Fifth Annual Conference on Carbon Capture & Sequestration

Steps Toward Deployment

Terrestrial Sequestration

Carbon Dioxide Emission Offset Costs: Economic Consequences of Terrestrial Carbon Sequestration in a Seven-State Region of the U.S.

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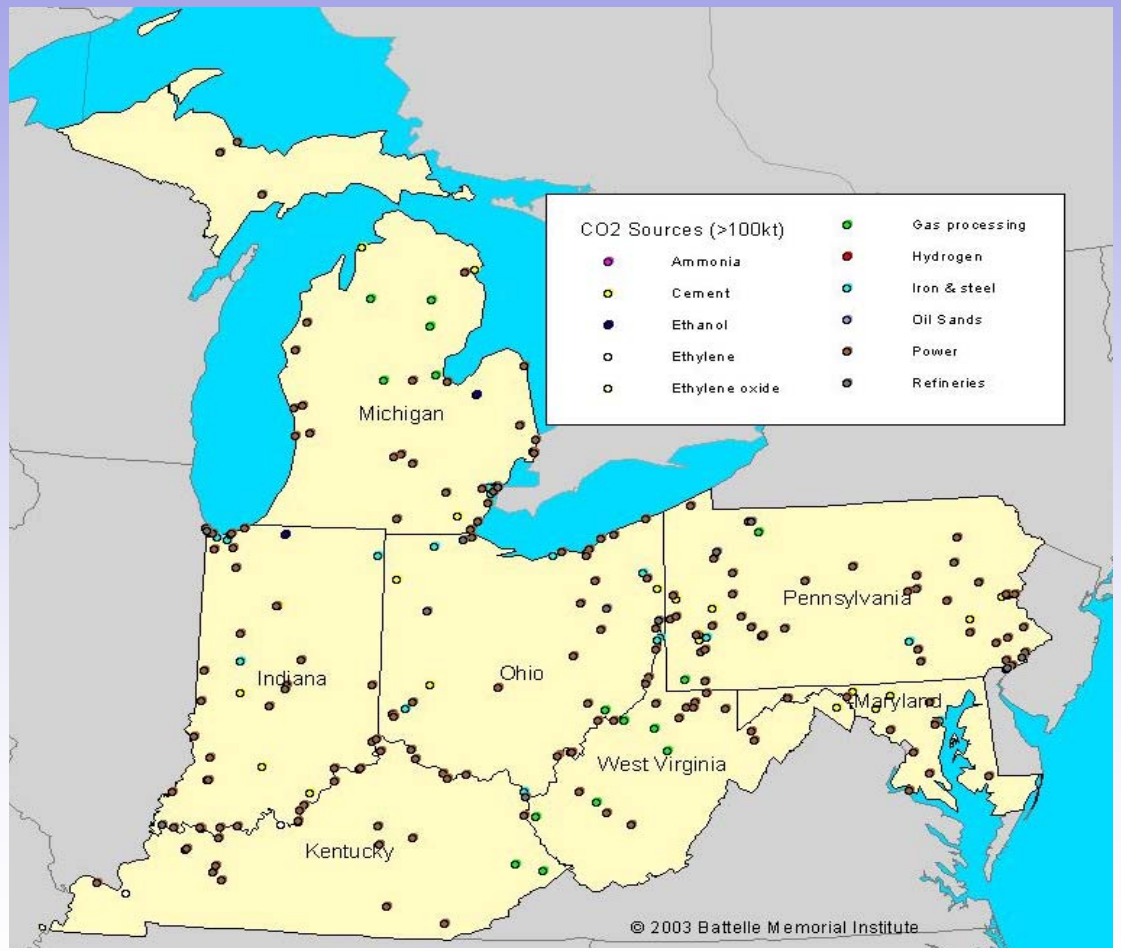
May 8-11, 2006 • Hilton Alexandria Mark Center • Alexandria, Virginia

