ABSTRACT

Title of Thesis:	DISTRIBUTION AND VARIABILITY OF CARBON STOCKS IN MID-ATLANTIC TIDAL MARSH SOILS
	Jordan Dong-Soo Kim, Master of Science, 2022
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Tidal marsh wetlands have the capacity to store disproportionately large quantities of C despite their small areal extent. Good estimations of this “blue C” are now more critical than ever due to implications for the global C cycle and climate change, especially since C storage in tidal marshes has historically been understudied. In this study, we set out to measure, more accurately estimate, and conceptually model the C stocks in representative tidal marshes of the Mid-Atlantic region. We found that C storage differs significantly in marshes formed among various pedogeomorphic settings due to differences in pedogenic processes and soil morphology. Further, we have demonstrated that the mean C densities of particular soil materials can be used in conjunction with soil morphological descriptions to reliably estimate the C stocks in the absence of laboratory data. Finally, we augmented existing concepts of tidal marshes in the region by incorporating newly gained understandings of the spatial changes in morphology and C stocks across marshes within different pedogeomorphic settings.

DISTRIBUTION AND VARIABILITY OF CARBON STOCKS IN MID-ATLANTIC TIDAL MARSH SOILS

by

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Table of Contents

List of Tables

List of Figures

Introduction

The increase in the combustion of fossil fuels has elevated the global concentration of the greenhouse gas CO_2 by 47% since the start of the Industrial Revolution to the current figure of 414 parts per million (ppm) (Buis, 2019; Lindsey, 2022). This is the highest concentration of C in the atmosphere in the last 800,000 years (Lindsey, 2022). Greenhouse gases, such as CO_2, trap and radiate heat through the atmosphere, warming the Earth (United States Environmental Protection Agency, 2015). Anthropogenically induced warming reached 1° C above pre-industrial levels in 2017 (Allen et al., 2018).

Plants mediate the balance of the C in the atmosphere by taking up CO_2 during photosynthesis. A series of chemical reactions converts CO_2 to other C compounds and incorporates it into the biomass of the plant. The C can be returned to the atmosphere if it is oxidized by microbial organisms, but it can also be input into the soil—the largest terrestrial reservoir of C (Lal et al., 2021).

Soils are an important component of many ecosystems, but one that is of particular importance is wetlands. Wetlands are areas that experience periods of saturation by water such that they support vegetation adapted to living in saturated conditions and drive the formation of hydric soils. These environments are perhaps one of the most important ecosystems for the sequestration of atmospheric C. Oxygen is depleted more rapidly than it is replenished via diffusion in saturated soils, resulting in periods of anaerobic conditions. Under such conditions, soil microbes seek alternate electron acceptors in order to oxidize organic matter (including organic C) as an energy source. These alternate electron acceptors are less energetically favorable, which means that the decomposition of organic matter is greatly slowed and outpaced by accumulation. Thus, wetland soils have a larger potential for C storage and sequestration than that of many other terrestrial soils, which may have shorter or infrequent periods of saturation.

Tidal wetlands sequester more C relative to other wetlands. This is because they are constantly saturated (and therefore anaerobic) due to frequent tidal inundation. Tidal marshes, a type of tidal wetland, represent only 0.4% of land in the United states (Tiner, 2013), but their soils store a disproportionately large quantity of C. Marshes are particularly effective at C burial due to their ability to vertically accrete and keep pace with sea level rise. Given sufficient inputs of C-rich materials, the marsh surface maintains elevations roughly that of sea level. Some studies estimate that tidal marshes may bury 40 to 50 times more C than terrestrial forests (Mcleod et al., 2011). However, tidal wetland area (including marshes) in the United States has been declining. Between 2004 and 2009, 16,600 ha (or 2.8%) of estuarine emergent wetlands (i.e., salt and brackish marshes) were lost at a rate three times greater than a previously determined loss rate between 1998 and 2004 (Dahl, 2011). The historical loss of tidal marshes could be attributed to past attitudes toward these wetlands. Marshes were once unappreciated and were perceived as wastelands that offered little value (Darmody and Foss, 1978), which also resulted in a paucity of both research and data surrounding tidal marshes and their soils (including data on C storage).

Today, we more thoroughly understand the value of marshes; they provide numerous ecosystem services such as wildlife habitat, nutrient cycling, and storm surge attenuation (Barbier et al., 2011). A number of studies have especially highlighted the C storing capacity of marsh soils (Rabenhorst, 1995; Chmura et al., 2003; Mcleod et al., 2011; Hinson et al., 2017; Macreadie et al., 2017; Holmquist et al., 2018; Gorham et al., 2020; Wardrup, 2021), which emphasizes the need for the preservation of these ecosystems so that C may remain in the soil rather than be released into the atmosphere as CO_2. Some studies have attempted to quantify the magnitude of C stored in tidal wetlands. However, these efforts to estimate C across regions or the entire country may utilize approaches that are oversimplified, especially if applied to smaller regional scales, as they do not incorporate known variations in soil properties within tidal marshes. For example, past research in the Mid-Atlantic region (specifically Maryland) has documented that soil properties vary distinctly among certain geomorphic settings in which marshes have formed (Darmody and Foss, 1979). Thus, more data are needed to understand if and how these factors may impact regional measurements of C stocks in tidal marsh wetlands.

Objectives

The overall objective of this study is to use a pedological approach in order to understand the role of geomorphic setting and soil morphology on the distribution and variability of C stocks in Mid-Atlantic tidal marsh soils.

The specific objectives of this project are:

1. To quantify C stocks in tidal marsh pedons located in representative geomorphic settings and to determine the impact of sampling depth on the quantification of C stocks.
2. To identify the various types and mean C densities of tidal marsh soil materials and evaluate whether the mean C densities can be used in lieu of laboratory data to reliably estimate C stocks.
3. To formulate conceptual models of the nature and properties of marsh soils in each geomorphic setting, including the spatial distribution of C stocks.

