.77	NA	93.07
WV	104.40	181.54	68.68	NA	65.77

Economic value estimated as opportunity cost of land use change divided by change in carbon sequestered through the land use change.

Carbon sequestration in restored tidal marshes at Blackwater National Wildlife Refuge

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Maryland Department of Natural Resources Power Plant Research Program
Maryland Energy Administration

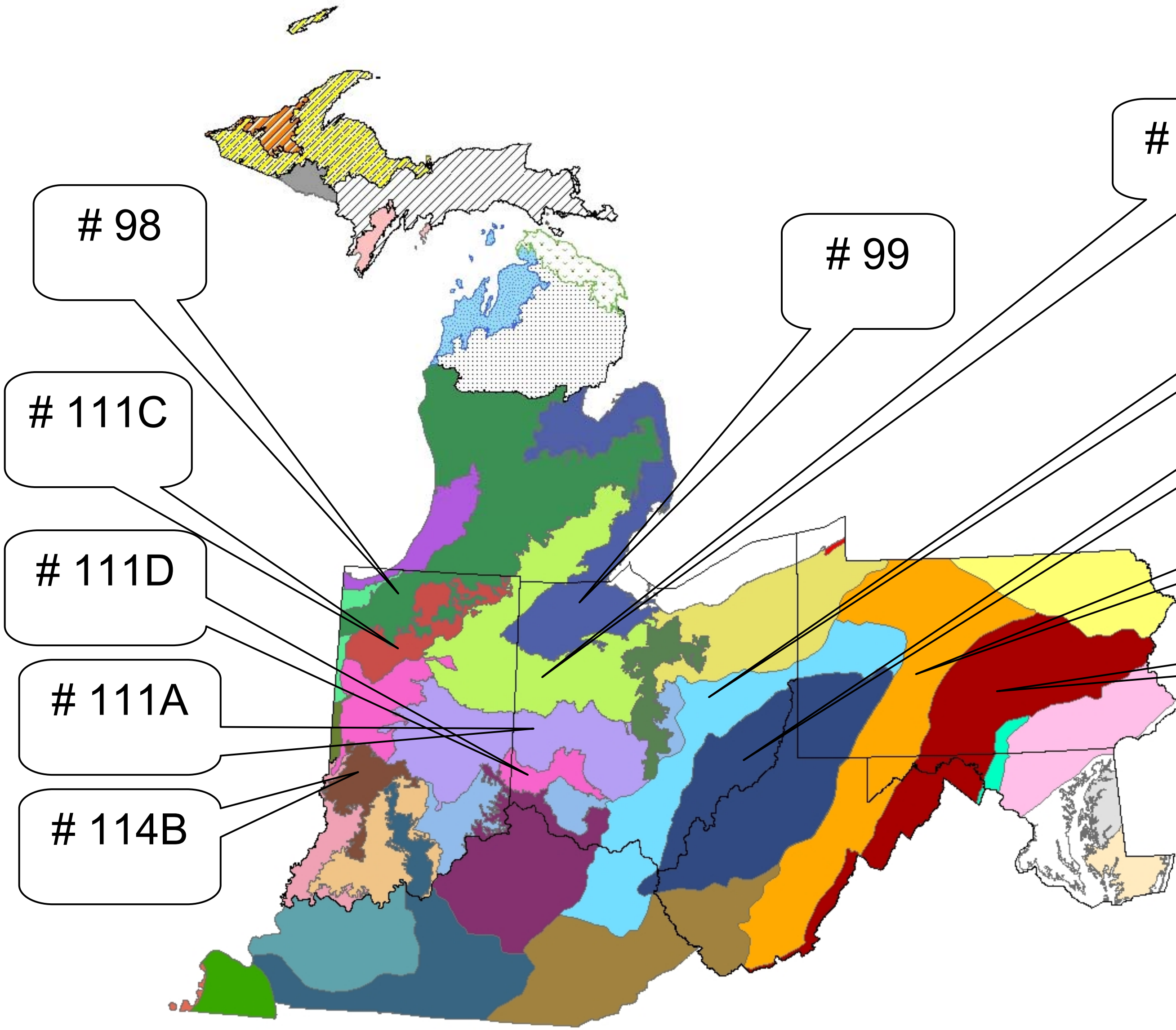
Field validation design

- Tidal marsh cells
  - One newly created 5-acre cell (2003)
  - One older cell (1983)
  - One natural marsh cell
- Surface and subsurface elevation changes monitored by USGS
- Feldspar markers are being used to mark initial surfaces
- ~50 plots per cell sampled annually
- Cells instrumented for water table, temperature, and redox potential

Research outcomes

- Develop estimates of C sequestration rates in restored marshes across time
- Understand influence of management practices on C sequestration rates in restored marshes
- Improve fundamental understanding of basic processes controlling C sequestration in marsh soil profiles
- Develop sampling protocol for C sequestration validation in restored marshes

MRCSP region showing the distribution of different MLRA’s and sampling sites for crop land



Different color represents different MLRA

I. Quantify C sequestration in croplands.

Site selection

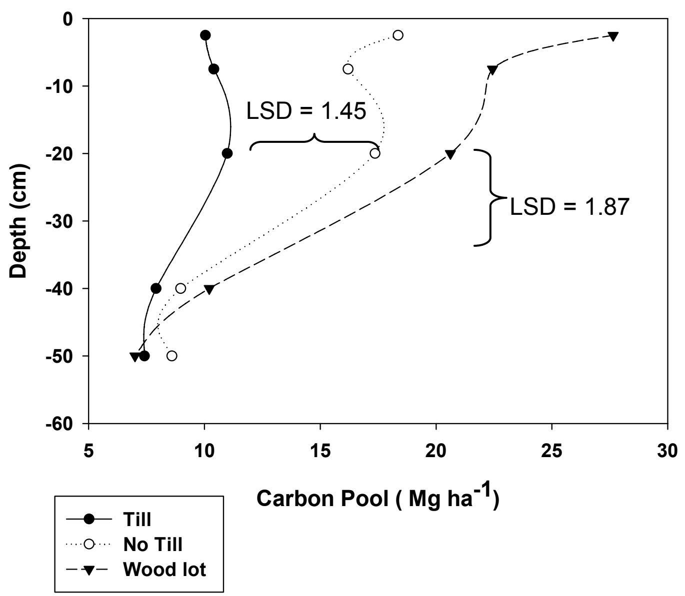
- Identified main MLRAs in the MRCSP region
- 12 MLRAs with large area and high potential for C sequestration chosen
- In each chosen MLRA, NT and CT farms and control site (forest) were identified.