MRCSP Region



MRCSP
MIDWEST REGIONAL
CARBON SEQUESTRATION
PARTNERSHIP

- Population: 50.8 million (one in six Americans)
- Gross Regional Product: $1,534 billion (16% of U.S. economy)
- 21.5 % of all electricity generated in the U.S.
- 77% of electricity generated from coal
- 1990 CO_2 emissions 919 Tg

MRCSP Land-Uses Analyzed and Team

- **Non-eroded Cropland** – The Ohio State University: **Rattan Lal**
- **Eroded Cropland** – Purdue University: **William McFee and Larry Biehl**
- **Marginal Land** – Pennsylvania State University: **Sjoerd Duiker**
- **Mine Land** – West Virginia University: **Mark Sperow**
- **Wetland and Marshland** – University of Maryland: **Brian Needelman**
- **Modeling all Land Classifications** – Michigan State University: **Peter Grace**

C Accumulation Methods

- Reduced tillage intensity – conventional to no till
  - Contributes to soil C only
    - Non-eroded cropland
    - Eroded cropland
- Set Aside – remove cropland from crop activities
  - Contributes to soil C only
    - Eroded cropland – plant grass/pasture
    - Wetlands – convert cropland to wetland
- Afforestation
  - Contributes to soil C, aboveground biomass C, and litter layer C
    - Marginal cropland
    - Mine land

Distribution of Non-eroded Cropland

State	Area (kha)	20 yr Tg C	Mg C ha^{-1}
IN	5,137	23.5	0.23
KY	1,412	5.2	0.18
MD	355	1.5	0.21
MI	3,603	19.7	0.27
OH	4,085	21.4	0.26
PA	118	2.3	0.97
WV	117	0.2	0.09
Total	15,285	73.9	0.24

Distribution of Prime-Eroded Cropland and Potential C

State	Area (kha)	20 yr[1] SOC Tg	20 yr[2] SOC Tg	SOC (Mg ha^{-1})
IN	933	7.2	36.1	0.39
KY	39	0.2	1.1	0.26
MD	0	0	0	0
MI	80	0.6	3.2	0.38
OH	513	4.3	21.4	0.42
PA	0	0	0	0
WV	0	0	0	0
Total	1,565	12.3	61.8	0.39

[1]60% of native C recovered with NT

[2]All native C recovered with set-aside

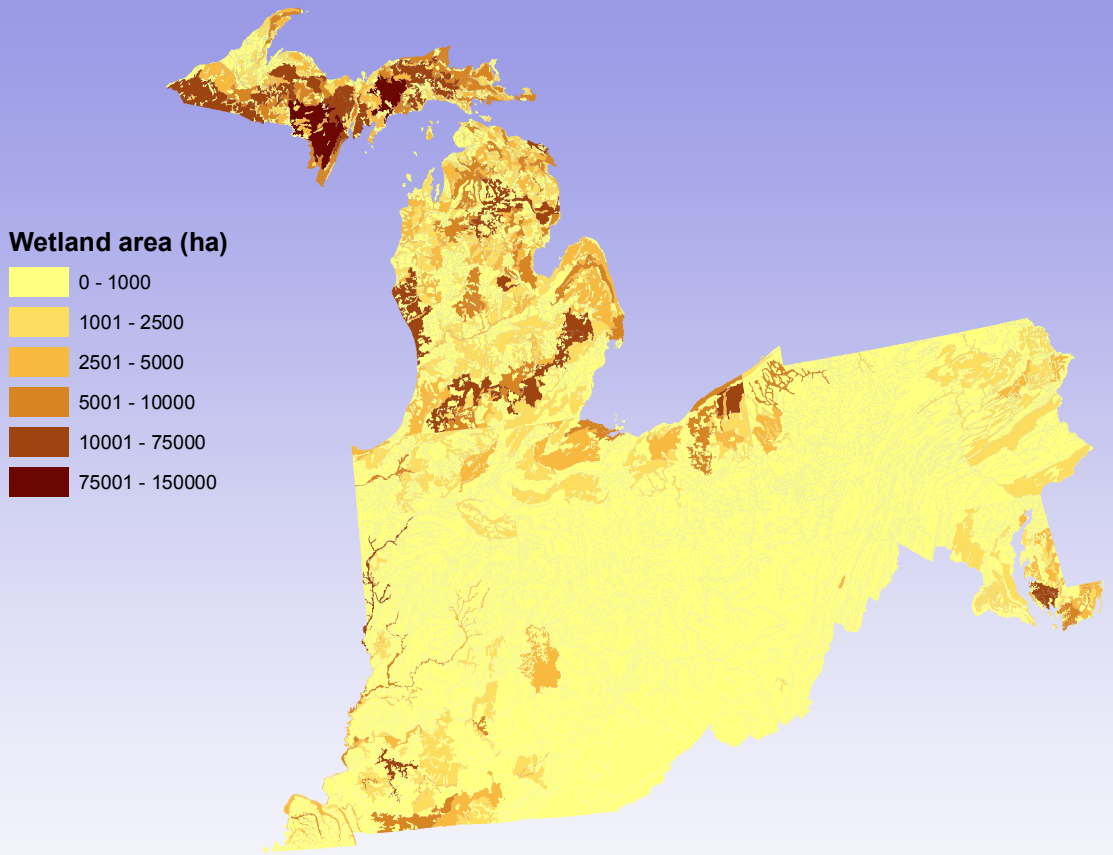
Distribution of Marginal Land and Potential C from Afforestation