Hypotheses

1. Marshes in certain geomorphic settings will store different amounts of C due to the systematic variations in soil morphologies among settings.
2. Carbon density will differ between types of tidal marsh soil horizons and the mean C densities can be used to reliably estimate C stocks in the absence of laboratory data.

3. There are systematic spatial patterns to soil horizon thickness and properties across tidal marsh landscapes, and therefore predictable patterns in the storage of C should be observed within marshes of a particular geomorphic setting.

Chapter 1: Background

1.1 TIDAL MARSHES

Tidal marshes are wetlands that exist at or near sea level at the interface of terrestrial and marine ecosystems. They experience alternating periods of inundation and exposure brought on by periodic rising and falling tides. Saturated conditions support vegetation specifically adapted to these unique landscapes (United States Environmental Protection Agency, 2015). There are differing terms used to describe these wetlands, including tidal marsh and coastal marsh (Cowardin et al., 1979; Odum et al., 1984). However, these descriptors are synonymous. Tidal marshes occupy approximately 2.4 million hectares in the United States (Tiner, 2013). Most are located along the Atlantic coast and extend along the Gulf of Mexico; only about five to ten percent of these marshes are dispersed on the Mid-Atlantic coast (Field et al., 1991; Rabenhorst, 1995).

Tidal marshes are commonly classified based on the halinity of the waters flowing into them. Halinity is determined by the concentration of ocean derived salts, mainly sodium chloride, in the water (parts per thousand [ppt]) (Park, 2021). Tidal freshwater marshes have halinities less than 0.5 ppt (Cowardin et al., 1979). They are located in the upstream reaches of an estuary where tidal influence is still present but where the flow of fresh water dominates (Odum et al., 1984). Tidal salt marshes are located downstream toward the ocean where the influx of sea water increases the concentration of salt. The exact ranges of salinity in a tidal saltwater marshes have been variously defined (Odum, 1988). As reviewed and suggested by Odum (1988), salt marshes can be generally recognized as having halinities greater than 18 ppt. Between the fresh and salt marshes are oligohaline (0.5-5 ppt) and mesohaline (5-18 ppt) marshes (Cowardin et al., 1979). Systems with this intermediate halinity range can be referred to as brackish marshes.

Within a particular marsh, local elevation further differentiates the wetland. Tidal marshes of all halinities have landscapes that decrease in elevation as they transition from the terrestrial border to open water (Darmody and Foss, 1979; Odum et al., 1984). Areas along the marsh slope will experience different frequencies and durations of inundation according to elevation range between low tide and high tide levels (Tiner, 2013). Therefore, the marsh is often separated into two general zones called the "low marsh" and the "high marsh". The low marsh is located closest to open water and at lower elevation. It is regularly flooded at least once a day (Tiner, 2013). Conversely, the high marsh exists at higher elevations. It is less frequently flooded and exposed to air for longer periods (Tiner, 2013).

Tidal marsh landscapes are populated by hydrophytic vegetation. Water halinity is a dominant factor that affects both species diversity and composition (Odum, 1988). In freshwater marshes, the hospitable halinity regime allows for greater overall species diversity (Odum et al., 1984). Tidal freshwater marshes on the east coast can have up to 40 species with a dozen or more than may be equally dominant (Simpson et al., 1983; Odum, 1988). Salt marshes, on the other hand, tend to be populated by far fewer species than their freshwater counterparts (Odum, 1988; Bertness, 1991). This is because the high halinity conditions do not allow as many species to persist and thrive. Those that can survive have adapted to tolerate this high stress environment (Odum, 1988). Brackish marsh species diversity is higher than that of salt marshes (Perry and Atkinson, 2008). Additionally, where salt marshes may see large monospecific areas, these areas tend not to exist in brackish marshes (Perry and Atkinson, 2008).

Regardless of halinity, elevation differences between the low and high marsh tend to differentiate plant communities further. Species separation, or zonation, occurs due to fluctuations in tide levels and a plant's ability to withstand inundation (Odum et al., 1984; Tiner, 2013). Plant zonation in freshwater marshes is present, although not as apparent as in salt marshes. The low marsh is commonly populated by herbaceous, emergent plants like *Pontederia cordata* (pickerelweed), *Peltandra virginica* (arrow arum), *Nuphar advena* (spatterdock), and grasses (Simpson et al., 1983; Odum et al., 1984). Higher elevation areas of the freshwater marsh contain a greater number of species. Herbaceous vegetation, like *Impatiens capensis* (jewelweed), *Polygonum spp*. (smartweeds), and *Persicaria sagittata* (tearthumb) grow along with perennials including *Typha spp.* (cattails) and grasses (Odum et al., 1984). There is a broad overlap in plant habitats in freshwater marshes. They typically lack the physical characteristics, such as high halinity, that causes distinctive zonation (Odum, 1988). Many species are often found dispersed along multiple parts of the freshwater marsh gradient. (Simpson et al., 1983; Odum, 1988). For example, while common in the low marsh, pickerelweed, arrow arum, and grass species can also grow in the landward parts of the marsh (Simpson et al., 1983; Odum et al., 1984).

