Louisiana Blue Carbon Science
Highlights, Landscape-Scale Carbon
& Additional Research Needs?

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Atmospheric CO$_2$

- Gaseous Emissions (Decomposition)
  - Burial (Preservation)
  - Gaseous Emissions (Decomposition)

C Fixation (Make Organic Matter)

- CH$_4$  CO$_2$

C Sequestration
# Global Carbon Reservoirs

\[10^{14} \text{ kg}\]

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric CO(_2)</td>
<td>7</td>
</tr>
<tr>
<td>Biomass</td>
<td>4.8</td>
</tr>
<tr>
<td>Fresh water</td>
<td>2.5</td>
</tr>
<tr>
<td>Marine</td>
<td>5-8</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>30-50</td>
</tr>
</tbody>
</table>

Reddy and DeLaune, 2008
Will Any Soil Do?
Will Any Soil Do?  No

• Upland soils typically range in 1-6 % carbon

• Wetland peat soils range 30-40 % carbon

• Wetland peats on average have more than 10x more carbon stored
World’s Coastal Deltas

Formed as sea level slowed ~ 7000 ybp

Exist as fresh water/fresh marsh expanses within the salty coastal zone
Through coupled processes of subsidence and sea level rise, Deltas can play a substantial role in the global carbon cycle.
Carbon Density

Legend
Carbon Density [g/cm³]

<table>
<thead>
<tr>
<th>Carbon Density [g/cm³]</th>
<th>Area [km²]</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0.100 - &lt;= 0.280</td>
<td>64.69</td>
<td>0.10</td>
</tr>
<tr>
<td>&gt; 0.050 - &lt;= 0.100</td>
<td>3754.17</td>
<td>0.94</td>
</tr>
<tr>
<td>&gt; 0.008 - &lt;= 0.012</td>
<td>6964.62</td>
<td>11.02</td>
</tr>
<tr>
<td>&gt; 0.005 - &lt;= 0.008</td>
<td>8575.73</td>
<td>13.57</td>
</tr>
<tr>
<td>&gt; 0.003 - &lt;= 0.005</td>
<td>3148.71</td>
<td>5.41</td>
</tr>
<tr>
<td>&gt; 0.002 - &lt;= 0.018</td>
<td>947.30</td>
<td>1.50</td>
</tr>
<tr>
<td>&gt; 0.018 - &lt;= 0.030</td>
<td>2325.12</td>
<td>3.68</td>
</tr>
<tr>
<td>&gt; 0.030 - &lt;= 0.050</td>
<td>9564.97</td>
<td>15.13</td>
</tr>
<tr>
<td>&gt; 0.050 - &lt;= 0.100</td>
<td>2557.57</td>
<td>4.05</td>
</tr>
<tr>
<td>&gt; 0.100 - &lt;= 0.280</td>
<td>534.91</td>
<td>0.85</td>
</tr>
<tr>
<td>Not rated or water</td>
<td>24497.32</td>
<td>38.76</td>
</tr>
</tbody>
</table>

Total area of soil units: 63205.12 km²
Atmospheric CO$_2$

C Fixation
(Make Organic Matter)

We need plants!
Will Any Plant Do?
Wetland Area in Louisiana

26 % of all wetlands in the contiguous United States
40 % of all coastal wetlands
Area of Coastal Marsh ~ 988,888 ha
Global Carbon Reservoirs

$[10^{14} \text{ kg}]$

- Atmospheric CO$_2$ 7
- Biomass 4.8
- Fresh water 2.5
- Marine 5-8
- Soil organic matter 30-50

Reddy and DeLaune, 2008
Blue Carbon

- Decomposition of organic matter is driven by oxygen availability
- Oxygen diffuses through water 10,000 times slower than in air
- Wet environments become anaerobic and the rate of decomposition is very slow
Atmospheric CO$_2$

In Wetlands

C Fixation
(Make Organic Matter)

Burial (Preservation)

Gaseous Emissions (Decomposition)

Big

Small

C Sequestration

CH$_4$, CO$_2$
Land change 1932-2010
Land 1932
Combined Effects of Global Eustatic Sea Level Rise and Coastal Subsidence

Eustatic Sea Level Rise Rate = 2-3 mm y\(^{-1}\)
Mean Subsidence Rate = 9 mm y\(^{-1}\)

Greater C Sequestration with faster rising sea level (keeps the C wet)

Coastal wetlands can only accrete C as fast as sea level rises

But Wait, there’s more!
Atmospheric CO$_2$

C Fixation
(Make Organic Matter)

