Benthic invertebrate and soil characteristics of created and natural marshes in south Louisiana

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Abstract

Louisiana's coastal wetlands have been left susceptible to natural and human-induced changes to the environment. To combat wetland loss, marshes are being created yet little is known about how soil and invertebrate communities respond to marsh creation sites. Soils provide the base for many of the biological and chemical processes that make wetlands vital ecosystems. Open water and decomposition of emergent vegetation with subsequent buildup of organic matter permits marshes to vertically accrete, allowing them to keep up with subsidence and rising sea levels. Invertebrates also play a crucial role via nutrient cycling and litter processing while also being the base trophic level for fish and birds that utilize wetlands. Both soil and invertebrates provide wetlands with the necessary tools to support a healthy ecosystem. This study analyzes the soil composition and invertebrate communities across three created marshes completed in 2010, 2016, and 2020 respectively, and two adjacent natural marshes (n=5) near Lafitte, Louisiana. Soil samples were collected at two random sites per marsh (n=10) and analyzed for bulk density, organic matter content, and nutrient composition. Soil invertebrates were also sampled at the same two sites per marsh (n=10) and separated by order. This study will provide insights into the differences between soil and invertebrate communities at created and natural marshes to inform management to ensure they are functioning as healthy ecosystems. Additionally, analysis of the age of created marshes will provide insights into the time needed for restoration to gain ecosystem services provided by natural coastal wetlands.

Introduction

Along the Northern Gulf Coast, a multitude of environmental and anthropogenic stressors have led to abundant marsh loss (Mitsch and Gosselink 2000, Ligget 2020). To combat this loss, Louisiana's Coastal Master Plan developed by the Coastal Protection and Restoration Authority (CPRA) designates funds to marsh creation and restoration in locations most affected or that provide the most benefit. Wetlands provide many ecosystem services including flood prevention, wildlife habitat, and increased water quality depending on their landscape position (Mitsch and Gosselink 2000). However, there is little follow up after construction to see if these created sites are functioning as natural marshes. Since soil and invertebrate communities provide the building blocks for wetland ecosystems it is crucial to consider them when studying restoration sites. An increase in food and cover on the marshes similar to natural conditions will inevitably increase the carrying capacity of marsh fauna that depend on these as the basis of survival.

Benthic invertebrates are especially important to marsh habitat as they are often the vital source of nutrients for fish, birds, and other invertebrates (Adams 1990). As the lower trophic level for these predators, they do the important task of converting plant sugar and nutrients into usable energy for the primary consumers (Hornung and Foote 2006)(Kang and King 2013). Invertebrates are an important food source for waterfowl as they provide proper protein for egg production that would otherwise be non-existent on a completely herbivorous diet (Sedinger 1997). This is especially important as a parallel research project is attempting to compare secretive marsh bird abundance in these same created and natural marshes.

While benthic invertebrates are the building blocks to the animal biota, soil is the building block for plants. Soils provide the necessary layering for root anchoring and catalyst for chemical activity to occur (Anderson et al. 2005). Soil along many coastal regions is constantly in flux between subsidence and vertical accretion that are both supportive of and dependent on vegetation (Nyman et al. 2006). The type of soil, either mineral or organic matter, heavily influences the biota and vegetation it is able to support (Anderson et al. 2005). This comparison of soil properties has been documented from past research specifically looking at organic matter, bulk density, and cation exchange capacity (Ligget et al. 2020). This project intends to further that comparison of soil properties to the benthic invertebrates that inhabit these sites.

Objectives

What is the time it takes for dredged soil to contain enough organic matter to sustain a healthy vegetative structure? Does soil illuviation or eluviation occur in a measurable time frame from dredged material? At what rate does insect colonization occur on a newly created substrate or the surrounding area? Our specific research objectives are as follows:

1. Compare invertebrate abundance and species composition between created and natural marsh sites.
2. Compare soil organic matter and bulk density between created and natural marsh sites.
3. Compare invertebrate abundance, soil organic matter content, and soil bulk density of created sites of varying ages.

Methods

Study Area

We sampled a total of 3 created marsh sites (BA-36, BA-125, and BA-164) and 2 natural sites (CRMS4103 and CRMS4218) in Barataria Bay near Lafitte, Louisiana. BA-36 was completed in 2010, BA-164 was completed in 2016, BA-125 was completed in 2021 allowing for a 12, 6, and 1 year comparison, respectively (Table 1).