State	Area (kha)	20 yr Tg C	Mg C ha^{-1}
IN	1,238	105.3	4.28
KY	1,012	91.6	4.55
MD	246	20.8	4.07
MI	1,230	87.9	3.58
OH	1,156	95.3	4.15
PA	1,181	96.8	4.06
WV	481	41.5	4.37
Total	6,543	529.2	4.11

Distribution of Mine Land and Potential C from Reforestation

State	Area (kha)	20 yr Tg C	Mg C ha^{-1}
IN	30.2	1.6	2.6
KY	67.8	3.5	2.9
MD	29.1	1.4	3.4
MI	68.3	3.6	2.9
OH	125.4	3.6	1.6
PA	63.4	5.1	4.7
WV	183.5	10.74	2.7
Total	567.7	29.5	2.8

Distribution of Wetlands and Potential C



Land Use	Area (kha)
Tidal Marsh	82
Peatlands	196
Crop to Wetland	100 - 435
Total	378 - 713

Land Use	Tidal Marsh	Peatlands	Crop to Wetland	Total
Tg 20 yr	4.1 – 9.3	0.9 – 1.4	16 - 68	5 – 78.7
SOC (Mg ha^{-1})	2.4 - 6.1	0.3 – 0.4	0.1 – 7.8	0.7 – 5.5

Economic Analysis Techniques

- Reduced tillage intensity – Eroded and Non-eroded Cropland
  - Analyze difference in profit from CT and NT
  - C value is based on annual C accumulation in soil and difference in returns from the two systems
- Set-Aside – Eroded Cropland and Wetlands
  - Land removed from crop production, so no income
  - C value is based on annual C accumulation in soil and NPV of future stream of lost income
- Afforestation – Marginal Cropland and Mine Land
  - Marginal Cropland – C value is based on annual C accumulation in soil, litter layer, and biomass, establishment costs, plus NPV of stream of lost income
  - Mine Land – C value is based on annual C accumulation in soil, litter layer, and biomass and establishment costs amortized over time land remains in forest

Reduced Tillage Intensity

- Data – crop enterprise budgets
  - NT and CT yields
    - Not statistically different for corn-soybean rotations
    - Different for continuous corn
  - Profits from no-till may be > profit from conventional till in the MRCSP region
    - Other factors preventing landowners from NT adoption
- Assume profits remain constant over time
- Estimation of minimum SOC value:

$$\text{C value} = (\pi_{CT} - \pi_{NT})/\text{SOC (Mg ha}^{-1}\text{yr}^{-1}\text{)}$$

- C value represents minimum payment required to encourage no-till adoption

Results: Reduced Tillage Intensity

State	Non-eroded Cropland C Value ($/Mg)	Eroded Cropland C Value ($/Mg)
IN	18.15	10.71
KY	-	-
MD	82.86*	-
MI	10.49	7.45
OH	66.93*	41.43*
PA	-	-
WV	-	-

* Indicates no-till profit > conventional till profit.