In contrast, distinct plant zonation is a defining feature of salt marshes. Salt tolerance and competitive exclusion mediates species separation. Plants in the low marsh must be able to withstand frequent inundation by saline waters. One prominent species is the salt tolerant grass *Spartina alterniflora* (smooth cordgrass). It is not rare to find Atlantic coast low marshes almost exclusively populated by *Spartina alterniflo*ra (Bertness, 1991). When moving between the low and the high salt marsh, *Spartina patens* (saltmeadow cordgrass) may become the dominant species (Bertness, 1991). Clear boundaries observed between near monocultures of *S. alterniflora* in the low marsh and *S. patens* in the high marsh illustrate the considerable effect elevation has on salt marsh species zonation. Further into the high marsh, salt stress decreases and more species appear (Tiner, 2013). *Distichlis spicata* (saltgrass), *Juncus roemerianus* (black needle rush), and *Iva frutescens* (high tide bush) commonly grow towards the upland (Tiner, 2013; Virginia Institute of Marine Science, 2022).

Hydrological patterns of tidal marshes create a unique environment compared to terrestrial wetlands, which are seasonally saturated. Evapotranspiration during warmer parts of the year lowers the water table. Then, as the temperature cools, evapotranspiration declines and the water table rises. This seasonal oscillation does not allow many inland wetlands to be constantly saturated. As a result, the defining hydrological characteristics of a wetland may only be observable during certain parts of the year. By contrast, since tidal marshes are located at or near sea level, the inundation and flooding of marine water maintains the water table close to the soil surface. Therefore, tidal marshes experience essentially constant saturation.

The water budget of tidal wetlands includes other hydrological factors that influence saturation (Tiner, 2013). Inputs such as precipitation, surface water, and groundwater discharge can all be sources of input water for tidal marshes (Tiner, 2013). Surface tidal waters are the primary hydrological source in most tidal wetlands (Vepraskas and Vaughan, 2016). Conversely, water losses from tidal marshes include evapotranspiration, surface outflow, and groundwater recharge. The interactions of all processes affect marsh saturation; tidal inundation is just one part (Tiner, 2013).

Tidal marshes provide numerous ecosystem services, one of which is habitat for numerous animal species. Protected species including bald eagles and diamondback terrapins often reside in tidal marshes and fill critical ecological roles (Chesapeake Bay Program, 2020). In addition, marsh plants also provide a home to crustaceans (Chesapeake Bay Program, 2020), and the drainage ways within tidal marshes can provide nursery habitat for fish (Barbier et al., 2011). Marshes also provide important coastal protection. Vegetation attenuates the energy from incoming waves and offers extra water uptake to reduce the impact of storm surges (Barbier et al., 2011). Plant communities also provide erosion control by trapping and stabilizing sediment (Stumpf, 1983). Water quality can be enhanced as water passes through marsh estuaries, where grasses take up nutrients and slow the water causing a decrease in energy and trapping the suspended sediment load (Barbier et al., 2011). Nutrient pollution can be partially mitigated from anerobic soil conditions that promote processes like denitrification (Barbier et al., 2011).

Tidal marshes can also directly serve human needs. They help to maintain fisheries by offering shelter for smaller or recently hatched species (Barbier et al., 2011). Marshes are also beautiful ecosystems that offer people opportunities to experience and learn more about nature through activities such as boating, hiking, and birding (United States Fish and Wildlife Service, 2020). Tidal marshes also represent a major blue C sink which helps mitigate against greenhouse gas emissions from marshes (Barbier et al., 2011). Blue C is the C stored in coastal ecosystems that would otherwise be released into the atmosphere contributing to climate change, but is instead sequestered in thick organic or mineral soil horizons (Mcleod et al., 2011). Tidal salt marshes sequester an estimated 0.21 kg C m^{-2} yr^{-1} (Charpentier et al., 2010).

1.2 TIDAL MARSH SOILS

As with all wetlands, tidal marshes contain hydric soils. These are soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA Natural Resources Conservation Service, 2016). Anaerobic conditions are highly influential on tidal marsh soils because they remain saturated continuously. Under better drained conditions, soil microbes generally use oxygen as a terminal electron acceptor during microbial respiration. However, oxygen diffuses much slower through water than through air. Consequently, in saturated tidal marsh soils, oxygen is depleted faster than it can be replenished. Due to the lack of oxygen, microbes must use alternate, less energetically favorable, electron acceptors such as oxidized forms of Mn, Fe and S. This has implications on soil morphology.

Tidal marsh soils display unique morphological characteristics that reflect their near continuous saturated and anaerobic conditions. One of the most pronounced features are depleted matrix colors in mineral horizons. In aerobic conditions, mineral subsoil horizons are commonly brown or red due to the presence of iron oxide coatings on soil particles. Since oxygen is quickly consumed under, more or less, permanently reducing conditions in tidal marshes, soil microbes commonly use any available ferric iron (Fe^{3+}), such as that found in the iron oxide coatings, as an alternate electron acceptor. Ferric iron is reduced to ferrous iron (Fe^{2+}) which is water soluble. Ferrous iron will move into lower parts of the soil profile, or it may react with microbially generated sulfide (S^{2-}) to form Fe sulfide minerals, like pyrite. In either case, these processes leave silicate mineral grains “uncoated”. Soil material without a coating of iron oxides appears grey in color and is referred to as a depleted matrix. If, upon exposure to oxygenated conditions, the matrix color reverts back to a reddish-brown (from the reoxidation of soluble Fe^{2+} present), the soil is called a reduced matrix.

Another pronounced morphological feature is the accumulation of thick, dark organic or C-rich mineral soil horizons. As primary plant production contributes organic material both above and below ground, heterotrophic soil microbes seek to oxidize this organic matter as an energy source. However, oxidation is greatly slowed under saturated anaerobic conditions relative to aerobic upland settings. As a result, partially decomposed organic matter tends to accumulate at the soil surface resulting in soil horizons enriched in organic matter that can either be mineral horizons or O horizons (Rabenhorst, 2011).