Table 1: Marsh age. Age class and location of source dredge material of created marshes

Marsh	**Completion Year**	**Source Material**
BA-125	2021	Turtle Bay/Little Lake
BA-164	2016	Mississippi River
BA-36	2010	Bayou Rigolettes/Bayou Perot

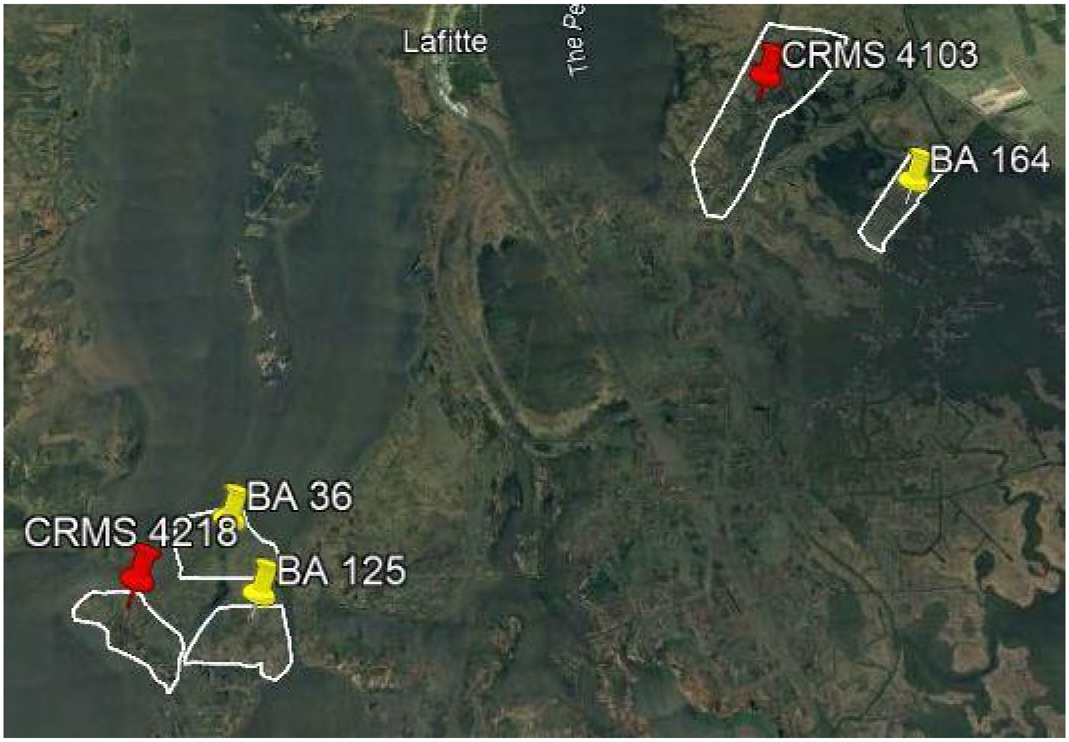

Figure 1: Study site near Lafitte, LA. Red pins are natural marshes, yellow pins are created marshes.

Invertebrate sampling

Invertebrates were sampled March 23 and 24, 2022 at two locations per marsh for a total of 10 samples. For each sample a 10-centimeter (cm) diameter by 5 cm deep core was used to collect benthic invertebrates. The 5 cm depth was determined based on shorebird's maximum foraging depth (Sherfy et al. 2000). The sample material was stored in an ice chest as soon as possible and then frozen. After thawing, all samples were washed through a 500-micrometer sieve, stained with Rose Bengal stain, and stored in 70% denatured ethanol (Sherfy et al. 1999). Each sample was then hand-sorted and invertebrates were identified. Rose Bengal assisted in differentiating between invertebrates and vegetation/seeds by staining only the cell membranes of invertebrates but not the cell walls in vegetation (Sherfy 1999, Craft 2000).

Soil sampling

During summer of 2022, June 13 and August 17, a total of ten soil cores were taken, two cores per marsh, with a 6-inch diameter PVC core to an average depth of 35.4cm. The depth varied due to the ability to drive the cores into the soil. As quickly as possible after extraction (within 10 hours) the cores were placed in a 4-degree Celsius cooler until next day analysis. Soil was extruded the next day and cut into three cm sections, or ‘cookies’, and each was weighed individually. After recording the wet weight, samples were dried in a 60-degree Celsius dryer for approximately three days, or until the weights stabilized. After reweighing, the bulk density was calculated from wet weight minus the dry weight. The dried cookies were then ground with mortar and pestle into a fine, homogenous powder and a representative sample was placed into a crucible. After weighing the sample in the crucible, they were placed in a muffle furnace for 550 degrees Celsius for four hours to burn off the organic matter. This method followed the Louisiana Coastal Protection and Restoration Authority guidelines for soil organic matter analysis (CPRA, Todd). Once cool enough to handle, the crucibles were reweighed, and organic matter was calculated with dry weight minus burned weight and the total divided by the dry weight.