Sampling Protocol

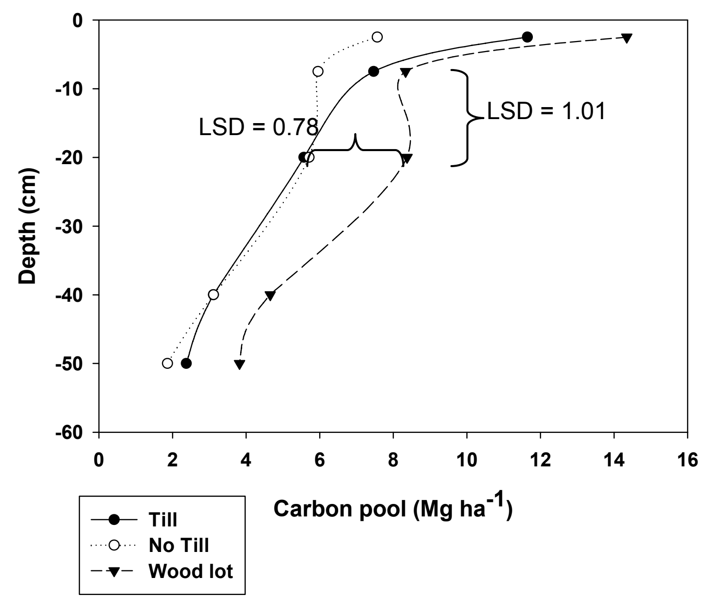
- 150 m (contour) x 150 m (slope) grids were established for each tillage method and the control
- Samples were collected from points that are 100 m apart in the up-slope direction and 100 m apart in the across slope direction
- Soil sampled at 0-5, 5-10, 10-30, 30-50, and >50 cm depths
- Sampling occured ~March 20 to early May

Carbon Pools in cropland soils

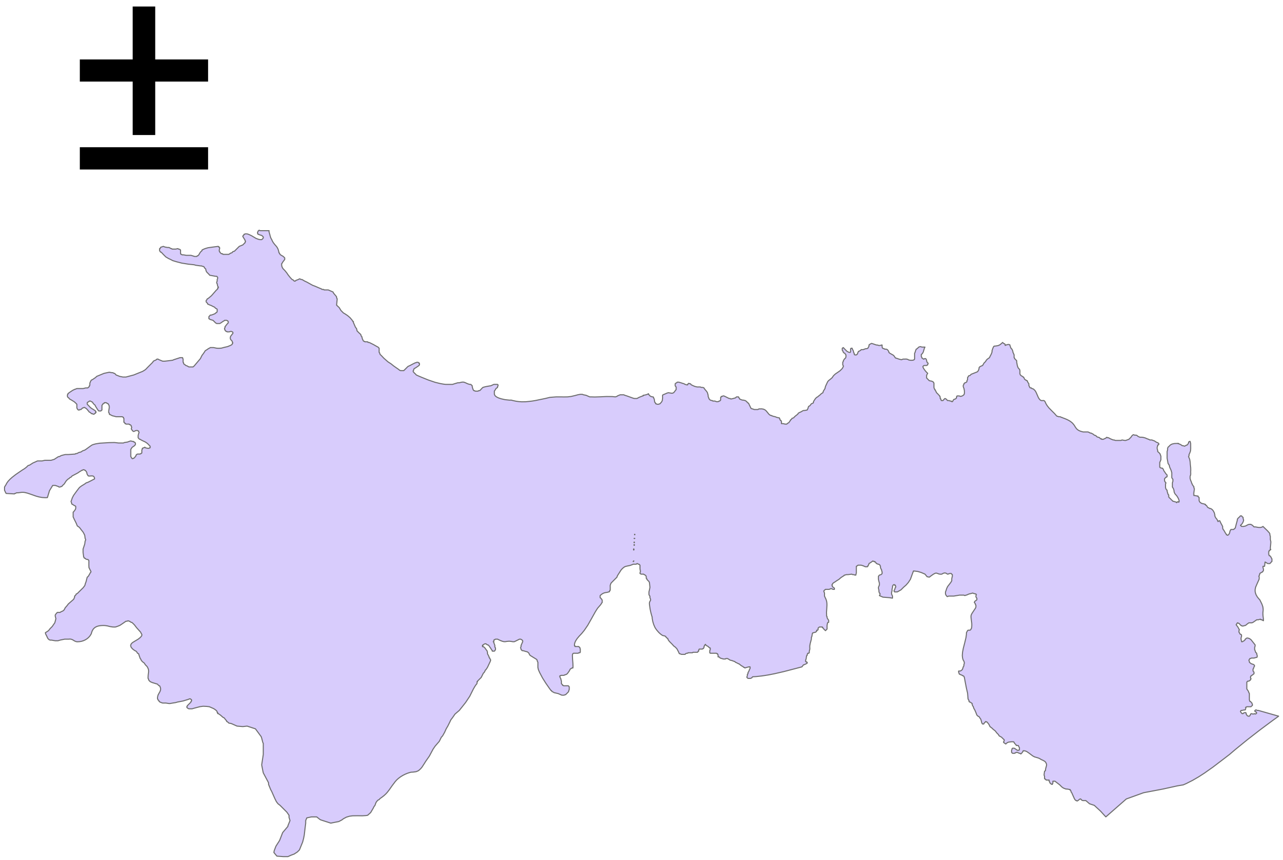
Depth distribution of Carbon Pool in different landuses in 111A MLRA

