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Investigating the Effects of Salinity on Soil Carbon, Bulk Density, and Species Diversity of Brackish and Freshwater Marshes in the Chesapeake Bay Watershed

Abstract:

This study investigates how salinity effects important ecological and soil properties in brackish and freshwater marshes within the Chesapeake Bay watershed. Soil carbon, bulk density, and species diversity are critical indicators used in determining the composition of a wetland as well as its health and function. Marshes are fragile ecosystems and sensitive to changes in variables like salinity and understanding the effects of salinity on these ecosystems in important for managing them. Soil and vegetation data was collected from both brackish and freshwater marshes across different salinity gradients within the watershed. It was revealed that higher salinity levels significantly alter soil carbon storage. Brackish marshes exhibited a higher organic carbon content than freshwater marshes, most likely due to slower decomposition rates in saline conditions. Bulk density was found to be higher in freshwater marshes, likely due to denser, more compacted soils with lower organic matter content. Species diversity showed a clear inverse relationship with salinity, with freshwater marshes supporting more diverse plant communities than brackish marshes. These results emphasize the complex relationship between salinity and marsh ecosystem processes and highlight the influence salinity has in soil and biodiversity dynamics. The study emphasizes the need for continued monitoring and management of marsh habitats in the Chesapeake Bay to preserve their ecological functions in the face of rising salinity levels linked to sea-level rise and other environmental changes.

Introduction:

Tidal wetlands are dynamic ecosystems that are influenced by tidal cycles which regulate water and salinity levels. They play a critical role in nutrient cycling, water filtration, and habitat making them an important ecosystem to study. The Chesapeake Bay watershed has several types of tidal wetland with its range. The Chesapeake Bay Environmental Center is a tidal brackish marsh, meaning it has a higher salinity level than the freshwater marsh investigated at the Patuxent Wetland Park.

Bulk density and organic matter are two important descriptors in determining the composition of a wetland. They are also used to determine the amount of carbon in the soil as well as potential carbon sequestration which is an important metric for understanding the ecosystem services of a wetland and how to value it (Hansen and Nestlerode, 2013). Carbon sequestration is a vital service that wetlands provide for mitigating climate change. Salinity is also a key factor in determining the type of wetland it might be. In this study, we explore how salinity's influence on soil properties and biodiversity across two types of wetland.

Tidal salt marshes have lower species diversity and different dominant species than freshwater marshes due to higher salinity levels requiring adapted plants (Odum, 1988, Leck & Leck, 2005, Perry & Hershner, 1999). In addition, soil bulk density is higher in brackish marshes compared to freshwater marshes due to the higher density of salt and minerals in the water (Wang, 2016).

Carbon stocks in freshwater marshes are also expected to be higher than soil carbon stock in brackish marshes due to slower decomposition rates (Baustian, et al., 2017). Understanding these interactions is important for managing and predicting how wetlands will respond to changing environmental conditions like climate change and rising sea levels.

Methods:

Data was collected from two sites. The Chesapeake Bay Environmental Center (CBEC) provided data for brackish marshes while the Patuxent Wetland Park (PWP) provided data on freshwater marshes. Each site had 3, 100m2 plots making 6 total plots that data was collected per group. Data was shared across groups, totaling 18 sets of data from each site.

Each site was marked with a measuring tape to make a 100m2 plot and remained marked as it was worked in. Soil samples were collected in each plot with a soil core cutter and soil knife and were later dried and weighed in the lab to determine bulk density and organic matter of the soil with analyses run in R studio and Excel. One sample was taken with a deeper auger at each location (CBEC and PWP) until the point of resistance was reached. The soil was dried and weighed to determine percent carbon in the soil. At the CBEC location the deepest sample taken was at 65cm while at PWP it was 300cm. Vegetation was identified with the help of a field guide (Tiner RW, 2009) and iNaturalist. Percent cover was estimated after all known vegetation was identified within the plot and visualized through charts made in Excel. Water depth was measured using a measuring stick while salinity was tested through a salinity refractometer and compared to other variables in excel and R studio.

Results:

The auger samples showed CBEC had 0.043 gC/cm3 while PWP was 0.027 gC/cm3 (Figure 3). The organic matter in the large auger sample at CBEC was 56.98% while at PWP it was 17.35% (Figure 3). The small soil samples across the 18 sites showed average bulk density of 0.071 g/cm3 at CBEC site and 0.185 g/cm3 at the PWP site (Figure 4). The t-test showed a p value <0.05 for both bulk density and organic matter, indicating that there is statistical significance (Figure 4). Salinity was higher in the brackish marsh at CBEC at 18% while the freshwater marsh at PWP was 2% (Figure 2). The dominant species in CBEC was *Juncus roemerianus* or more commonly black needle rush while the dominant species in PWP was *Nuphar lutea* or more commonly spatterdock (Figures 6 & 7).