Due to the accumulation and thickening of O horizons, tidal marsh soils contain much higher amounts of soil organic carbon (SOC) compared to terrestrial, non-wetland soils (Rabenhorst, 1995). Although wetlands as a whole only account for fewer than 6% of Earth’s land area, they store a disproportionately high amount of C, nearly 15% (Rabenhorst, 1995; Mcleod et al., 2011). Marsh soils also have a smaller bulk density than non-wetland soils since organic soil materials have less mass than mineral soil constituents. Thus, the same volume of marsh soil will have a lower bulk density than that of an upland soil.

Four general processes, recognized as Simonson’s Generalized Theory of Soil Genesis, drive the formation of soil horizons: additions, removals, transfers, and transformations (Simonson, 1959). Additions of organic matter are particularly important; organic matter is primarily deposited as plant biomass from local or nearby terrestrial settings (Orson et al., 1985). Due to the slowed rate of microbial decomposition in anaerobic environments, organic matter remains partially decomposed and accumulates over time at or near the soil surface (Rabenhorst, 2011). The accumulation of mineral particles as eroded sediment also contributes to pedogenic additions. Deposited sediment helps to maintain the surface elevation of a marsh (Orson et al., 1985). Sedimentation occurs during tidal floods when water borne particles are moved to the marsh surface and settle (Stumpf, 1983; Christiansen et al., 2000). Marsh vegetation further assists by slowing the flow of water and allowing sediment to settle out or become trapped on plant shoots (Stumpf, 1983; Weis, 2016). Tidal creeks, another source for mineral particles in marshes, may sustain greater sediment deposition in close proximity to the streams (Leonard, 1997; Christiansen et al., 2000). Marsh edge erosion, which may initially be thought of as a pedogenic loss, also contributes to sediment deposition when the eroded sediment is deposited back onto the marsh surface (Hopkinson et al., 2018). Edge eroded particles have the potential to satisfy an estimated 30% of the mineral sediment needed for the rate of accretion in some marshes to keep up with sea level rise (SLR) (Hopkinson et al., 2018).

Losses or removals constitute a second important pedogenetic process. Edge erosion is a major factor driving land loss in tidal marshes (Nyman et al., 1994; Sapkota and White, 2019). Edge erosion occurs when wave action wears away at the marsh edge below the soil root zone. The portion of soil left intact overhangs and will eventually collapse back into the water, exacerbating shoreline retreat (Sapkota and White, 2019). Another process contributing to material losses in tidal marshes is related to microbial decomposition. Although decomposition is slowed greatly in wetlands, microbes are still active and contribute to the loss of organic matter (Valiela et al., 1985). If conditions are reducing enough such that methanogenesis becomes the primary method of anaerobic respiration, some microbes will reduce carbon dioxide (CO2) to methane (CH4). Methane is then emitted from the marsh soil further contributing to losses (Poffenbarger et al., 2011). Further, any plant litter that is not swept away by incoming tides or buried by sediment is eventually consumed by microbes in the marsh (Valiela et al., 1985).

Transfers, or the physical movement within the soil profile, represents a third important process. Burrowing fauna (such as crabs) are common in many salt marsh ecosystems. Although they may not be “soil material”, burrowing crabs promotes pedogenic transfers. Oxygen and nutrient-rich water can infiltrate into the soil via crab burrows (Katz, 1980). Further, the bioturbation caused by some crabs mix surface soil deeper into the profile and can accelerate decomposition and nutrient cycling (Wang et al., 2010).

The biogeochemical transformation of chemicals and compounds represents Simonson’s fourth pedogenic process. Transformations of organic matter happen continuously, albeit slowly, in anaerobic marsh soils as soil microbes oxidize organic molecules during decomposition (Simonson, 1959; Valiela et al., 1985). These molecules start out large and complex as fresh plant structures, but are transformed into smaller, simpler humified and more refractory components (Valiela et al., 1985). Another transformation involves the reduction of sulfate (SO_4^{2-}) during microbial respiration (Poffenbarger et al., 2011; Tiner, 2013; Vepraskas and Vaughan, 2016). Highly anaerobic conditions in tidal marshes commonly cause microbes to use SO_4^{2-} as an alternate electron acceptor reducing it into S^{2-} (Vepraskas and Vaughan, 2016). In some marshes, this process produces a "rotten egg" odor from the formation of hydrogen sulfide (H_2S) gas that escapes from the marsh (Tiner, 2013). If reactive iron is present in the system, it will react with S^{2-} to form iron sulfide minerals (FeS, FeS_2) (Vepraskas and Vaughan, 2016). Soluble S^{2-} can also chemically reduce oxidized forms of iron as well (Vepraskas and Vaughan, 2016). These four general groups illustrate how pedogenic processes in tidal marshes are kept in an intricate balance and allow the ecosystem to cope with environmental changes.

1.3 MID-ATLANTIC TIDAL MARSHES AND THEIR SOILS

The Mid-Atlantic region of the United States contains approximately 206,000 ha of the country's 4 million ha tidal marshes (Field et al., 1991; Tiner, 2013; UC Davis California Soil Resource Lab, 2020). In this chapter, the Mid-Atlantic region will be recognized as Maryland, Delaware, and New Jersey, which are essentially all in the mesic soil temperature regime. Of the Mid-Atlantic tidal marsh soils, nearly 99,000 ha are located in Maryland (UC Davis California Soil Resource Lab, 2020).

Maryland marshes can be categorized according to the distinct geographic setting in which they are found: submerged upland, estuarine, and coastal areas (Figure 1-1) (Darmody and Foss, 1979).