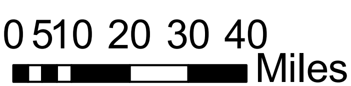


Depth distribution of Carbon pool in in different landuses in 114B MLRA



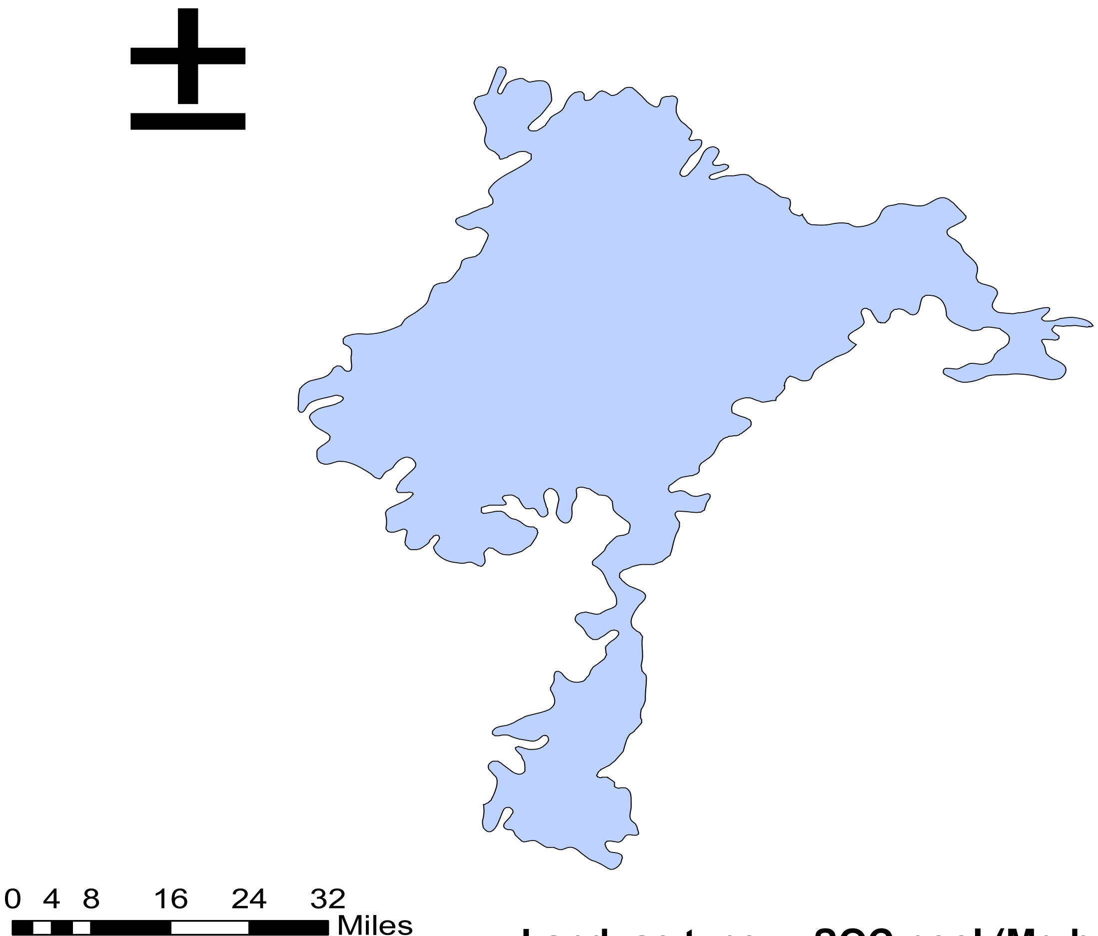
SOC and N Pool in Different landuses in 111A MLRA





Landuse type	SOC pool (Mg ha^{-1})	N pool (Mg ha^{-1})
Till	234 ± 21	10.6 ± 3
No Till	432 ± 14	14.6 ± 1.2
Woodlot	701 ± 9	16.5± 1.9

SOC and N Pool in Different landuses in 114B MLRA



Landuse type	SOC pool (Mg ha^{-1})	N pool (Mg ha^{-1})
Till	56 ± 12	6 ± 1
No Till	56 ± 19	5.8 ± 1
Woodlot	118 ± 18	7.4 ± 1.6

Rate of C sequestration in selected MLRAs

MLRA	Till C Pool (Mg ha^{-1})	No till C pool (Mg ha^{-1})	Time of No till (Years)	Rate of C sequestration (Mg $ha^{-1}yr^{-1}$)
111B	230.49	252.96	20	1.12
124	124.27	102.95	30	- 0.71
147	281.33	313.55	9	3.5

II. Geospatial analysis to predict carbon stock at regional scale.

- Soil carbon stock for the region will be predicted from soil profile data and readily available secondary information.
- The secondary information used will be terrain attributes derived from digital elevation model, landuse data, weather station data (temperature and precipitation) and soil reflectance data.

Data collected - Soil carbon data

- Collected soil organic carbon profile data
- 675 point data for Kentucky, Ohio, Pennsylvania and Indiana.
- 156 points across 12 MLRA’s analyzed for SOC.

III. Quantify HISTORIC LOSS OF C ON USING $\delta^{13}C$

Table 1. Sampling locations and dates, 2006, Ohio

County	Delaware	Coshocton	Henry
MLRA	111	124	99
Location	Dublin	Coshocton	Hoytville
Parent material	Till plain	Glacial till	Glacial Lake Plain
Sites	Woollot, conventional till, and no-till		
Samplings	Soil and plant residue samples as well as Core samples for bulk density		
Depth	0-10, 10-20, 20-30, and 30-40 cm with 4 replications and about 20 m apart		
Sampling date	July 20th	July 10th	July 6th