Discussion:

It was found that percent carbon was higher in the brackish marsh at the CBEC location. There are several reasons for this, including higher salinity which was also found in the brackish marsh. Higher salinity levels cause decomposition to be slower, which prevents the carbon dioxide from being released into the atmosphere and instead allows it to stay in the soil (Baustian, et al., 2017). Slower decomposition rates also leads to higher amount of organic matter which was supported in our results (Richardson & Vepraskas, 2001). In addition, saline tolerant plants often have a higher productivity and larger biomass compared to freshwater marshes. However, the bulk density was higher at the freshwater marsh at the PWP. This is due to the large amounts of organic material which has a higher bulk density (Wang, 2016). The plant species differed across each site as well and the dominant species in each location were different due to the salinity of the marshes (Odum, 1988, Engels, 2010). The freshwater marsh had more plant diversity and was more spatially balanced than the brackish marsh which had fewer species, and the dominant species was much more prevalent than the rest of the species identified.

Figures and Tables:

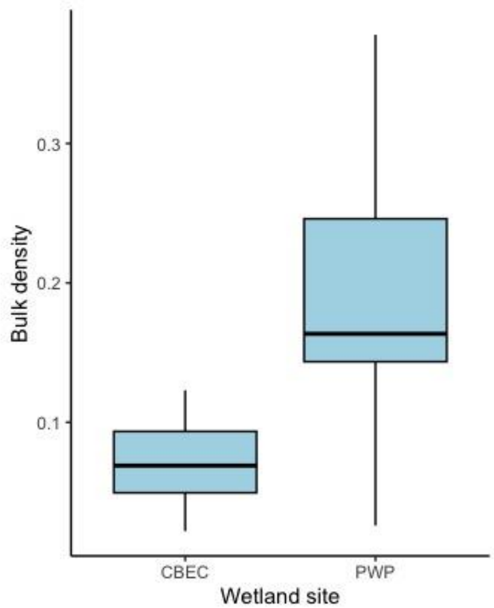

Figure 2: Bulk density in each location

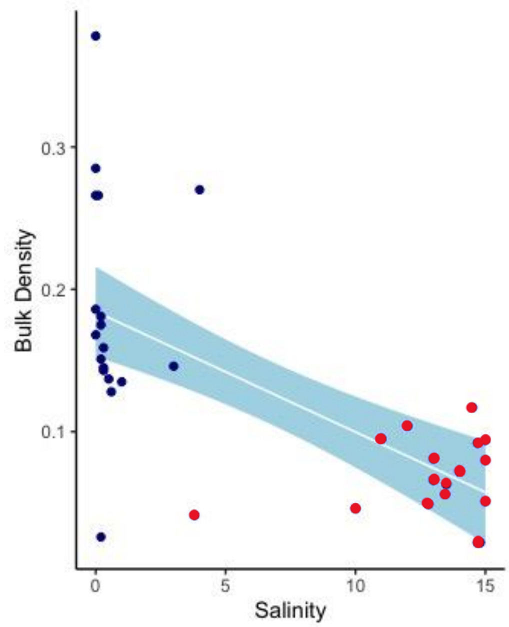

Figure 1: Salinity and bulk density across both locations with confidence level shaded light blue. CBEC salinity labeled with red dots, PWP salinity labeled with blue dots.

Site	Core depth (cm)	Wetland size (ha)	Total C in entire core (g/cm2)	Total C in core to 1 m depth (g/cm2)	Total C in the Wetland (Mg)	Total C in the Wetland to 1 m depth (MgC)	Soil C density across entire core (gC/cm3)	Organic matter across the entire core (%)
CBEC	65	701.2	2.13	2.13	149342	149342	0.043	56.98
PWP	300	410.2	7.45	4.75	305671	194625	0.027	17.35

Figure 3: carbon and organic matter data from auger at CBEC and PWP site

	Site	t-test results

	Tidal Brackish (CBEC)		Tidal Freshwater (PWP)		|t|	df	P
	Mean	SE	Mean	SE			
Bulk Density (g/cm3)	0.071	0.0070	0.185	0.0188	-5.709	22	9.65E-06
Organic Matter (%)	49.17	2.852	38.19	4.571	2.037	28	0.0512

