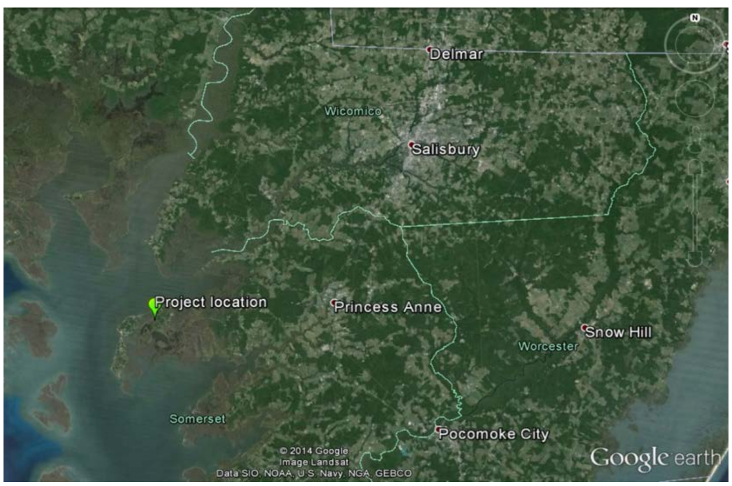
Validating a Model for Methane Emissions in Brackish Marshes for Use in Carbon Crediting

Methane is a potent greenhouse gas that may offset a significant portion of the carbon sequestration benefit of many brackish marshes. Methane emissions from tidal, brackish wetlands are not well understood, and measuring these emissions is time-intensive and expensive. Previous work has determined negligible methane emissions from polyhaline systems (salinity > 18 ppt); however, rates of methane emission in marshes of lower salinity can be highly variable (Poffenbarger et al. 2011). A carbon crediting methodology for tidal wetland restoration is currently being developed for the Verified Carbon Standard. This methodology does not have a default value for methane emissions from brackish marshes due to this high variability. The methodology does allow for the modeling of methane emissions from these systems; this is likely to be the most cost-effective solution to estimate these emissions. We will calibrate and validate an addendum to the Marsh Equilibrium Model (MEM) to estimate methane emissions from brackish marshes using field and laboratory data gathered from two field sites on the Deal Island Peninsula located in Somerset County, MD (Figure 1). This would be the first time that a model was calibrated and validated to estimate methane emissions that would meet the requirements of the Verified Carbon Standard methodology.

Figure 1: Project Location



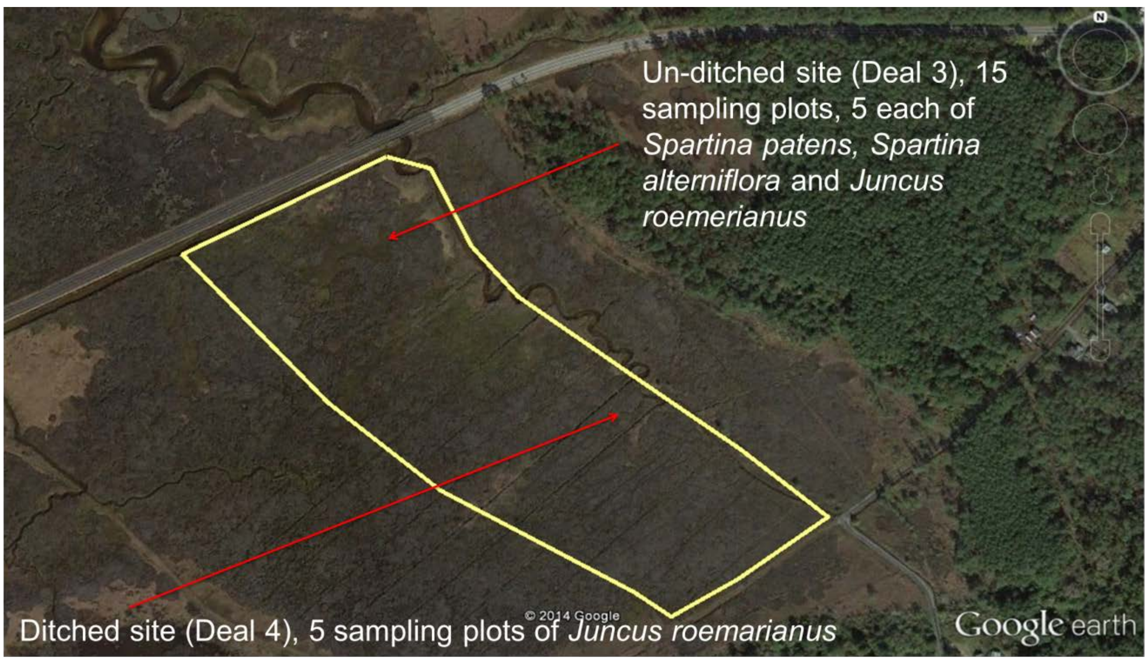
Currently, the Marsh Equilibrium Model uses above and below ground biomass production, inundation and relative sea level rise, and sediment load data to predict future marsh elevation change. This model can be easily calibrated to marshes with intensive data sets (Schile et al. 2014). The model is being appended to estimate the annual flux of methane emissions, which will allow carbon creditors to determine their emissions without performing more costly direct monitoring. MEM is an excel based model, and is available online for public use (jellyfish.geol.sc.edu/model/marsh/mem.asp).