MLRA 99
Henry July,
2006


Syracuse University
Homecoming 2005
Ohio State
Coshocton
MLRA 124
corn field

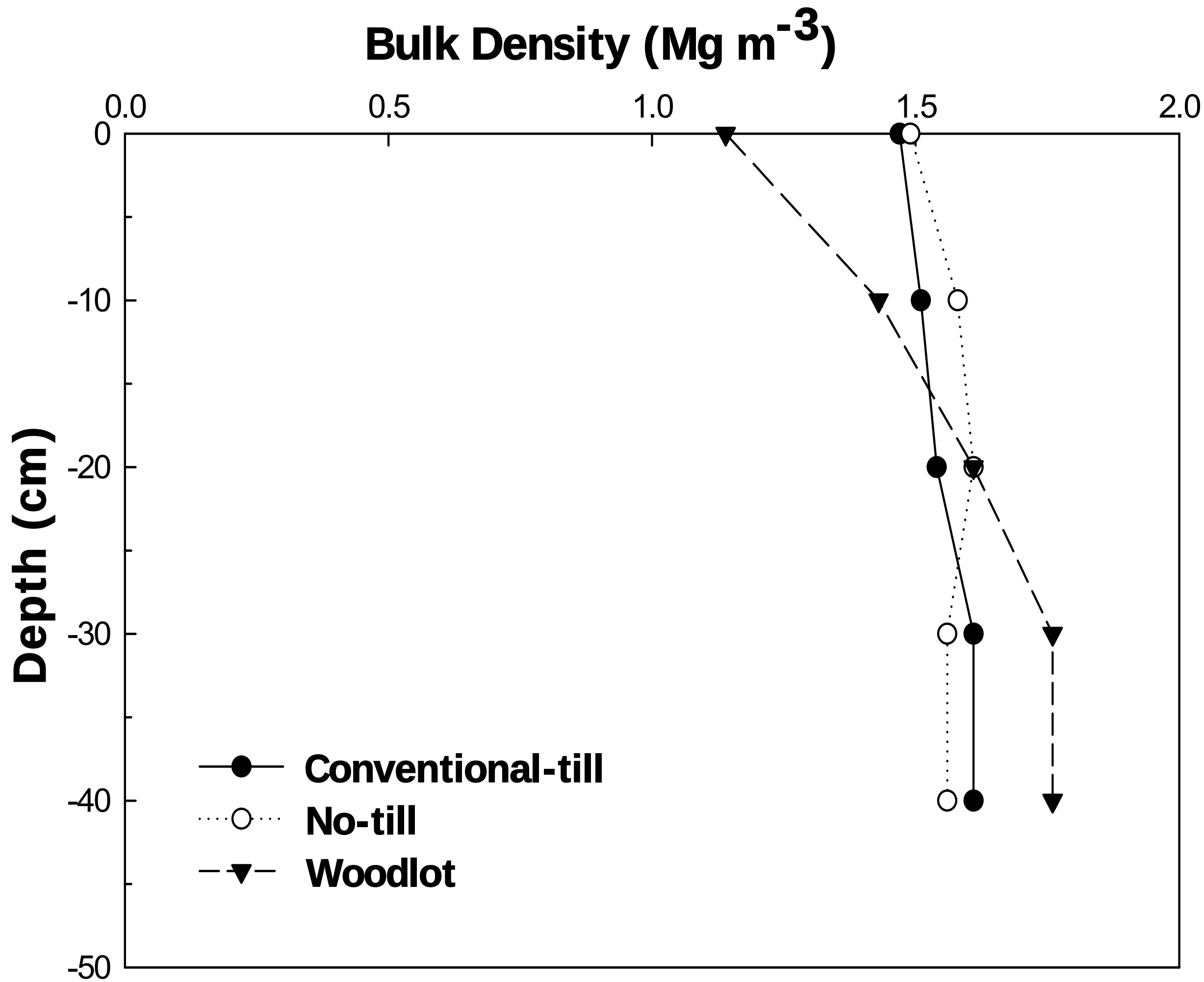


Fig1. Average bulk density (Mg m^{-3}), 0-40 cm for three land use (WL,CT, and NT) in Coshocton and Delaware, Ohio.

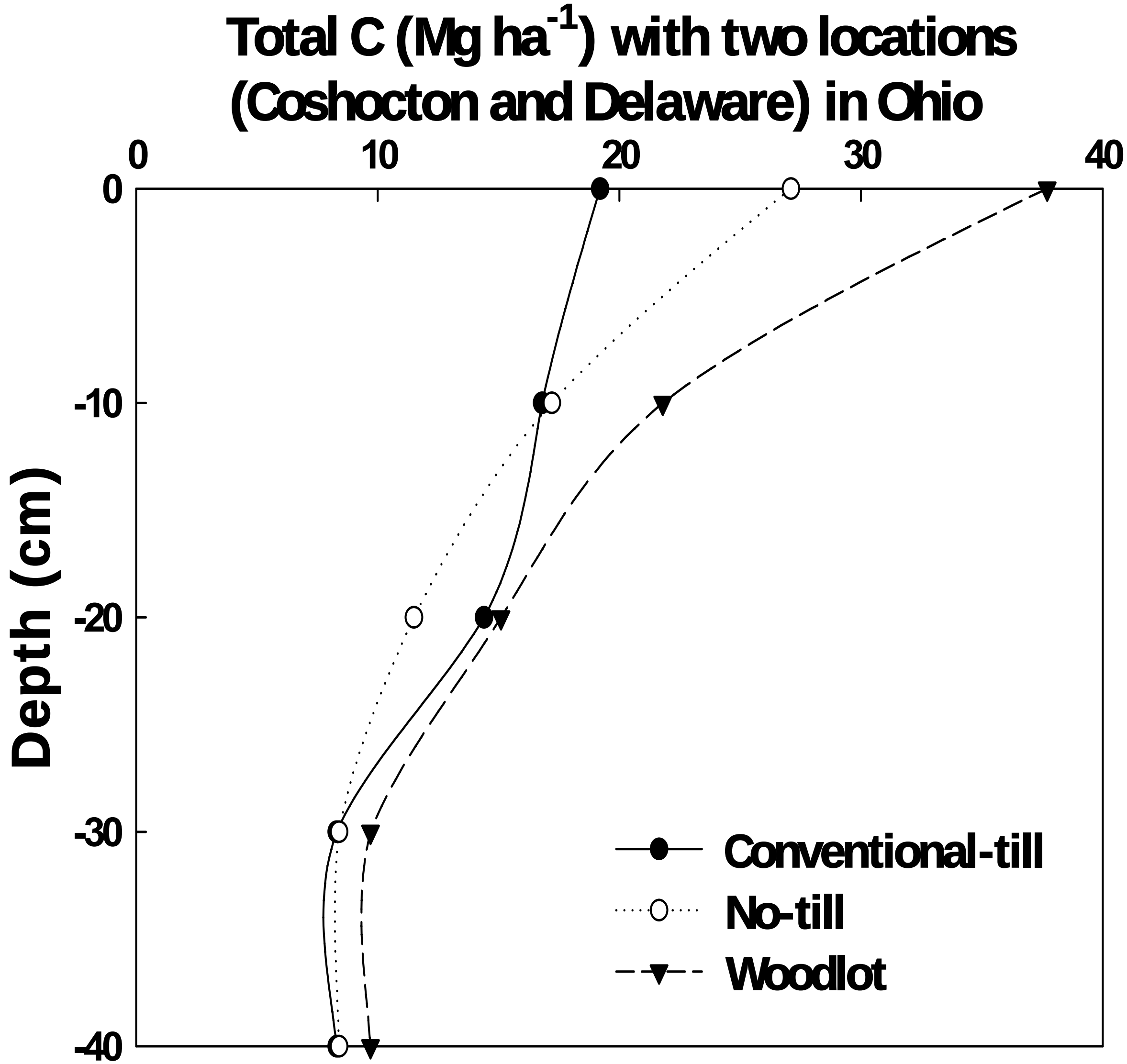


Fig 2. Average total C (Mg ha^{-1}), 0-40 cm at three land use (WL, CT, and NT) in Coshocton and Delaware, Ohio.

	CT	NT	WL
	---------Mg ha^{-1}----------		
Total C (0-40 cm depth)	**67.0**	**72.6**	**93.9**
C loss	**26.9**	**21.3**	**0**

Table 1. Total C loss after land conversion from woodlot to crop land, 0-40 cm for three land use (WL, CT, and NT) in Coshocton and Delaware, Ohio.