Figure 4: bulk density and organic matter across sites

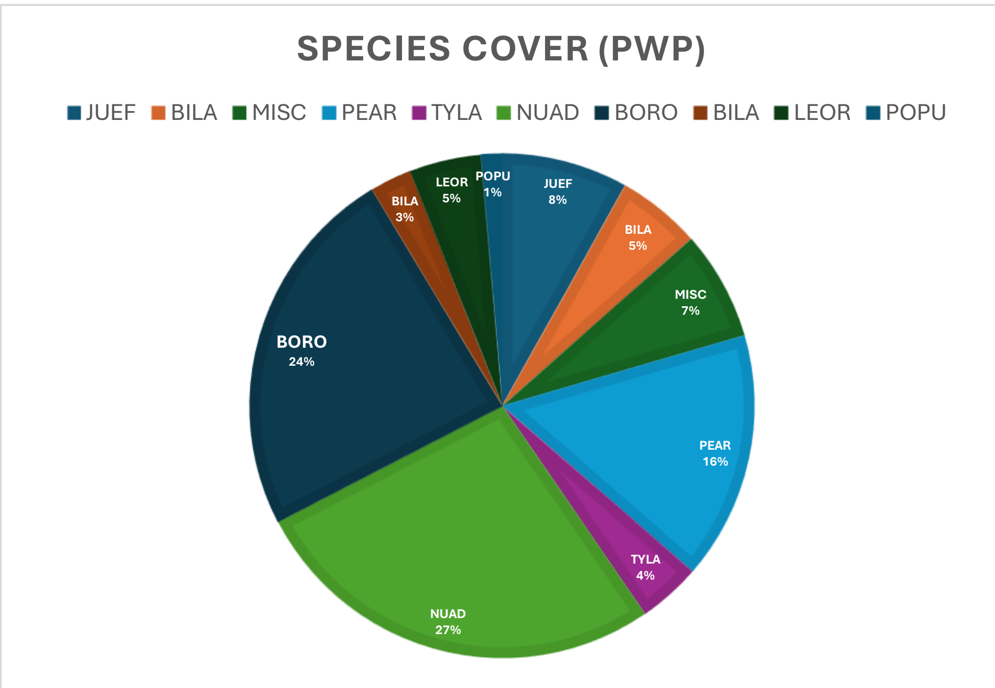

Figure 6: percent species cover of identified vegetation at PWP site

Code	Species and Genus	Common name
DISP	*Distichlis spicata*	saltgrass
SPPA	*Spartina patens*	salt meadow cordgrass
BOMA	*Bolboschoenus maritimus*	salt marsh bullrush
JURO	*Juncus roemerianus*	black needle rush
LYSA	*Lythrum salicaria L.*	loosestrife
SYTE	*Symphyotrichum tenuifolium*	Perrenial Saltmarsh aster
BORO	*Bolboschoenus robustus*	seacost bulrush
PHAU	*Phragmites australis*	common reed
IVFR	*Iva frutescens L.*	Marsh elder
CIDO	Cicuta douglasii	water hemlock
PEAR	*Persicaria arifolia*	halberd-leaved teerthumb
NULU	*Nuphar Lutea*	spatterdock
JUEF	*Juncus effusus*	smooth rush
BILA	*Bidens laevis*	smooth beggartick
TYLA	*Typha latifolia*	broadleaf cattatil
MISC	*Mikania scandens*	climbing hempvine
LEOR	Leersia oryzoides	ricecut grass
POPU	*Polygonum punctatum*	dotted smartweed

Figure 5: plant species key

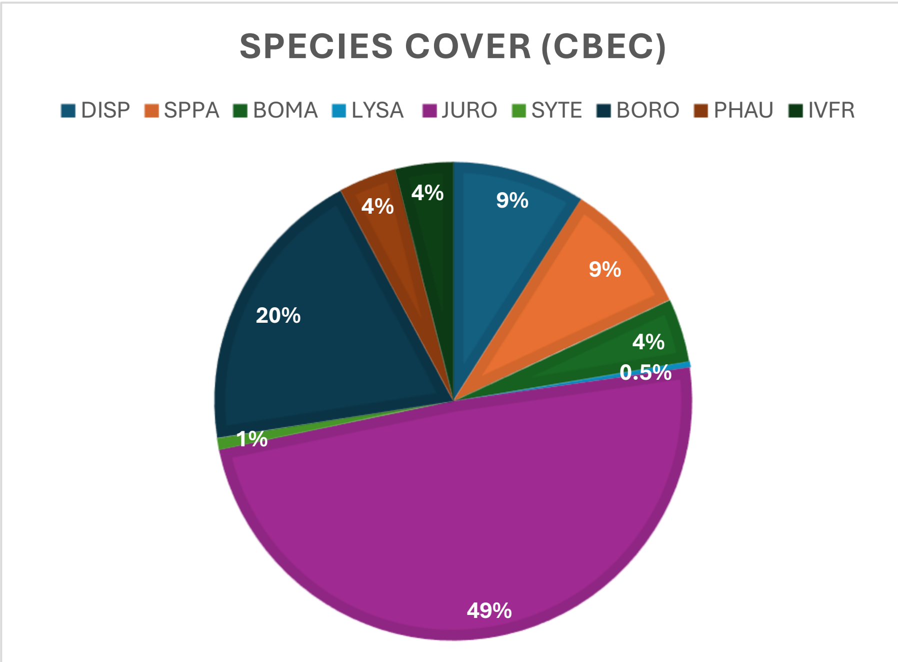

Figure 7: percent species cover of identified vegetation at CBEC site

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