Landscape Attributes, Hydrology, and Edaphic Conditions of Southern New England Vernal Pool Wetlands

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Introduction

Wetlands are estimated to store 20-30% of the earth's terrestrial carbon pool. One of the current debates is whether wetlands serve as sources or sinks of carbon and which carbon form of greenhouse gas, carbon dioxide (CO_2) or methane (CH_4), is released from wetland soils. Typically, wetland soils accumulate more soil organic matter (SOM) over time than upland soils because of the long periods of saturation that result in anaerobic conditions in these soils, ultimately slowing decomposition rates. Highly anaerobic conditions, however, lead to the formation of CH_4, which is a much more potent GHG. In this study, we examine decomposition of soil organic matter (SOM) and measured fluxes of CO_2 and CH_4 from vernal pools in southern New England. Vernal pools are small isolated wetlands that typically covered by shallow water in the winter and spring, and completely dry for most of the summer and fall. The small size of vernal pools and the seasonal and spatial variations between ponding, saturation, and unsaturated conditions, allows for focused studies on the impact of hydrology on organic matter decomposition and GHG fluxes over short distances.

Objectives

The purpose of this study was to investigate the relationship between hydrologic regime and key wetland processes. We examined the rate of organic matter decomposition in the different hydrologic zones of the vernal pools. We also investigated whether the unique hydrologic characteristics vernal pools cause their CO_2 and CH_4 fluxes to differ.

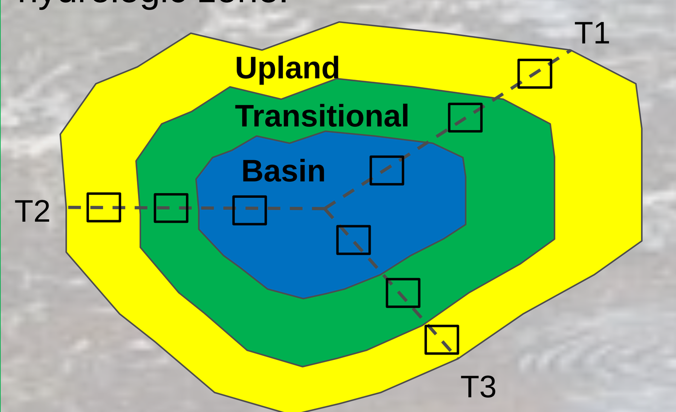
Methods

Site Selection

Four vernal pools were selected throughout the Pawcatuck River Watershed in southern Rhode Island. Pools were selected based on hydroperiod and soil parent material.

Experimental Design

Three hydrological zones were defined and identified in each vernal pool site, based on the wetland's predominant edaphic, hydrologic, and botanical characteristics. Three transects were established at each of the four vernal pools. On each transect, three research plots were established, one in each hydrologic zone.



Basin: Seasonally ponded in winter and spring, hydric soils present

Transitional: No significant ponding; saturated soils present

Upland: Area surrounding vernal pool; no hydric or saturated soils present

Sample Collection

Research was conducted along T1.

Organic Matter Decomposition

Five replicate nylon mesh leaf-litter bags filled with dried, pre-weighed leaves and five pre-weighed northern white birch dowels were secured at the soil surface at each plot and removed three months later. The leaf litter bags and dowels were dried at 60ºC and weighed in order to determine the loss of organic matter over time.

GHG Flux

Two PVC collars were inserted at each research plot at least one week prior to sampling. The collars were closed to the atmosphere and three gas samples were obtained from each collar within a period of 30 minutes (T0, T15, and T30) in order to measure CO_2 and CH_4 flux over time. Gas samples were analyzed with a Shimadzu gas chromatograph.