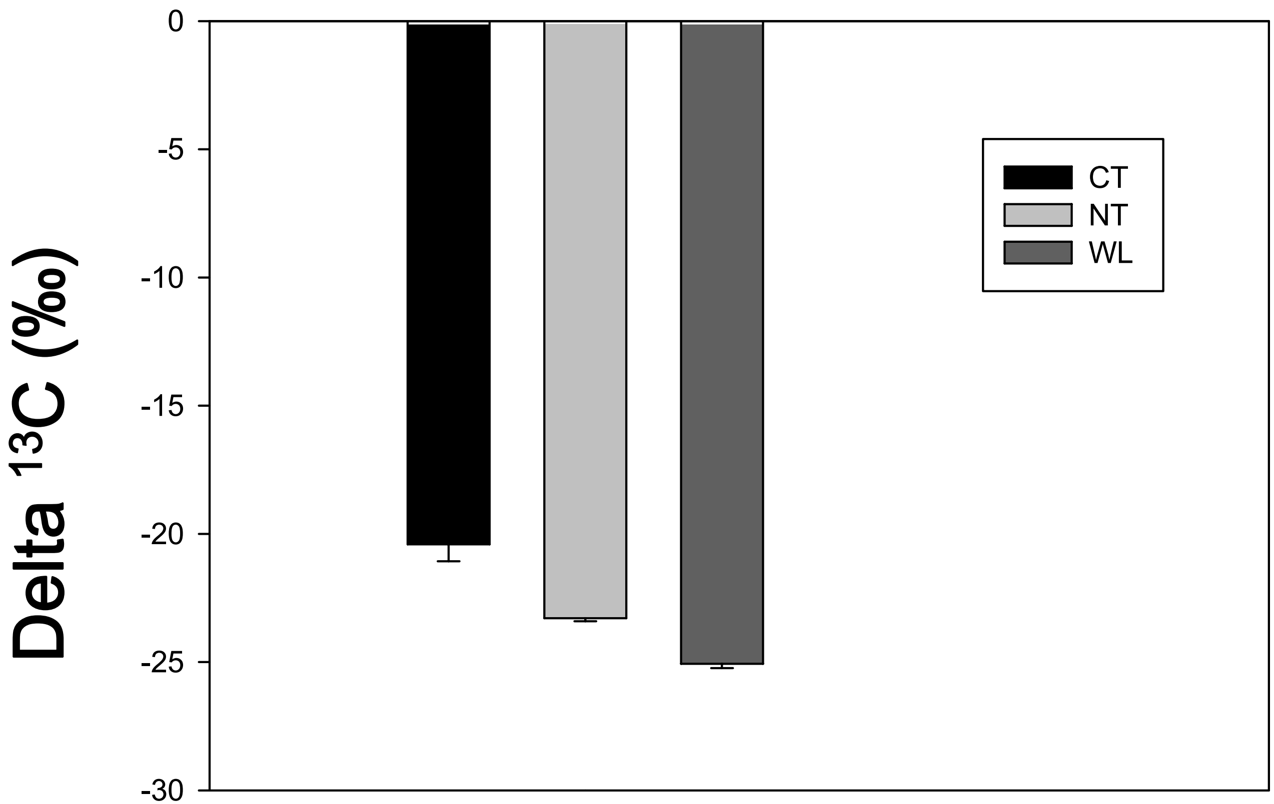
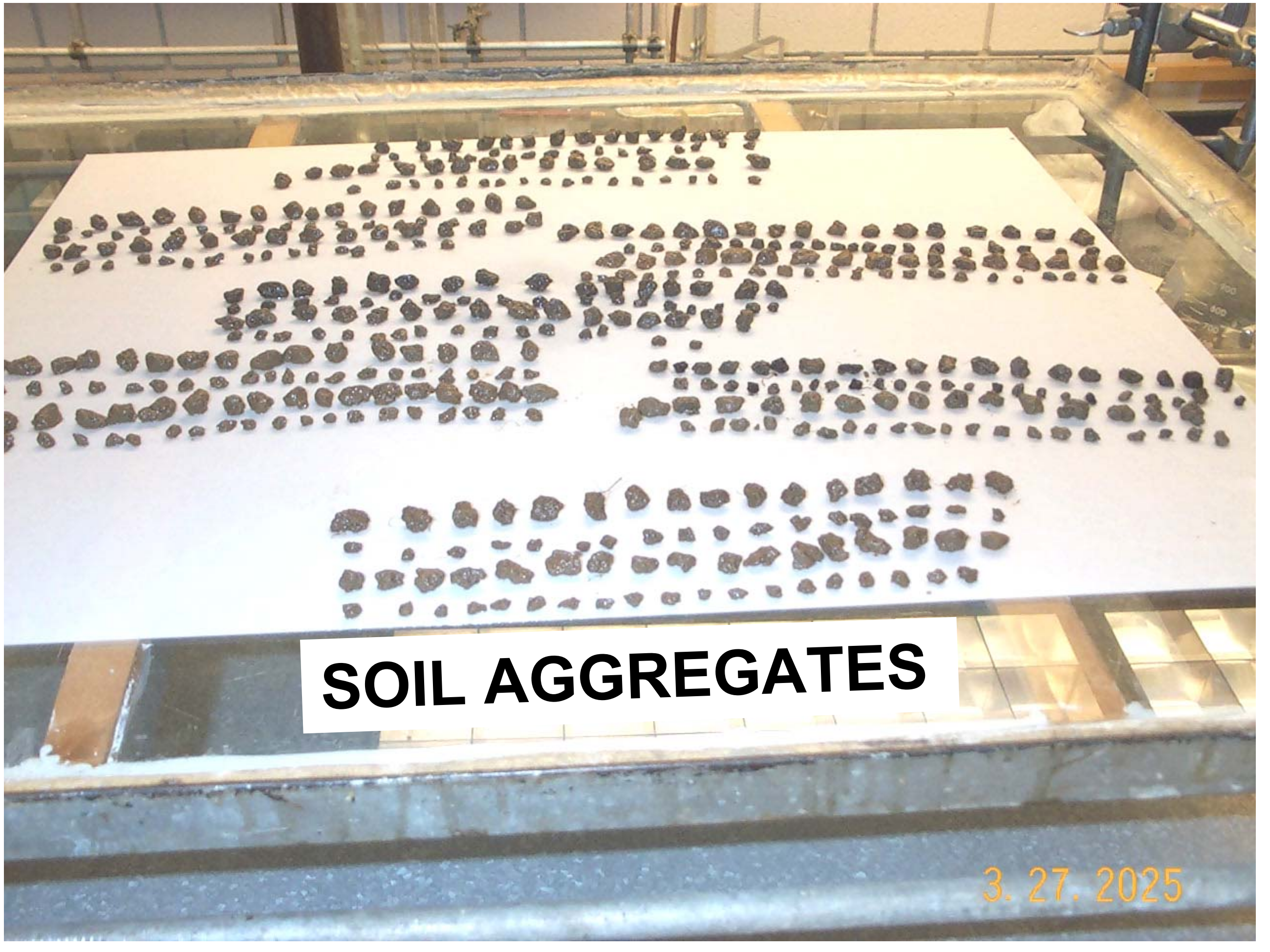


Fig. 3. Average δ^{13}C (‰), 0-40 cm at three land use (WL, CT and NT) in Coshocton and Delaware, Ohio.