Site description

Our field sites are located on the Deal Island Peninsula on the Eastern Shore of Maryland. Sites were selected to represent two hydrology and two vegetation conditions: low and high marsh (frequent and less frequent inundation, respectively) and two different plant species. All sites contain five methane sampling plots. The first site is located at "Deal 4" (Figure 2), which is a ditched tidal wetland that was restored in 2014 by plugging the ditches. This marsh is primarily vegetated with *Juncus roemerianus* (black needlerush). The ditching and subsequent plugging in this marsh area has led to frequent inundation of the marsh surface. This site is the "low *J. roemerianus*" hydrology/plant treatment.

The other three sites are located at "Deal 3", an unditched marsh with more varied vegetation than Deal 4. The dominant species in this marsh are *Spartina patens* (saltmeadow cordgrass), *Spartina alterniflora* (smooth cordgrass), and *Juncus roemerianus*. Each species represents a different elevation/hydrology regime, with *S. patens* and *J. roemerianus* being higher than the *S. alterniflora* areas. The *J. roemerianus* site at this marsh represents the "high *J. roemerianus*" hydrology/plant treatment. The *S. patens* site is the "high *Spartina*" hydrology/plant treatment, while the five *S. alterniflora* site is the "low *Spartina*" hydrology/plant treatment.

Figure 2: Deal 3 and 4



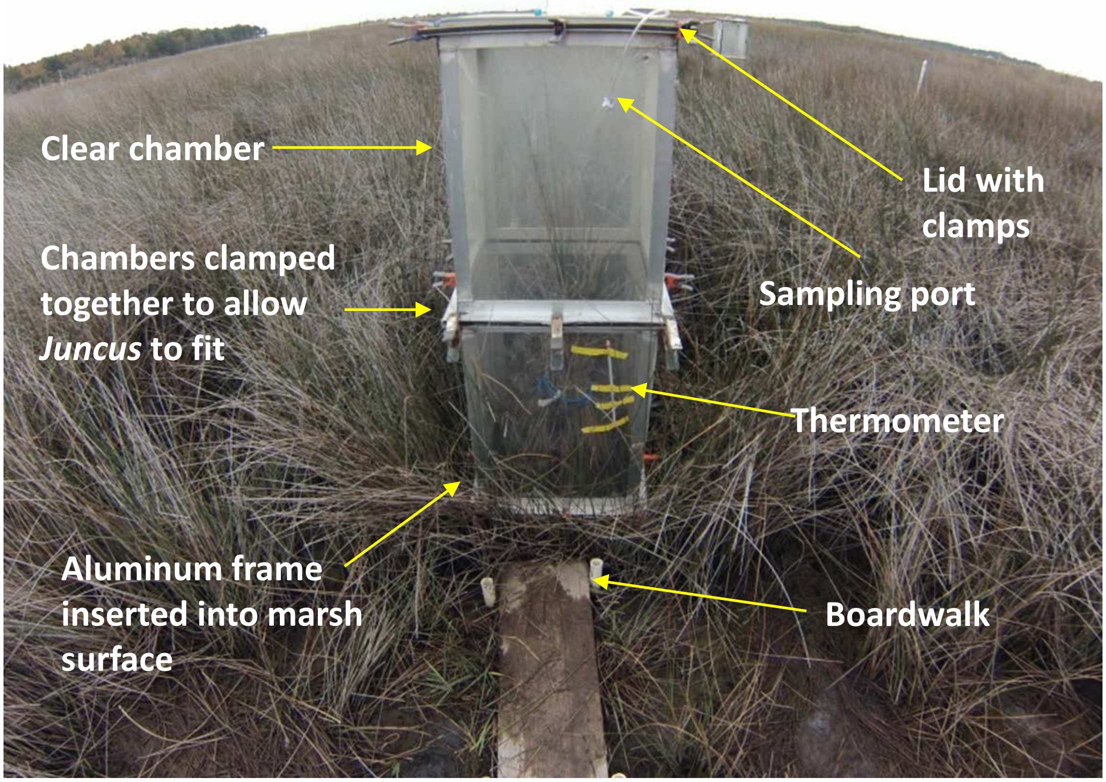
Field Methods

We will sample each site monthly for one year, except for winter months (December-March), when methane production is assumed to be minimal. Sampled parameters at each plot will include methane flux, air temperature, water level and temperature, inundation period, porewater, and soil temperature. Porewater samples will be taken at 10-cm depth, and will be sampled for porewater methane, pH, conductivity, ammonium, phosphate, sulfate and hydrogen sulfide. One porewater sample will be collected at each plot on each field sampling visit.