Hydrologic Measurements

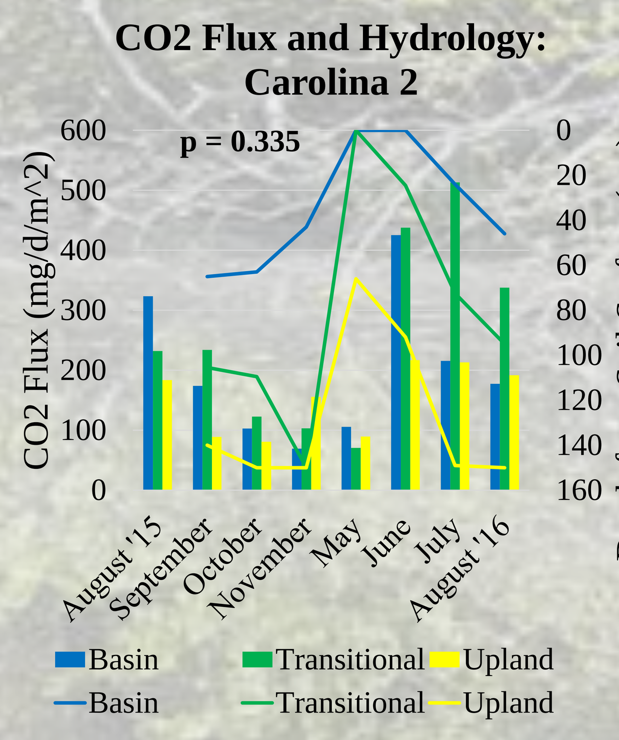
One well was installed at each research plot and manual water table measurements were taken monthly at each well.

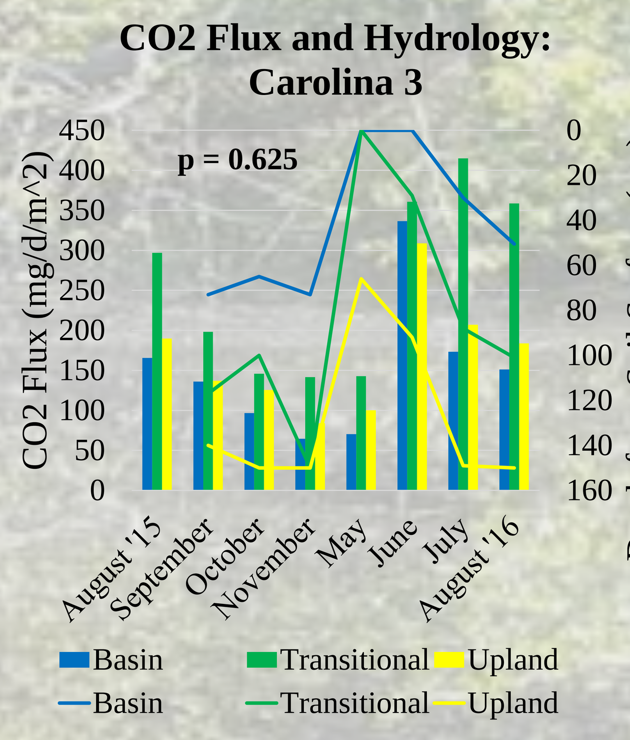
Statistical Analysis

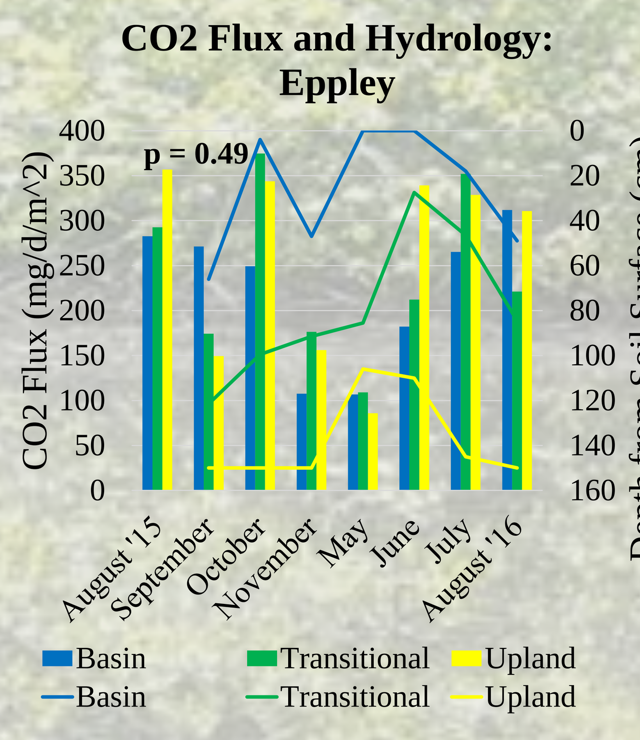
One-way ANOVAs were performed using R statistical software in order to explore the impact that hydrologic zone has on gas flux and organic matter decomposition.