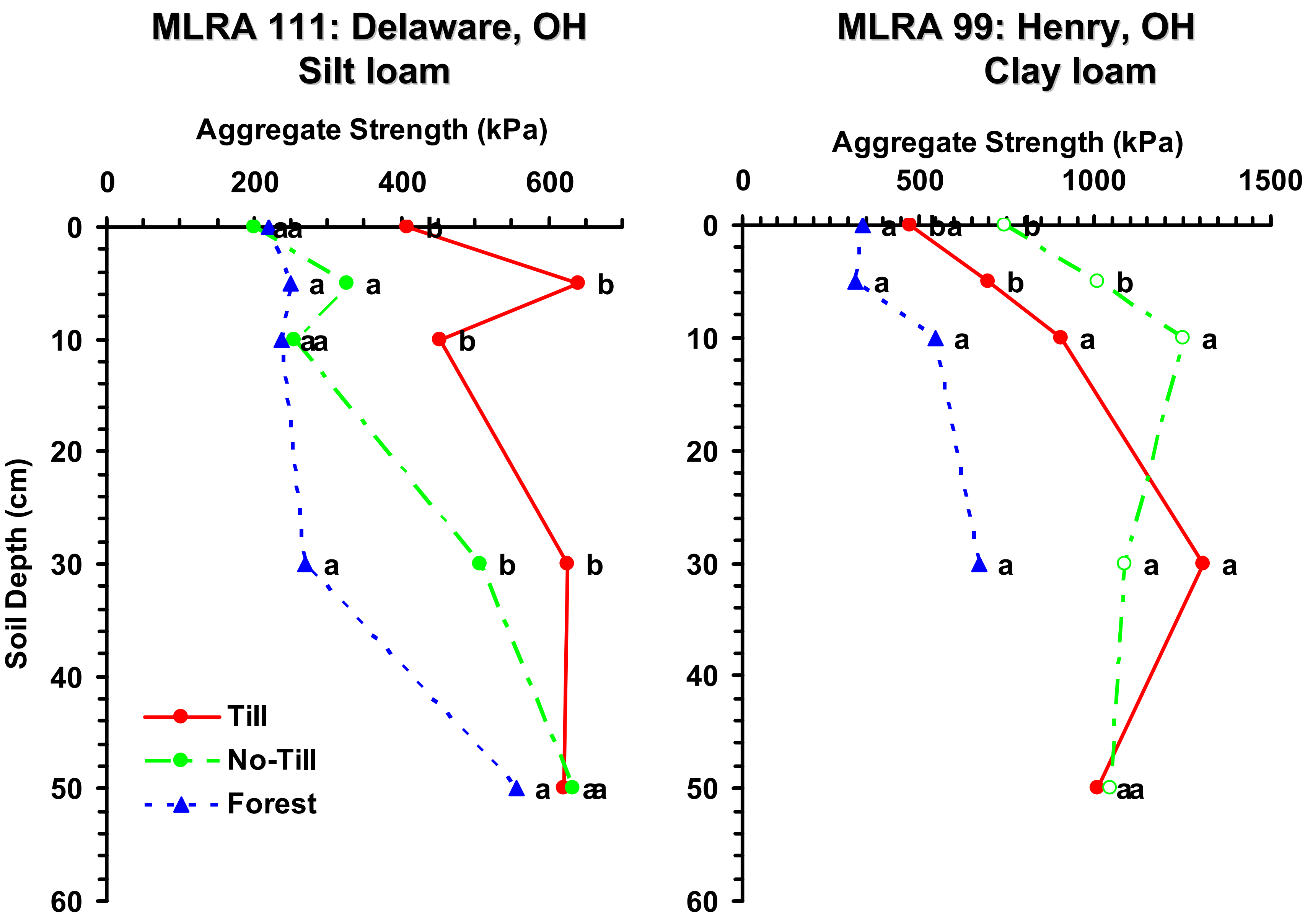
Depth	Contribution of C from	
	C4 plants	C3 plants
cm	---------------%-----------------	
0-10	28.6	71.4
10-20	25.9	74.1
20-30	23.9	76.1
30-40	18.4	81.6

Table 2. Contribution of C from C4 and C3 plants collected in Coshocton and Delaware, Ohio.

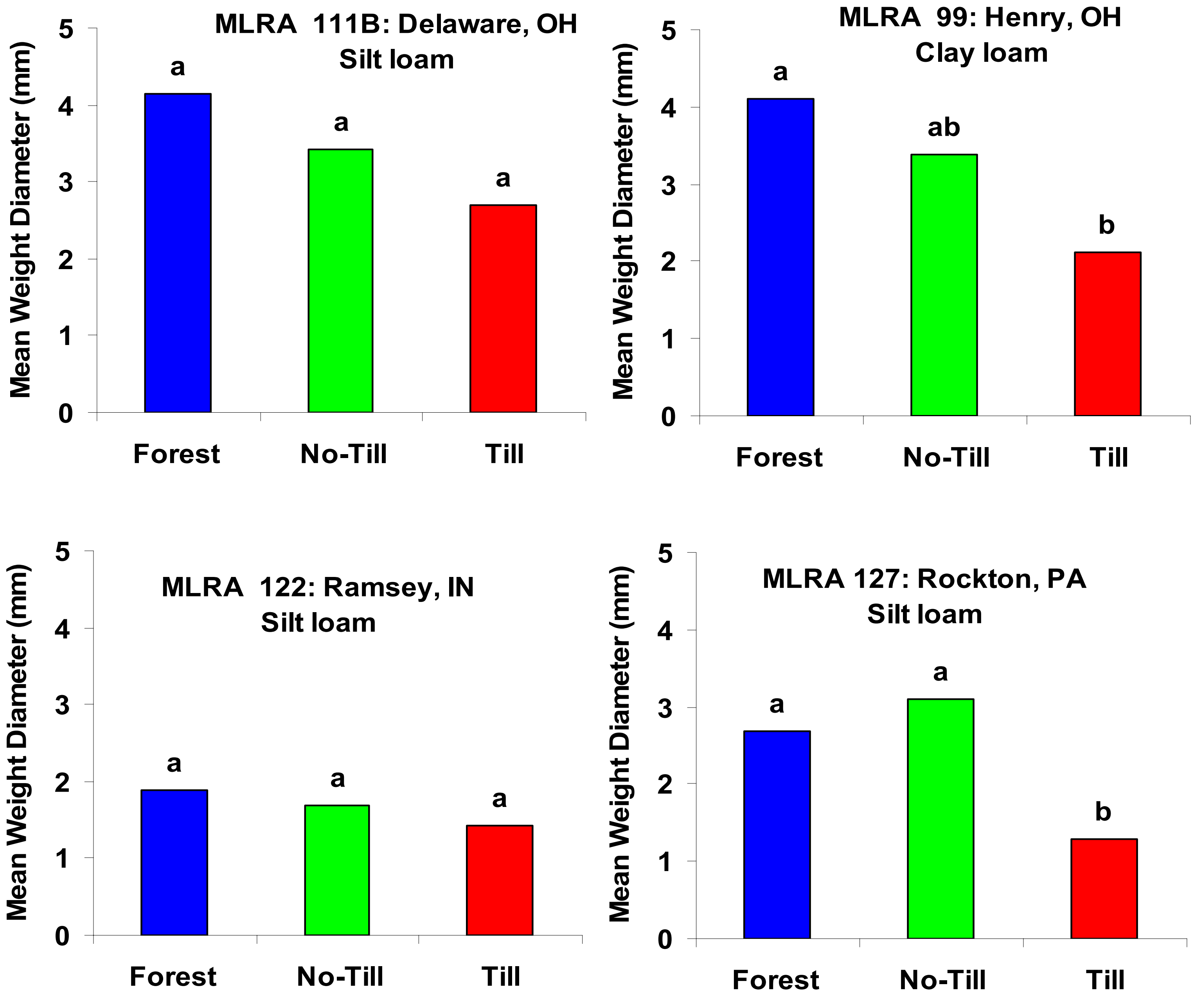
IV. Relating soil carbon stock to soil quality