Methane flux samples (air sample and air temperature) will be conducted over a one-hour period for each sample. Each air sample will be withdrawn from the chamber from a sampling port (see Figure 3) and stored in an exetainer vial until analyzed using gas chromatography.

Porewater methane will be collected and stored in exetainers for analysis with air methane flux measurements. Conductivity, pH and hydrogen sulfide samples will be analyzed as soon as possible after collection, while all other porewater samples will be frozen and parameters analyzed during the winter. In addition to the above samples, we will collect soil cores from each cover type to be analyzed in the lab over the winter. Soil samples will be collected at estimated peak emissions, in July or August 2015. These samples will be kept in an anaerobic state at low temperature until they are processed. When processed, the soil organic matter will be removed and incubated in controlled anaerobic conditions to estimate the ratio of carbon dioxide production to methane production. This ratio is crucial to the function of the MEM Methane addendum.

Figure 3: Methane Flux Chamber



<u>Current Project Status</u>

The project is currently underway, with collections of emissions data scheduled to begin in spring 2015, during the second semester of my Master's thesis program. Our four study sites have been identified; the 20 plots were selected in June, 2014. The metal frames for the attachment of the sampling chambers were installed in August, 2014. Boardwalks for access to the study site were also installed in August, 2014. A trial run of methane flux sampling was conducted in late October, 2014, and was a successful demonstration of the field methods that will be used this coming year.

Benefits to Coastal Wetlands

The potential for wetlands to store carbon is well understood (Chmura et al. 2003). However, without the ability to estimate the emissions of methane from tidal brackish wetlands, carbon creditors will not be able to receive funding for this ecosystem service. This study is the first test of a technique to estimate these emissions without direct monitoring. With further refinement, this model could be applied to tidal wetland systems worldwide, greatly increasing the knowledge of how these ecosystems both store carbon, and release methane into the atmosphere. Validation of the MEM Methane addendum will also allow for easier carbon crediting for tidal wetland restoration projects, therefore decreasing the restoration costs and making these projects more attractive and affordable.

Use of Scholarship Funds

This scholarship will fund the water level and inundation portion of the project. Accurate water level and inundation data are a very important parameter for both the marsh equilibrium model, and the site specific rates of methane emissions. Having localized water level data for each different vegetation type will provide the model with the necessary data it needs in order to generate the predicted methane emission rates compared to the actual emission rates we will measure. I am predicting a total cost of $4,963 for equipment necessary to collect water level data at all four vegetation types (Table 1).

Table 1. Proposed Use of Funding

Item	Cost (USD)	Number Needed	Total Cost (USD)
HOBO Water Level Logger, Model: U20L-01	299	10	2990
HOBOware Pro Software	99	1	99
HOBO Logger Base Station, Model: Base-U-4	124	1	124
Waterproof Laptop Case	150	1	150
Semi-Rugged Field Laptop	1600	1	1600
Total			4963

Output and Research Sharing

If successfully validated, the methane component of the Marsh Equilibrium Model will be able to be used by carbon creditors who wish to gain carbon credits through tidal wetland restoration. This study will be the first test of this model, and will validate it for use in similar tidal wetlands in the Chesapeake Bay. Two chapters of my Master's thesis will be submitted as manuscripts to peer-reviewed journals. The first will describe methane emissions of this brackish tidal wetland ecosystem as a function of hydrology over the one year sampling period. The second publication will describe how well the model was able to estimate these emissions as a function of hydrologic and plant species variability. Additional information describing why and how the model performed in the manner it did will also be included in this publication. The results of this study will be presented at multiple national wetland conferences, as well as workshops in the rapidly expanding field of blue carbon.

References

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Schile LM, Callaway JC, Morris JT, Stralberg D, Parker VT, et al. (2014) Modeling Tidal Marsh Distribution with Sea-Level Rise: Evaluating the Role of Vegetation, Sediment, and Upland Habitat in Marsh Resiliency. PLoS ONE 9(2): e88760. doi:10.1371/journal.pone.0088760

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