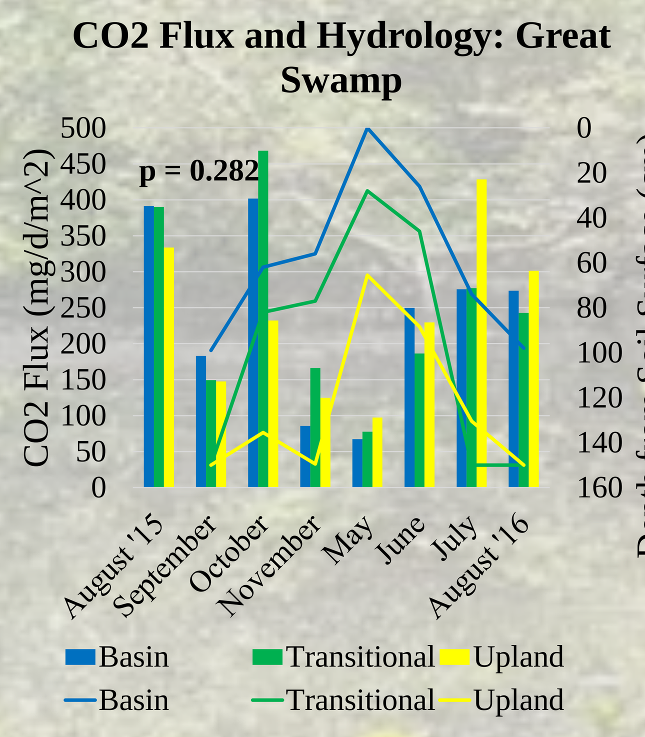
Results and Discussion

GHG Flux



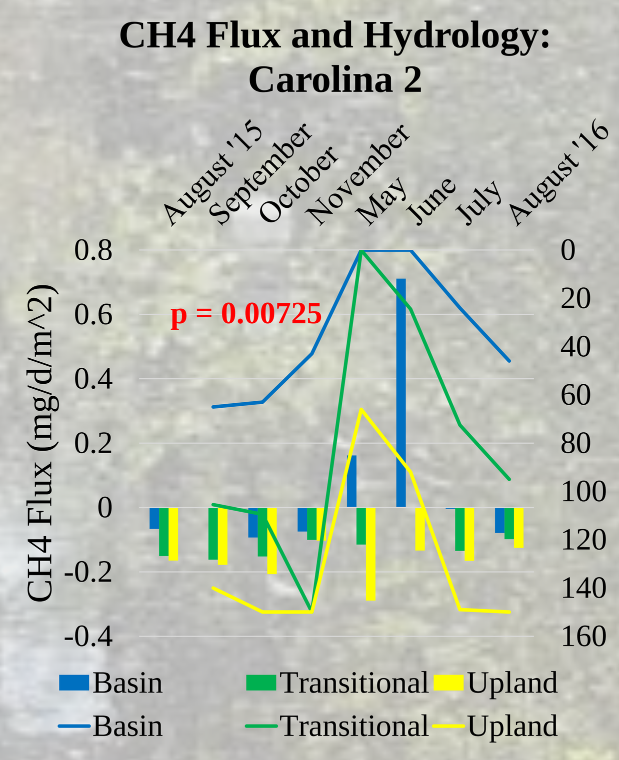


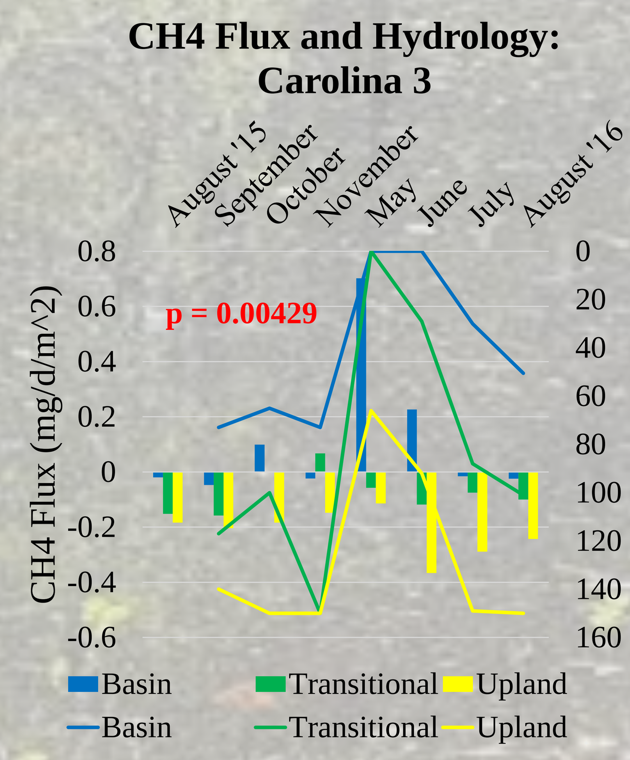