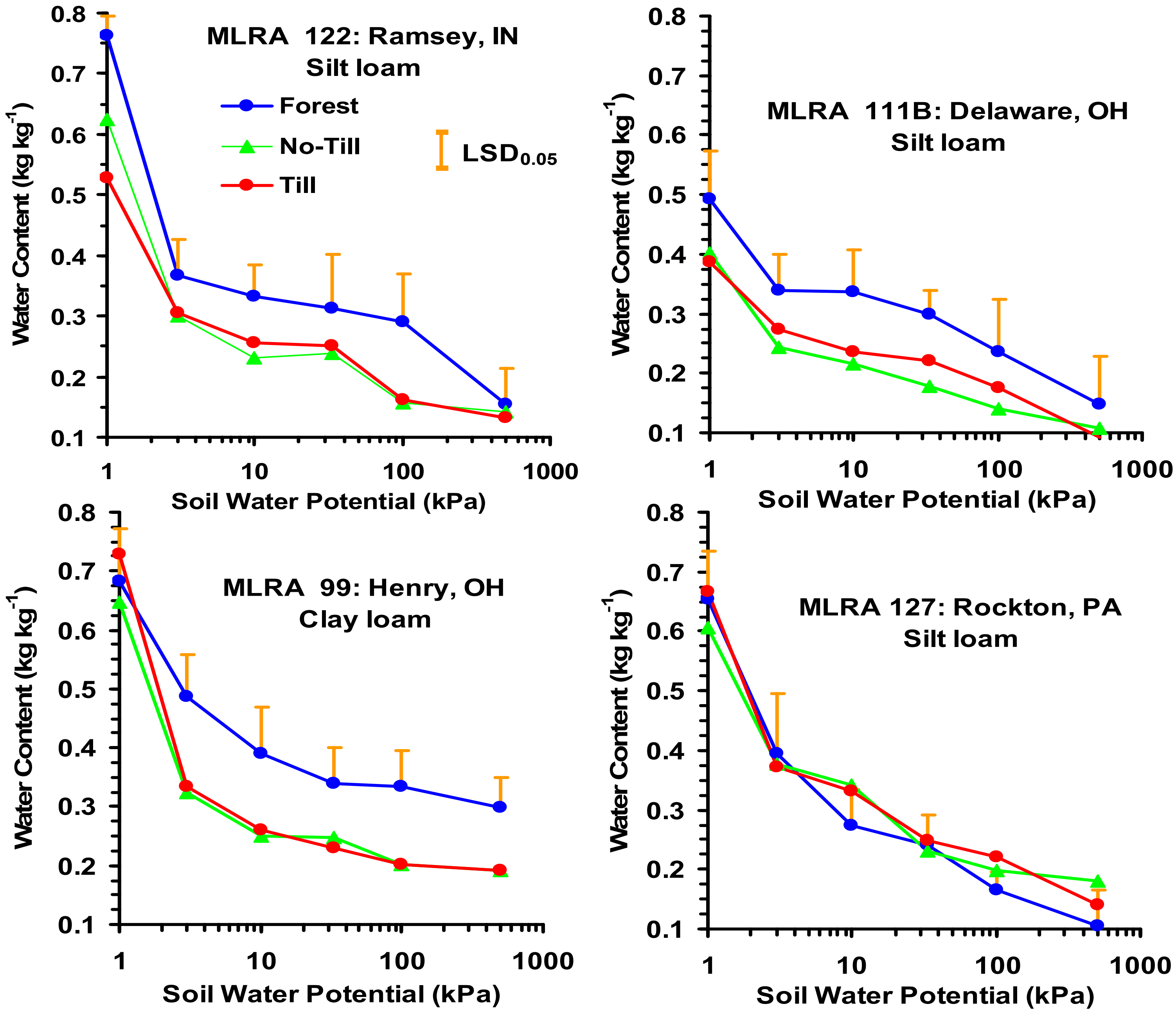
AGGREGATE STRENGTH



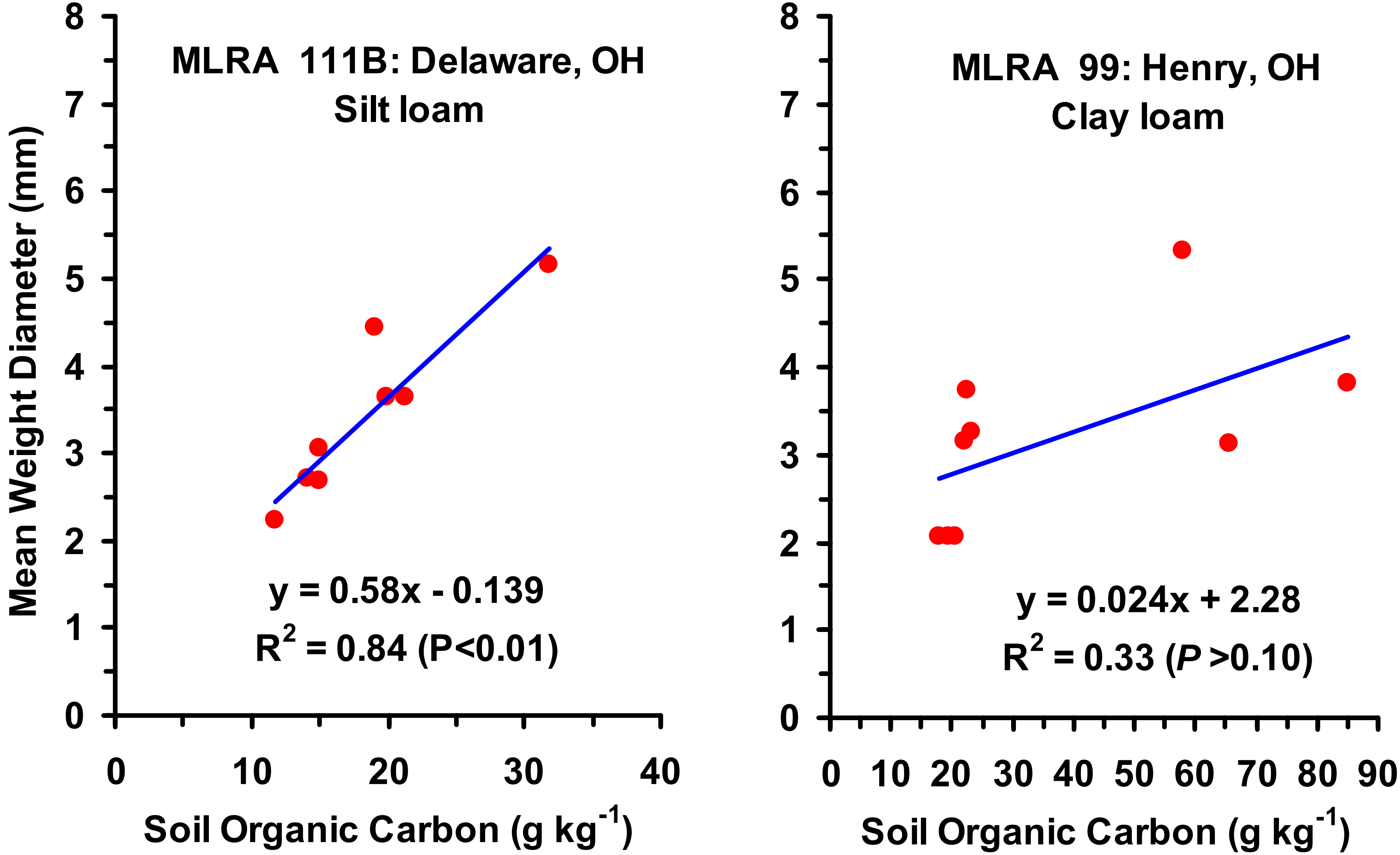
AGGREGATE STABILITY



SOIL WATER RETENTION CHARACTERISTICS

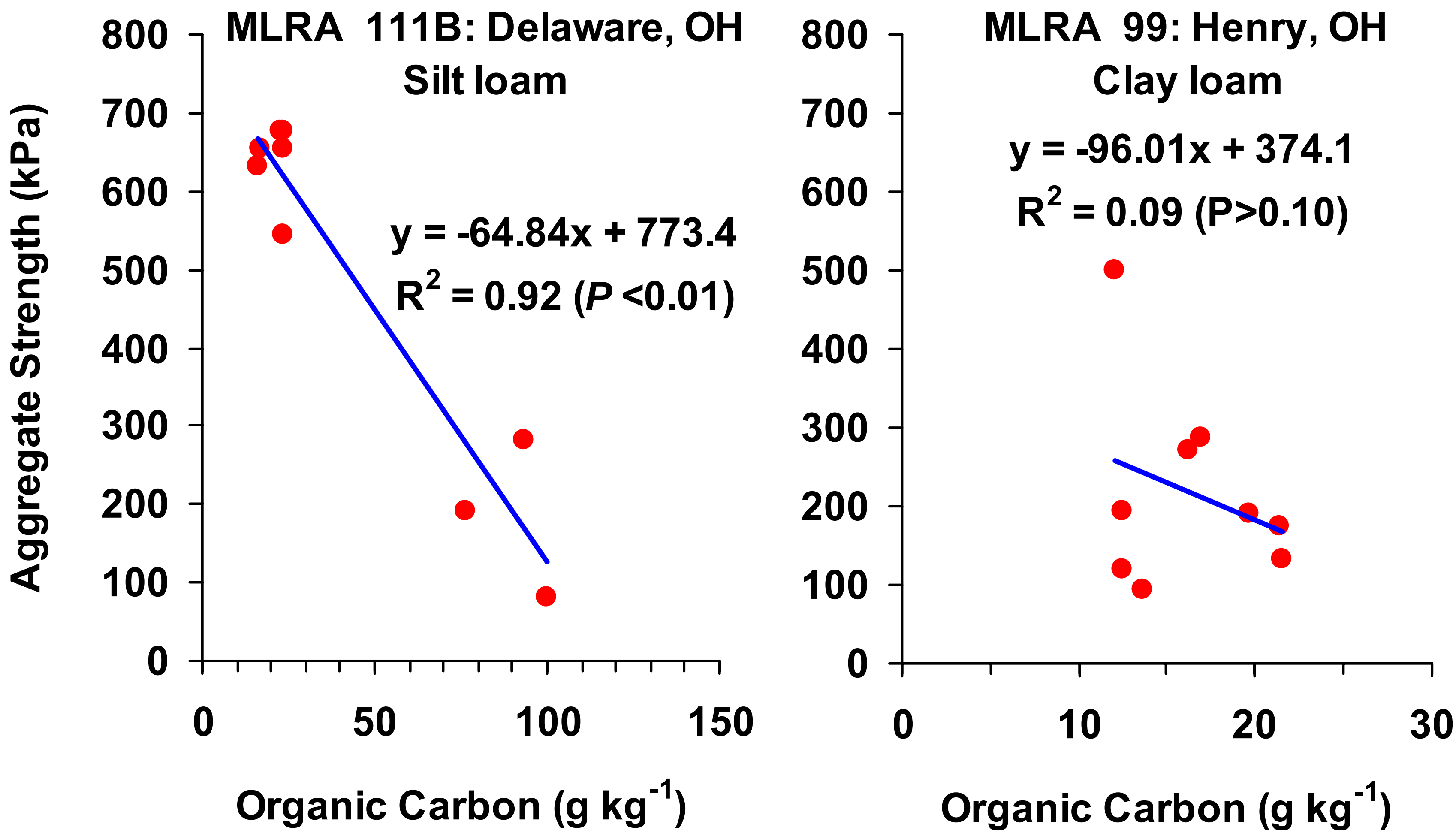


RELATIONSHIP BETWEEN AGGREGATION AND SOC



Increase in SOC concentration increased macroaggregation in silt loam (MLRA 111B) more than in clay soil (MLRA 99)

AGGREGATE STRENGTH AND SOC



Increase in SOC concentration reduced aggregate strength in silt loam (MLRA 111B) but not in clay soil (MLRA 99)

Future work

- Collection of weather, landuse data and spatial modeling (Decision regression tree or Artificial neural network).
- Prediction and validation of SOC map
- Research sites where only C4 plants have been grown after land conversion to be identified for estimation of historic C loss.
- Complete the analysis of δ13C in all samples and estimate the historic C loss based on δ13C values.
- The methodology of historic C loss will be tested in other MLRA's.
- Completion of aggregate analyses (strength, stability, density, moisture retention and wettability) for all MLRA's.
- Collection of grain and biomass yields.
- Development of relationships between aggregate properties and SOC concentrations.
- Determination of C distribution by aggregate size (5-8 mm, 2-5 mm, and <2 mm diameter).
- Determination of C content distribution in clay and silt fractions.
- Relating SOC rates to site variables