Bigger

Burial
(Preservation)

Gaseous Emissions
(Decomposition)

CH$_4$  CO$_2$

Small

C Sequestration
Peat Mining in Ireland – Release of Carbon Stores
Peat Mining in the Netherlands – Release of Carbon Stores
Annual Carbon Sequestration Assessment
For Louisiana Coastal Marshes

Mean of 3 metric tons of C ha\(^{-1}\) yr\(^{-1}\)

- Freshwater Tidal
- Brackish
- Salt Marsh

Area of Coastal Marsh \(\sim 988,888\) ha

Annual sequestration coast wide: 
~ 2,966,664 metric tons/yr

At $15 per ton; $44,499,960/yr
Atmospheric CO$_2$

C Fixation
(Make Organic Matter)

Burial (Preservation)

Gaseous Emissions (Decomposition)

CO$_2$  CH$_4$

C Sequestration
But Wait, there’s more?

\[ \text{CH}_4 \rightleftharpoons \text{CO}_2 \]

~21 times
## Carbon Dioxide Emissions

<table>
<thead>
<tr>
<th>Marsh Type</th>
<th>mg C m$^{-2}$ d$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh marsh</td>
<td>900-4400</td>
</tr>
<tr>
<td>Brackish Marsh</td>
<td>245-4950</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>125- 940</td>
</tr>
</tbody>
</table>

>10 measurements over year

DeLaune and White 2012
# Methane Emissions

<table>
<thead>
<tr>
<th>Marsh Type</th>
<th>mg C m$^{-2}$ d$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh marsh</td>
<td>0 - 1950</td>
</tr>
<tr>
<td>Brackish Marsh</td>
<td>2 - 1035</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>1 - 37</td>
</tr>
</tbody>
</table>

>10 measurements over year

DeLaune and White 2012
Carbon Sequestration Impact (kg CO₂-C eq m⁻²)

Fresh Marsh

Time (y)

Min

Median

Max

Minimum

Median

Maximum

Min

Median

Max

CH₄

CO₂
Brackish Marsh

Carbon Sequestration Impact (kg CO₂-C eq m⁻²)

Time (y)

-60
-40
-20
0
2
4
6
8
10

Minimum
Median
Max

Min
CO₂
CH₄

Median
CO₂
CH₄

Max
CO₂
CH₄

Minimum
Median
Maximum
Carbon Sequestration Impact (kg CO₂-C eq m⁻²)

Time (y)

- Minimum
- Median
- Maximum

Salt Marsh
Wetland Type

• Salt Marshes have Lowest Methane Emissions
  – Trading a CO$_2$ sequestered with CO$_2$ released
  – Louisiana has very large tracts of salt marsh
  – Most of the losses of salt marsh are in Louisiana
    Perfect marsh type to target for restoration
There is Some Uncertainty
Carbon Dioxide

35% of variance explained by type, location and season

- Error
- Marsh Type
- Within Marsh Location
- Seasonality
Methane

24% of variance explained by type, location and season

- Blue: Error
- Red: Marsh Type
- Green: Seasonality
Large Error Term

• Spatially not well described
  – Presence of vegetation
  – Flooding

• Temporally
  – Season
  – No data on fine scale (Over 24 hours)

More Work (measurements) needs to be done
Any More Credit in Subsiding Salt Marshes?
Peat Collapse

- Mud flat → Fresh marsh → Salt marsh → Vertical accretion deficit & stress → Marsh loss on open water or ponding

Subsidence and sea level:
- Subsidence and sea level

Diagram:
- Water
- Low bulk density organic deposits with small amount of mineral sediment
- Riverine sediment (high bulk density)

1 to 1.5 m
Restoration in Context of C Credit

46,000 ha preserved by river re-introduction

2.07 Million US Dollars per year
as a restoration benefit

Plus
Prevented loss of a meter of stored C
Which has a value of 207 Million US Dollars

Conservation Projects
Uncertainty

Where does the Carbon go in Eroding Coastal wetlands?
• Carbon Credit Potential is greatest in Salt Marsh Systems

• Great temporal and spatial Uncertainty in gas flux rates

• Preservation of Coastal Marshes may provide superior credits due to the maintenance of the large stores of soil C and low methane flux
Projected land change 2012-2050 (moderate scenario)
Projected land 2050 (moderate scenario)
Carbon Storage Capacity Over Time
Using Wetland Vegetation Zone Maps & CRMS Data

Atchafalaya 47% ↑

Terrebonne 42% ↓
River Re-introduction
Carbon Credits as a Mechanism to Fund Coastal Restoration?