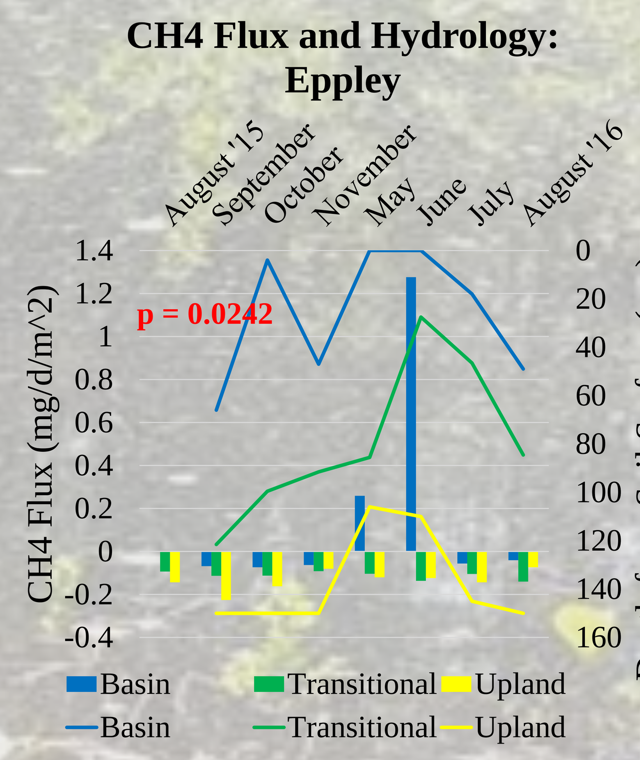


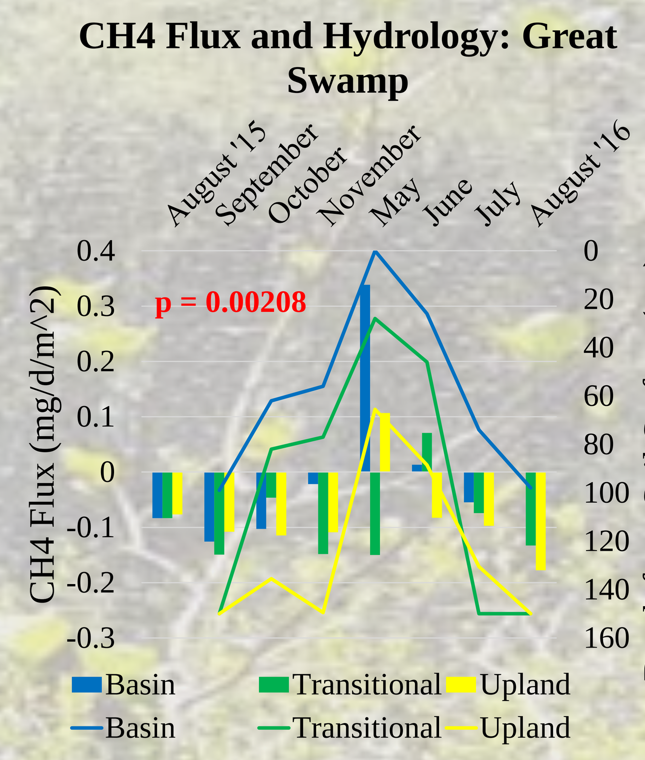
No significant relationship between water table level and CO_2 flux in any study sites (p-values > 0.04).