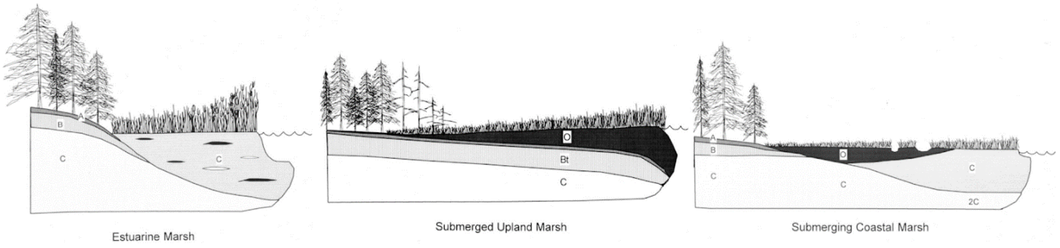

Figure 1-1. Geomorphic classifications of Maryland tidal marshes identified by Darmody and Foss (1979) (after Darmody and Foss, 1979 and Rabenhorst and Needelman, 2016).

Submerged upland marshes formed as SLR permanently inundated extensive areas of nearly level terrestrial land (Darmody and Foss, 1979). Soils of this setting show evidence of pedogenic processes normally associated with upland soils, such as argillic horizons, which formed during extended periods prior to submergence. Submerged upland marshes are the most extensive group in Maryland, comprising 54% of the State's tidal marshes (Darmody and Foss, 1979). Estuarine marshes formed from the accumulation of sediment in filled stream channels or estuarine meanders (Darmody and Foss, 1979). Estuarine systems comprise 38% of Maryland tidal marshes and can be found along major river channels throughout Chesapeake Bay (Darmody and Foss, 1979). Coastal marshes, formed from sediment deposited by tides and storms, are found behind Atlantic coast barrier islands around the perimeter of coastal lagoons (Darmody and Foss, 1979). Immediately behind the barrier island, these marsh soils are expected to be sandy with eolian and water deposits from the barrier island itself. Each of these tidal marsh landscapes are distinct in their past processes of formation which are reflected in their present characteristics.

Tidal marsh soils in the Mid-Atlantic region are mainly classified in the orders of Histosols, Entisols, and Alfisols. Soils in the Histosol order have at least 40 cm of organic materials within the upper 80 cm of the soil (Soil Survey Staff, 2014). Organic soil-materials have greater than or equal to 12% SOC; this definition was simplified by a recently approved proposal at the 2022 Northeast Regional and National Cooperative Soil Survey Conferences[1]. Suborders of Histosols are based on the degree of decomposition within the subsurface tier (usually 30-90 cm). These include Fibrists, Hemists, and Saprists for organic materials that are slightly, moderately, and highly decomposed, respectively (Table 1-1). The vast majority of the tidal marsh soils in Maryland, Delaware, and New Jersey have been correlated into Hemists. This may be an artifact because at the time that most tidal marsh soil series were being defined in Maryland, Sulfi- suborders for fibric and sapric Histosols did not exist (Soil Survey Staff, 1992). The criteria for organic materials currently include both rubbed fiber content and sodium pyrophosphate extract color, but there is another proposal currently under consideration to only use rubbed fiber content

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[1] A proposal to change the definition of organic soil material to those materials with ≥ 12% SOC regardless of clay content or saturation frequency was approved at the 2022 Northeast Regional and National Cooperative Soil Survey Conferences.

(Stolt and Bakken, 2014; National Cooperative Soil Survey, 2019). Fiber content and pyrophosphate color have a weak relationship with each other, and the application of the color test is uncommon among practicing soil scientists (Stolt and Bakken, 2014).

Table 1-1. Types of organic soil materials and their defining criteria. These criteria are under consideration, as there is a proposal to only use rubbed fiber content (Soil Survey Staff, 2014).

Organic material type	Criteria
Fibric	≥ 3/4 fibers after rubbing; OR ≥ 2/5 fibers after rubbing, *and* Sodium pyrophosphate solution extract color with value and chroma less than 7/1, 7/2, 8/2, or 8/3
Hemic	Does not meet criteria of either fibric or sapric.
Sapric	< 1/6 fibers after rubbing, *and* Sodium pyrophosphate solution extract color with value and chroma less than 5/1, 6/2, or 7/3

In the Mid-Atlantic region, the Histosol great groups of importance are Sulfi- for salt or brackish marshes and Haplo- for fresh marshes. Histosols in the Sulfi- great groups have sulfidic materials in the upper 100 cm of the soil surface (Soil Survey Staff, 2014). Sulfidic materials contain oxidizable sulfur compounds and become extremely acid with pH < 4 when incubated under moist aerobic conditions (Soil Survey Staff, 2014). If sulfidic compounds are lacking, such as in freshwater marshes, Histosols may be categorized in the Haplo- great group (Soil Survey Staff, 2014). All but one of the Histosols mapped in the Mid-Atlantic are Sulfihemists, although, as suggested above, some may actually be Sulfisaprists.

At the subgroup level, Histosols in the Mid-Atlantic are divided into either Terric or Typic subgroups based on the thickness of the organic soil horizons. Terric subgroups have O horizons that extend to a depth between 40 and 130 cm before transitioning into mineral soil materials. Typic subgroups are those that have organic horizons greater than 130 cm (Soil Survey Staff, 2014).

Scientists working in peatlands have long used the von Post Scale of Humification. Commonly used outside of the United States, this scale assesses four factors to determine the degree of organic matter decomposition (Rokus, 2020). After squeezing an organic soil sample by hand, a researcher will observe 1) the quantity of water expressed, 2) the nature of water expressed, 3) the portion of the sample extruded between their fingers, and 4) the nature of the remaining soil material (Rokus, 2020). When these factors have been assessed, a classification between H1 (least decomposed) and H10 (most decomposed) is applied (Rokus, 2020). More recently, soil scientists have generally equated Von Post stages 1-3 with Fibric materials, stages 4-7 with Hemic materials and stages 8-10 with Sapric materials (Rokus, 2020).

