Plant biomass carbon inputs, losses, and storage in re-established marshes in the Sacramento-San Joaquin Delta

By Robin L. Miller
Location of Sacramento-San Joaquin Delta in California and depth of subsidence
Demonstration Project 1997–present

- Two 3 ha wetlands
- Continuously flooded
- Non-tidal system
- Water management

Measurements include:

Land-surface elevation change and sediment accretion:
- Plant biomass production
- Decomposition of organic matter
- Gaseous CO2 and CH4 fluxes
- Environmental Factors (i.e. pH, temperature, dissolved oxygen, etc.)
Change in elevation over time by wetland environment

- 25 cm deep wetland
- 55 cm deep wetland-mash
- 55 cm deep submerged and floating
mid season standing live biomass

Dry wt (g/m²)

Year

Scirpus litter in 55 cm deep water

- Proportion left vs. days of decomposition
- Decomposition rates slowed over time.
- Early decomposition was slower in the 25 cm deep wetland.
- Later decomposition was slower in the 55 cm deep wetland.
DDV: Location of decomposition bags in the 55 cm deep wetland
DDV: Scirpus decomposition by location and vegetation

- inlet submergent
- mid submergent
- inlet marsh
- mid marsh
- 25 cm marsh

Days of decomposition vs. percent remaining

- Y-axis: percent remaining
- X-axis: days of decomposition
Average water temperatures in marsh and submergent vegetation (4/30/06-5/2/06)

- Emergent marsh surface
- Submergent vegetation surface
- Emergent marsh midpt (-18 cm)
- Submergent vegetation midpt (-30 cm)
water temperature in emergent marsh by location (April 30 - May 2, 2006)

- Inlet marsh surface
- Mid marsh surface
- Inlet marsh mid depth (-18)
- Mid marsh mid depth (-18)
## Spatial variability in wetland environments

<table>
<thead>
<tr>
<th></th>
<th>Submergent Vegetation</th>
<th>Emergent Marsh Edge</th>
<th>Emergent Marsh Interior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water residence time</td>
<td>Shortest</td>
<td>Mid</td>
<td>Longest</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>Warmest</td>
<td>Cooler</td>
<td>Coolest</td>
</tr>
<tr>
<td>pH</td>
<td>Highest</td>
<td>Lower</td>
<td>Lowest</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Highest</td>
<td>Lower</td>
<td>Lowest</td>
</tr>
<tr>
<td>NO3 (river source)</td>
<td>Available</td>
<td>Absent/Available</td>
<td>Absent</td>
</tr>
<tr>
<td>SO4 (river source)</td>
<td>Available</td>
<td>Available</td>
<td>Depleted/Absent</td>
</tr>
<tr>
<td>H2S</td>
<td>Absent</td>
<td>Elevated/Absent</td>
<td>Absent/Increased</td>
</tr>
<tr>
<td>Fe (sediment source)</td>
<td>Low</td>
<td>Low/Increased</td>
<td>Elevated</td>
</tr>
<tr>
<td>Decomposition rate</td>
<td>Fastest</td>
<td>Slowed</td>
<td>Slowest</td>
</tr>
</tbody>
</table>
Correlations among wetland environmental factors (p<0.0001)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Correlation</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>DO</td>
<td>positive</td>
<td>0.755</td>
</tr>
<tr>
<td>NO₃</td>
<td>DO</td>
<td>positive</td>
<td>0.533</td>
</tr>
<tr>
<td>SO₄</td>
<td>Total Fe</td>
<td>negative</td>
<td>-0.467</td>
</tr>
<tr>
<td>pH</td>
<td>SO₄</td>
<td>positive</td>
<td>0.454</td>
</tr>
<tr>
<td>pH</td>
<td>Total Fe</td>
<td>negative</td>
<td>-0.395</td>
</tr>
</tbody>
</table>

- pH indicative of relative wetland biogeochemistry
- 25 cm deep wetland had lower pH than the 55 cm deep wetland, but more sulfate and less iron.
- Shorter water residence time in shallower wetland influencing biogeochemistry; river water source of sulfate to wetlands.
Marsh CH₄ emissions are positively correlated to pH (coefficient = 0.333, only temperature, water depth and season stronger).

Wetland pH correlated to CO₂:CH₄, such that lower pH decreases CH₄ loss relative to CO₂ uptake (coefficient = 0.354, only water depth and plant number stronger).
plant methane effluxes by location in 25 cm deep wetland

P=0.0003
Gaseous C fluxes in re-established wetlands and drained peat

![Graph showing gaseous C fluxes over time]

- CH4 flux through plants
- CO2 uptake
- Diffusive CO2 flux
- Ag field CO2

Dates: 15-Mar-00, 01-Oct-00, 19-Apr-01, 05-Nov-01, 24-May-02, 10-Dec-02, 28-Jun-03, 14-Jan-04.
Greenhouse gas balance of CO2 uptake and CH4 loss in wetlands, where CH4 has 25x the GWP of CO2.
Conclusions

- Re-establishing marshes in the Delta can restore conditions for carbon storage and reverse subsidence.
- The plant community significantly affected the wetland environment and accretion rates.
- Decomposition rates of marsh vegetation slowed over time, and differed by location with the slowest decomposition occurring in the marsh interior, where water residence time was greatest.
- Wetland pH significantly decreased over time, was significantly related to decomposition rates, and was strongly correlated to methane emissions and the availability of electron acceptors, including DO, NO$_3$, NO$_4$, and Fe.
- Methane emissions affect the GHG balance of marshes, but spatial variability suggests hydrologic management potential.
- Measurements of gaseous C fluxes suggest the carbon storage potential of these wetlands can counterbalance the effects of methane losses, particularly when stop loss of CO$_2$ and N$_2$O* from drained peat is taken into account.
Thank you!

- Great thanks to the California Department of Water Resources for funding this research.
- Many thanks to the many hands that have helped with this study.