SOIL ORGANIC MATTER CYCLING IN EVERGLADES PEATLANDS

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Contrasting the EAA and Everglades Wetlands

- **Everglades Agricultural Area**
  - Drained conditions
  - Aerobic decomposition
    - CO₂ endproduct
  - Soil and nutrient loss

- **Everglades wetlands**
  - Flooded conditions
  - Anaerobic decomposition
    - CO₂, CH₄, N₂O endproduct
  - Nutrient inputs
  - Soil accretion
Soils of the Everglades Agricultural Area

• Originated under sawgrass prairie
• Organic (>80% organic matter by weight)
• Naturally P limited
• Oxidation of the organic soil resulted in historical loss of 3 cm/yr and current loss of 1 cm/year
  - related to water table depth
  - calcification of surface soil, elevated pH
  - enhances nutrient retention in forms unavailable to crops
  - water management increasingly critical
  - may limit land-use options in the future
CLASSIFICATION OF MUCK SOILS RELATIVE TO THICKNESS OF ORGANIC LAYERS OVER BEDROCK

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terra CEIA</td>
<td>150</td>
</tr>
<tr>
<td>Pahokee</td>
<td>120</td>
</tr>
<tr>
<td>Lauderhill</td>
<td>60</td>
</tr>
<tr>
<td>Dania</td>
<td>10</td>
</tr>
</tbody>
</table>

The graph shows the soil depth in centimeters for different locations: Terra CEIA, Pahokee, Lauderhill, and Dania. Terra CEIA has the deepest soil depth, while Dania has the shallowest.
GREENHOUSE GAS EMISSIONS

- Preflooding 2 weeks
- Treatment (24 weeks)
  - DD: Continuously drained
  - FF: Continuously flooded
  - SS: S draining + S flooding 6 cycles
  - SL: S draining + L flooding 4 cycles
  - LS: L draining + S flooding 4 cycles
  - LL: L draining + L flooding 3 cycles
- Gas flux
  - Over 1 h
  - Twice a week
  - Extra measurements flooding/draining events

Duration:
S: Short-term (2 weeks)
L: Long-term (4 weeks)
Average Daily Gas Fluxes

**CO₂**

![Graph showing CO₂ fluxes for different soil conditions](graph1.png)

**N₂O**

![Graph showing N₂O fluxes for different soil conditions](graph2.png)

**CH₄**

![Graph showing CH₄ fluxes for different soil conditions](graph3.png)
Global Warming Potential

- **CO₂**: 92-98%
- **N₂O**: 2-6%
- **CH₄**: < 2%

![Bar chart showing Global Warming Potential (GWP) with CO₂, N₂O, and CH₄ emissions.](image)
Global Warming Potential

Continuously drained  

Continuously flooded

GWP (CO$_2$ m$^{-2}$)

Hydroperiod (d)

$R^2 = 0.971$

$P < 0.001$ ***

Continuously drained

Continuously flooded

DD  FF  SS  SL  LS  LL

$R^2 = 0.971$

$P < 0.001$ ***
Managing Soil Organic Matter in the EAA

- Soil loss through oxidation
- Maintenance of high water tables retard decomposition
- Nutrient dynamics/fertilization
  - pH increases
- Seasonal flooding
  - New cropping systems/crops
- Organic matter addition
  - Compost/manure/mill mud
  - Green cane harvesting
Soil Organic Matter Decomposition in Everglades Wetlands

- Soil organic matter
- Enzyme Activity
- Dissolved organic C
- Electron donors
- Nutrient Addition and Hydrologic condition
- Aerobic Respiration
- Denitrification
- Sulfate Reduction
- Methanogenesis
SOIL ACCRETION PATHWAY

ABOVE-GROUND

Inflow
Water
Soil

Live
Standing Dead
Litter

New Soil

BELOW-GROUND

Live
Dead
RECENTLY ACCRETED SOIL DEPTH DETERMINATION

- Mean RAS depths in STA cells with variable vegetation
- Avg. RAS depth for STA-1W, STA-2 and STA-3/4 was 15 ± 5, 11 ± 3 and 10 ± 4 cm
SOIL ACCRETION

- Mean RAS depth is 10 – 15 cm
- Soil accretion rate range is 1.0 – 1.7 cm yr\(^{-1}\)
- Phosphorus accretion rate for these STAs ranged from 1.3 - 3.0 g P m\(^{-2}\) yr\(^{-1}\)
- Soil and phosphorus accretion rates showed decline through time
Greenhouse Gas Production in WCA-2a

**CO₂ and CH₄ Production (mg C kg⁻¹ h⁻¹)**

- **Impacted**: 1.4 - 3.3
- **Transitional**: 4.2 - 7.0
- **Unimpacted**: 8.4 - 10.1

**Methanogenesis - CO₂**
- Aerobic
- Nitrate reducing
- Sulfate reducing

**Methanogenesis - CH₄**

**Distance from Inflow (km)**

- 0
- 20
- 40
- 60
- 80
- 100
- 120
- 140

**CO₂ and CH₄ Production (mg C kg⁻¹ h⁻¹)**

- **k₁**
- **k₂**

**Graph Key**
- Aerobic
- Nitrate reducing
- Sulfate reducing
- Methanogenesis - CO₂
- Methanogenesis - CH₄
Greenhouse Gas Production in WCA-2a

Drained conditions
\[ y = 0.07x + 52 \]
\[ R^2 = 0.58 \]

Flooded conditions
\[ y = 0.06x + 26 \]
\[ R^2 = 0.72 \]
Conclusions

- **Soil Accretion and loss**
  - EAA – soil loss of 0.5 cm/yr
  - Wetlands – soil accretion of 1-2 cm/yr

- Aerobic decomposition dominates in EAA
  - regulated by $O_2$

- Anaerobic decomposition dominates in wetlands
  - dependent upon electron acceptor inputs

- Pathways of organic matter decomposition change with trophic state
  - Methanogenesis at interior of wetlands

- Higher catabolic activity in P-impacted wetlands
  - Nutrient generation
  - Internal load
  - Greenhouse gas production