Entisols are soils with little to no evidence of pedogenesis (Soil Survey Staff, 2014). In tidal marshes, Entisols may be found in areas with lower organic matter input and higher mineral sediment input (Rabenhorst, 1995; Vepraskas and Vaughan, 2016). Entisols with properties formed under saturated conditions are classified at the suborder level as Aquents (Soil Survey Staff, 2014). Most Aquents in saline or brackish tidal marshes of the Mid-Atlantic fall in the Sulfaquent great group; where brackish water is present, SO_4^{2-} reduction leads to the presence of sulfidic materials within 50 cm of the soil surface. Hydraquents (highly fluid Aquents; recently renamed Fluiaquents) and Psammaquents (sandy Aquents) are also found in Mid-Atlantic tidal marshes that do not contain sulfidic materials (Vepraskas and Vaughan, 2016).

Alfisols also comprise a smaller, but still significant, proportion of the tidal marsh soils in the Mid-Atlantic. These soils are much more strongly developed pedogenically than Histosols and Entisols in that they have a subsurface horizon enriched in illuvial clay (Soil Survey Staff, 2014). These soils acquired these argillic horizons when they were formerly upland Ultisols which have been permanently "drowned" by SLR. The salts in the encroaching water have dominated the cation exchange sites, increasing the base saturation to above 35% as required for Alfisols. These Aflisols mapped in Mid-Atlantic tidal marshes have developed under very wet conditions and therefore fall into the aqualf suborder and Endoaqualf great group.

1.4 CARBON DYNAMICS IN TIDAL MARSHES

Carbon stored in tidal marsh soils is in constant flux. Carbon storage represents a balance between the inputs and outputs of C in marsh soils. Carbon from organic plant materials is the primary C input to the marsh (Orson et al., 1985). When these inputs have local origins, they are termed autochthonous. Leaves, stems, or other above ground plant matter from productive marsh vegetation are deposited on the soil surface, but just as significant are the contributions to autochthonous inputs below ground as plant roots. Organic C can also enter the marsh via sedimentary inputs from external sources which is referred to as allochthonous. For example, plant debris can sometimes be “rafted into” tidal marshes (Van de Broek et al., 2018). Thus, allochthonous inputs can be derived from a non-local source, such as adjacent upland areas or from other marshes during tidal inundation. This allochthonous C has been shown to be the main component of sequestered C in certain pedogeomorphic settings such as in buried marsh sediments (Van de Broek et al., 2018).

Decomposition is a primary pathway for C outputs. Most organic matter is decomposed and lost via microbial respiration (Odum et al., 1984; Mitsch and Gosselink, 2015). Microbially oxidized C compounds are released into the atmosphere, further contributing to global C emissions (Theuerkauf et al., 2015). In freshwater marshes, SO_4^{2-} is limited and cannot be extensively used as an alternate electron acceptor to facilitate decomposition. Instead, bacteria reduce CO_2 to CH_4, a process known as methanogenesis (Poffenbarger et al., 2011; Mitsch and Gosselink, 2015; Vepraskas and Vaughan, 2016). However, it should be remembered that the rates of decomposition are significantly slower in marsh soils than in aerobic systems.

Erosion can lead to further loss of stored C from liberated marsh sediments (Theuerkauf et al., 2015). When eroded, organic matter from the soil and plant biomass is exposed to well-oxygenated water where it is decomposed by macrofauna and microbes (Sapkota and White, 2021). Plant litter that is not decomposed or buried is flushed out of the marsh by incoming tides (Valiela et al., 1985; Mitsch and

Gosselink, 2015), but it may likely be redeposited further inside the marsh (Bouchard and Lefeuvre, 2000).

Carbon is also lost from prescribed burns, which is an anthropogenic activity. Burning is a management practice done in some tidal marshes that can help prevent the spread of invasive species and can increase the production of wildlife food plants (Nyman and Chabreck, 1995). During marsh burning, aboveground and belowground biomass may be destroyed (Nyman and Chabreck, 1995). While rare, peat burns remove the actual soil material after the marsh is drained and dried (Nyman and Chabreck, 1995). However, prescribed burns can ultimately increase plant biomass (Bickford et al., 2012; Geatz et al., 2013). Although seemingly counterintuitive, canopy removal during marsh burning is the dominant factor driving the biomass response in marsh graminoids (Bickford et al., 2012; Geatz et al., 2013). This is due to increased light and heat reaching the bare soil surface, stimulating new shoot growth, and allowing stems to become denser without expending excess energy "breaking through" the previous year's senesced canopy (Bickford et al., 2012). Canopy removal after prescribed burns can also reduce decomposition rates. Geatz et al. (2013) found that canopy removal reduced ammonium and phosphate concentrations. Less nutrient availability later in the growing season may have caused resource stress in microbes, lowering decomposition rates (Geatz et al., 2013). Marshes that are regularly burned may have an overall greater amount of organic C due to increased biomass and lowered decomposition rates.