Results

Invertebrates were more abundant in created marshes than natural marshes overall. The diversity was similar, but on average the evenness of diversity was greater with the natural marshes. In fact, 89.9% of the created marsh were either nematodes or gastropods, while in the natural marshes they accounted for only 51.5%.

*Table 2: Invertebrates. *Uneven sample must be noted, results are from 6 created samples and 4 natural samples*

Invertebrates	Created marsh	Natural marsh
Total count	255	68
Total nematodes	175	30
Total gastropods	54	5
Non-gastropod, Non-nematode totals	26	33
Number of different Families	7	9

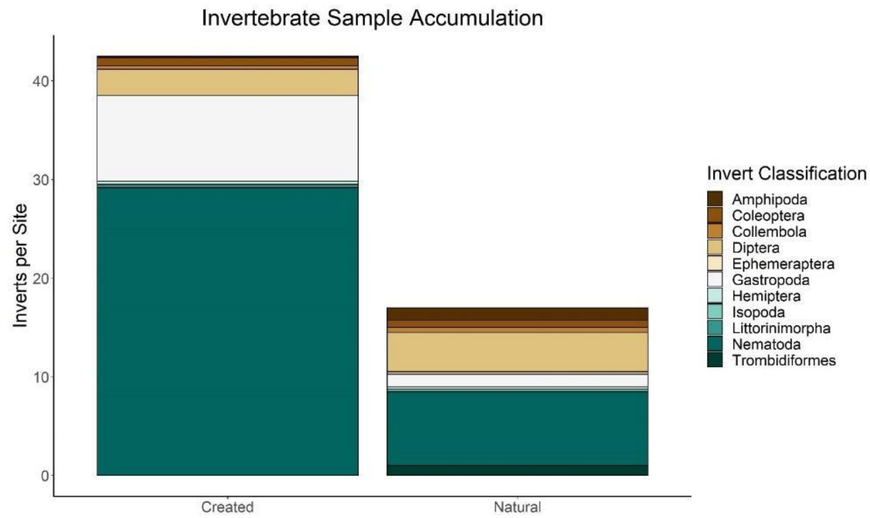

Figure 2: Proportional abundance of invertebrates per marsh types, created and natural.

Soil organic matter and bulk density means remained steady between each natural site, only fluctuating 25% and 0.2 g/cm^3, respectively. Not only did created marshes show higher bulk density and lower organic matter content, but the fluctuation between each mean was noticeable. For BA-164 alone, organic matter went from nearly 0% to 40% and bulk density ranged more than 1 g/cm^3. BA-125 and BA-36 did not show as much of a range as BA-164, but still was greater than any of the natural sites.

Nutrient levels have yet to be analyzed.

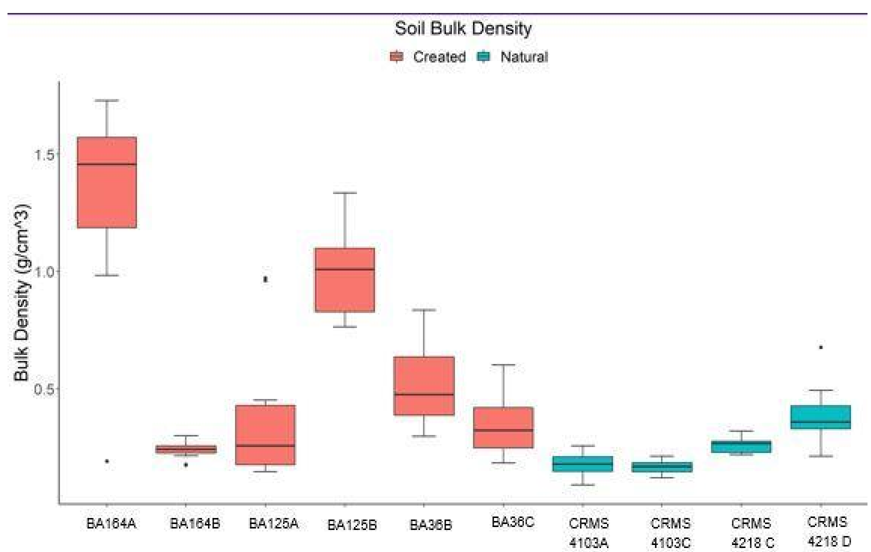

Figure 3: Soil Bulk Density split between sample sites.