Successful no-till depends on:

- Soils
- Climate
- Crop Rotation
- Drainage
- Compaction

Set Aside

- Data
  - 2005 Land rental rates (opportunity cost of land)
  - Rate of carbon sequestration
- 20- yr time frame considered
- Estimation:

$$\text{C value} = \text{Land Rental Rate} \,/\, \text{SOC (Mg ha}^{-1}\text{yr}^{-1}\text{)}$$

Results: Set Aside – Eroded Cropland

State	C Value ($/Mg)	Total C Tg 20 yr
IN	139.22	36.1
KY	101.63	1.1
MD	NA	0
MI	76.60	3.2
OH	139.22	21.4
PA	NA	0
WV	NA	0
Total		61.8

Results: Set Aside –Cropland to Wetlands

State	C Value ($/Mg)
IN	34.5 – 2693.4
KY	NA
MD	19.6 – 1532.1
MI	19.6 – 1532.1
OH	26.0 – 2026.3
PA	NA
WV	NA

Total C sequestration potential for area over 20 years: 16 – 68 Tg.

Range is based on range of C accumulation potential.

For comparison: Wetlands Reserve Program (WRP) average rental cost for region: $6133 ha^{-1}

Afforestation/Reforestation

- Data
  - C accumulation from biomass, litter layer, and soil
  - Forest establishment costs
    - Planting and seed/seedling costs
    - Additional grading and preparation costs for mine sites
- Assume average annual C accumulation
- Assume potential C price remains constant
- Initially, assume no harvest allowed
- If harvest allowed
  - Landowner charged for CO_2 emissions
    - based on proportion that enters long term storage and
    - Proportion that returns to atmosphere

Results: Afforestation/Reforestation No Harvest

State	Marginal Land C Value ($/Mg)	Marginal Land Total C Tg 20 yr
IN	44.29	77.8
KY	NA	0
MD	36.33	75.4
MI	39.16	64.0
OH	38.96	74.6
PA	NA	0
WV	NA	0

State	Mine Land C Value ($/Mg)	Mine Land Total C Tg 20 yr
IN	78.85	1.6
KY	70.87	3.5
MD	70.22	1.4
MI	72.11	3.6
OH	66.18	3.6
PA	93.07	5.1
WV	65.77	10.74

Opportunity cost for marginal land is lost crop income and amortized establishment costs. Opportunity cost for mine land includes only establishment costs.

Bare Land Value when C Value = \$50 Mg^{-1}

	Total Cost ($\$ha^{-1}$)	Timber Price ($\$m^{-3}$)	BLV	Optimal Rotation Length (Yrs)
Maple, Beech/Birch	534	91	3,891	32
Oak/Hickory	605	137	6,267	23
White, Red/Jack Pine	190	69	3,150	29

Conclusions

- Biophysical potential C sequestration: 32.5 Tg yr^{-1} (119 Tg CO_2) – 36.7 Tg yr^{-1} (141 Tg CO_2)
- Represents 12.9 to 15% of CO_2 emissions
- Range of C value:
  - Agricultural Soils: \$10.49 to \$139 Mg^{-1} (\$2.86 - \$37.90 Mg^{-1} CO_2)
    - Affects 16.8 Mha; 4.3 to 6.8 Tg yr^{-1}
  - Afforestation: \$36 to \$93 Mg^{-1} (\$9.81 - \$25.36 Mg^{-1} CO_2)
    - Affects 7.1 Mha; 27.9 Tg yr^{-1}
- C values compare favorably to EU market, higher than U.S.