Sea level has been rising since the end of the Pleistocene epoch roughly 15,000 years ago (Barnes et al., 1998). Modern marsh formation was initiated when the rate of SLR slowed significantly 5,000 to 6,000 years ago (Tiner, 2013). Two to three thousand years ago, SLR leveled off and further facilitated the creation of tidal wetlands (Redfield and Rubin, 1962; Tiner, 2013). The slowed rate of SLR prompted the accumulation of peat when barren areas above mean low water were colonized by flood tolerant grasses (Redfield and Rubin, 1962; Orson et al., 1985). Grasses trapped water-borne sediment and added organic matter as they senesced building the marsh peat vertically. Researchers have been able to determine the age of peat and its corresponding depth from within the marsh to estimate historical rates of peat accretion (Redfield and Rubin, 1962). The rate of peat accretion is closely linked to that of SLR, and, therefore, the two can be used to quantify one another (Redfield and Rubin, 1962). Thus, sea level rise is a driving factor in the vertical accretion of a marsh. Today, as sea level continues to rise, marshes with sufficient mineral and organic inputs will accrete vertically at a rate that keeps pace with SLR (Orson et al., 1985; Morris et al., 2002). Tidal marsh extent can also expand laterally in response to SLR depending on the slope of the adjacent mineral soil surface and sufficient supply of sediment (Orson et al., 1985). Tides may distribute sediment and nutrients farther across the marsh surface stimulating plant productivity (Orson et al., 1985) which further contributes organic matter. The process of peat accretion clearly illustrates the capability of tidal marshes to sequester organic C. If the rate of SLR were to outpace the rate of vertical marsh growth, the capacity to perform this critical ecosystem service would be lost.

1.5 CARBON STOCKS IN TIDAL MARSHES

Soil C stocks are the measure of C stored per unit area in a soil. The calculation of C stocks requires the use of three independent measurements: SOC content, bulk density, and horizon thickness. Carbon content is multiplied by bulk density in order to determine C density on a volume basis (e.g., g C cm^{-3}). The C density is then multiplied by the thickness of the soil horizon or layer in question to determine the total mass of C on a per area basis within the given horizon. When the data are summed by horizon to a given depth (typically 1 m), the mass of organic C can be reported as kg C m^{-2} or as Mg Ha^{-1} to a given depth.

Most commonly, SOC content is analyzed using high temperature combustion techniques (Nelson and Sommers, 1996). In order to remove the influence of inorganic C, carbonates can be dissolved with sulfurous acid prior to the C determination. Loss on ignition (where organic matter is burned off leaving behind soil minerals to be determined gravimetrically) can also be used to estimate SOC content (Nelson and Sommers, 1996), but this is generally considered less reliable because of a variety of complicating factors.

Bulk density (mass per unit volume) determinations require obtaining a soil sample of known volume. The sample is dried and weighed in order to obtain the mass, from which one is then able to calculate bulk density. Several methods are available to collect samples of known volume, including Macaulay samplers or handheld coring devices.

Soil horizon thickness can be delineated in the field by visual assessment of a core or the face of an excavated soil pit during the collection of a standard soil morphological description. In tidal marsh soils, organic rich O horizons are common, and are comprised of organic soil material in various stages of decomposition (Soil Science Division Staff, 2017). These are designated as Oi, Oe, and Oa horizons for fibric, hemic, and sapric soil material, respectively (Table 1-1). Other common types of tidal marsh soil horizons include organic enriched A horizons, fluid and non-fluid C or Cg horizons, and occasionally Bt or Btg horizons in submerged upland marshes as described earlier.

Due to the marked increase in global atmospheric concentration of CO_2 from the anthropogenic burning of fossil fuels, there have been numerous efforts to estimate the planet’s various C pools (Chmura et al., 2003; Mcleod et al., 2011; Hinson et al., 2017). However, there is a scarcity of reliable tidal marsh soil data needed to accurately estimate tidal marsh soil C stocks. One may notice insufficient data while using online resources such as the National Cooperative Soil Survey (NCSS) Soil Characterization Database. The database contains morphological, chemical, and physical data from sampled pedons and can therefore provide the information needed to calculate C stocks. However, not all records are complete. Many tidal marsh pedons physically sampled and entered into this database do not have the bulk density or SOC content (or both), which is necessary for determining C stocks (National Cooperative Soil Survey, 2021). The lack of complete records hinders researchers’ abilities to quantify C stocks solely from online research.

Data scarcity may be a product of mapping efforts that have been biased towards terrestrial soils, such as agricultural lands (Holmquist et al., 2018), since tidal wetlands were once thought of as wastelands (Darmody and Foss, 1978; Tiner, 2009). Further, tidal marsh soils are generally more difficult to survey (Holmquist et al., 2018). Together, it probably means there is greater uncertainty in current estimates of soil C in tidal marshes. Nevertheless, documenting tidal wetland C is especially important since these systems sequester a disproportionately high amount of C relative to their areal extent (Rabenhorst, 1995; Mcleod et al., 2011).

A study by Holmquist et al. (2018) set out to identify the best strategy for mapping C stocks in tidal wetlands, an effort necessary for estimation of C storage and emissions at local scales (Holmquist et al., 2018). The researchers concluded that applying a fixed C density value of 0.0270 g C cm^{-3}, rather than using data from existing maps, was the best performing method. Although the authors decided that relying on a fixed value was the best approach, their conclusion neglects the systematic spatial heterogeneity present in tidal marshes. For example, much variation is observed in the Maryland marsh classifications defined by Darmody and Foss (1979). Further, currently available tidal marsh pedon data from the NRCS Soil Characterization Database show that there are significant differences in C density among horizon type or material. More reliable practices should be used to better predict C stocks in tidal marshes. Therefore, research should continue to expand upon the work done by Holmquist et al. (2018), while recognizing that the quantifications of C stocks in tidal marshes can be variable and inaccurate (Mcleod et al., 2011).