CO_2 flux generally decreased with decreasing temperatures in 2015. Seasonal flux trends were not consistent across all pools in 2016.





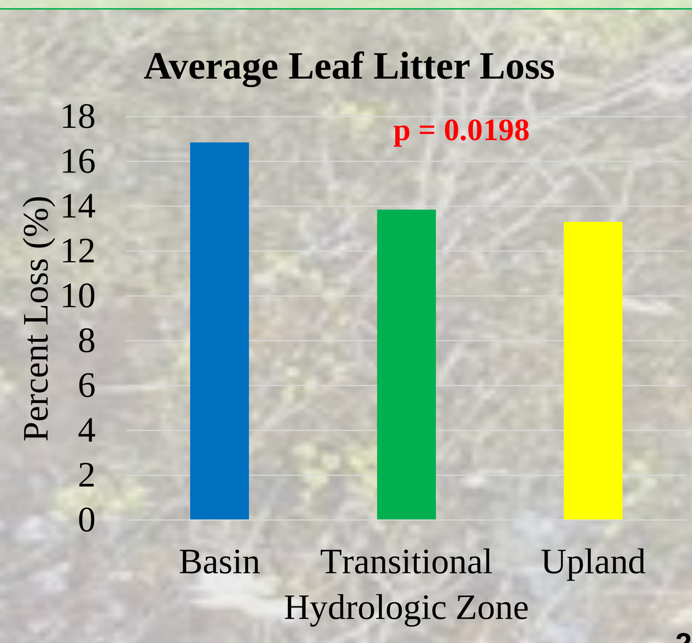


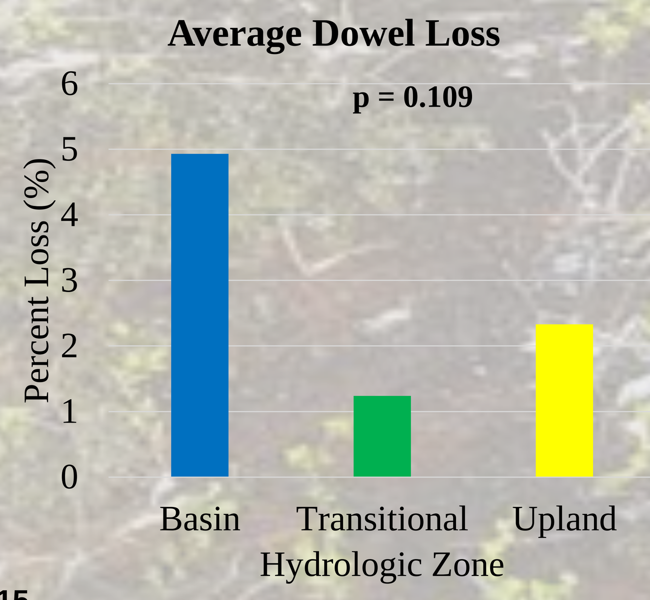


Significant relationship between water table level and CH_4 flux in all study sties (p-values < 0.03).