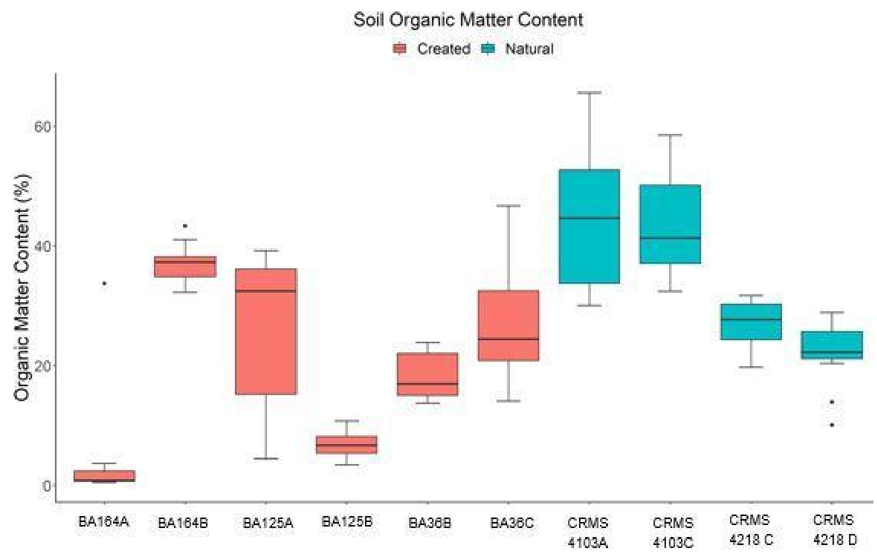

Figure 4: Soil Organic Matter split between sample sites.

Discussion

This research provides important insights into the invertebrate communities and soil composition at created marshes in Louisiana. While the invertebrate communities are not the same between created and natural marshes, they are similar, demonstrating that created sites may provide important habitat for invertebrates. Additionally, organic matter content and bulk density showed a strong similarity with natural marsh soil composition. However, there are several factors that may have influenced our results.

Firstly, the type of dredge material appears to have a larger factor than age. The marsh with the worst results, BA-164, was produced by dredging the Mississippi River. This river sediment will naturally contain more sand than that of an open body of water. This sand will result in higher bulk density, lower soil fertility/nutrient retention, and therefore, lower organic matter.

Secondly, sample locations appear to have a large role as some of the created sites produced similar organic matter and bulk density numbers compared to natural marshes while other created sample sites were higher or lower than natural sample sites. However, further studies should investigate these questions with a larger sample size.

Lastly, it would be beneficial to compare this closely with the vegetation composition at each site. This could potentially provide an insight into the large quantities of nematodes and gastropods found at some of the created marshes. While results do give the created marsh a higher abundance total, these invertebrates are primarily linked to nutrient cycling by consuming the bacteria that produce the nutrients (Yeates 2003). This is crucial for plant communities as it is assumed that 40% of the nutrients available to plants are produced by nematodes specifically (Yeates 2003). Perhaps the increased numbers of nematodes have still not reached equilibrium as the organic matter is still accumulating to the levels of natural marshes. However, it should be noted that these nematode communities are limited by predation within the community and not from outside megafauna (dos Santos 2011).

For marsh age, the oldest created marsh, BA-36, did in fact produce results with the closest resemblance to the natural marshes. This was true for both bulk density and organic matter content. Interestingly, the second best was the newest site, BA 125. This site still had fluctuations well outside of the range of natural marshes but considering that this material had been dredged only one year prior, the results are impressive. The middle-aged site, BA-164, really was a tale of the two sampled locations at that marsh. BA-164 A was nearly entirely sand and produced high bulk density with very low organic matter. BA-164 B on the other hand, was very representative of all of the other sites sampled from and produced consistent bulk density and organic matter.

Marsh creation is an important tool in the management of a shrinking coastline in south Louisiana. Our research shows that these expensive projects do, in fact, provide a benefit to the wildlife that inhabit them and facilitate the ecosystem services that marshes provide in a relatively short amount of time.

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