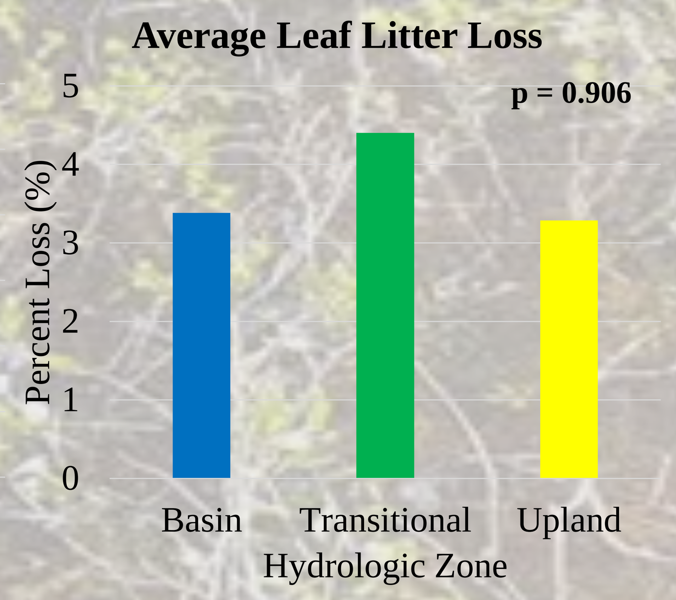
CH_4 emissions only occurred when vernal pools were ponded. Emissions in the basins during ponding typically exceeded the amount of CH_4 absorbed by the basins at other times during the year.

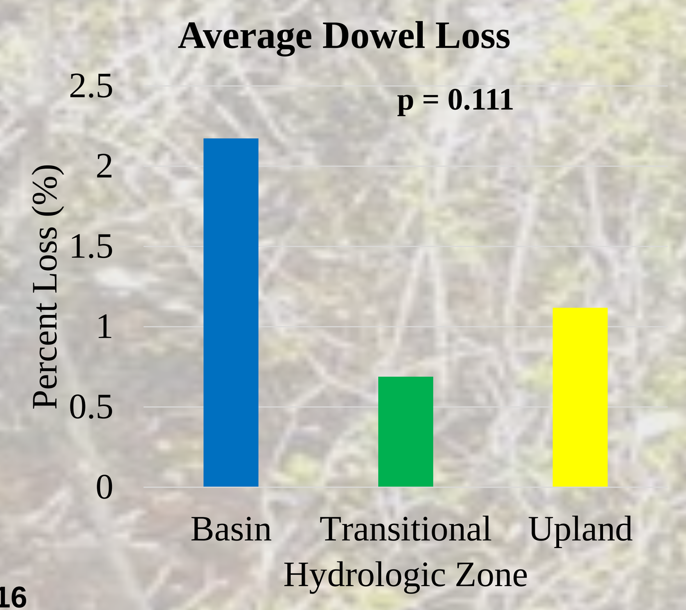
Organic Matter Decomposition





2015





2016

Significant relationship between hydrologic zone and leaf litter decomposition in 2015 (p = 0.0198).

No significant relationship between hydrologic zone and dowel decomposition in 2015, or leaf litter or dowel decomposition in 2016 (p > 0.04).

2015 trends revealed that increased decomposition occurred in the basin. Consistent trends were not found in 2016.

Conclusions

- During the wettest months of the sampling period (May and June), the basin zones of each pool were ponded and exhibited a positive CH_4 flux, highlighting the likeliness for vernal pool basins to serve as a source of the greenhouse gas CH_4 to the atmosphere during periods of extended ponding.
- We expected lower CO_2 fluxes in the basins than in the uplands, but found no significant difference between water table depths and CO_2 flux, which suggests that other factors may have a greater influence on soil respiration. Concurrent studies are investigating whether differences in autotrophic vs. heterotrophic CO_2 respiration could explain the lack of differences.
- The data in 2015 revealed trends between soil water table level and organic matter decomposition. Both the dowel and litter bag studies showed that the vernal pool basins exhibited the most decomposition. Excessively dry soil conditions in the upland may have induced stress in the microorganisms responsible for decomposition, slowing the process. Increases in soil moisture fuel microbial decomposition, increasing decomposition speeds until anaerobic conditions occur, at which point decomposition rates slow again. The markedly high temperatures of the summer of 2015 may have prevented anaerobic conditions from forming at the soil surface, allowing the increased basin moisture to fuel decomposition rather than inhibit it. The small percent of leaf litter and dowel weight lost in 2016 may have prevented an accurate comparison between hydrology and decomposition rates. Leaving the litter bags and dowels in the vernal pools for a longer period of time might allow for a more accurate assessment of decomposition over time.