A major contributor of this variability and inaccuracy emerges in numerous studies that sample tidal marsh soils in order to quantify C stocks (Craft, 2007; Loomis and Craft, 2010; Van de Broek et al., 2016; Gorham et al., 2020; Gu et al., 2020; Kauffman et al., 2020; van Ardenne et al., 2018). There is no “standard” depth to which researchers sample marsh soils, a circumstance which has led to reported sampling depths ranging from 30 cm to 300 cm (Figure 1-2) (Craft, 2007; Kauffman et al., 2020). Perhaps not surprisingly, samples comprising a greater range in depth result in larger C stocks (Rabenhorst, 1995; Hansen et al., 2017; Kauffman et al., 2020; Gorham et al., 2020), and a shallow sampling depth (e.g., 0 – 30 cm) can significantly underestimate C stocks because the horizon thickness used for C stock calculations will be relatively small. Shallow soil samples can especially underestimate C tidal marshes where soils contain considerable, or even elevated amounts of, organic materials deeper in the profile (Kauffman et al., 2020; Sapkota and White, 2021). Therefore, when conducting research to quantify C stocks, it may be best to sample as deep as reasonably possible for a particular study area.

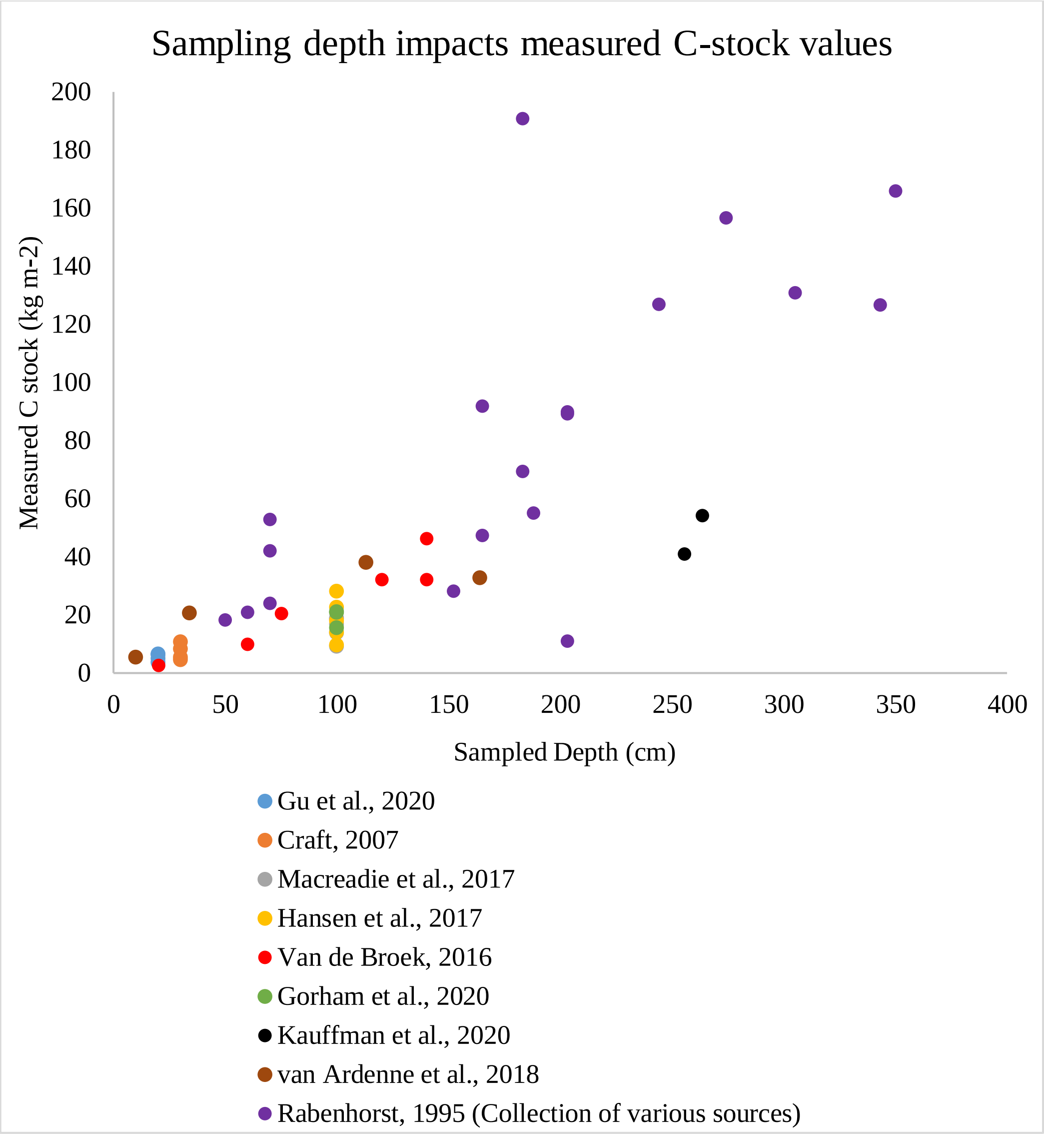


Figure 1-2. Reported C stocks (kg C m^{-2}) and corresponding sampling depths (cm) tidal marsh pedons. Deeper soil samples tend to result in greater measured C stock values.

The procedures used in the acquisition of soil samples may give rise to another source of variability. Soil properties including density, fluidity, and presence of plant fibers will guide a researcher's decision on the tools employed to sample soils, but certain sampling devices have been shown to decrease the precision of bulk density measurements (Stolt, 2019). To alleviate some of this variation, preliminary research suggests using multiple methods for sampling in tidal marshes to yield more precise results (National Cooperative Soil Survey, 2019). In one study, the “peat brownie” technique (for bulk density) of cutting out a block of soil was better as it yielded a lower coefficient of variation (CV), but its improved precision was limited to the upper part of the profile (Stolt, 2019). Data collected using a Macauley sampler, used for taking cores in more fluid soils, had low CV for bulk density measurements in deeper samples (Stolt, 2019). Used in tandem, these approaches may give more precise results when sampling marsh soils.

Many biotic and abiotic factors, such as halinity, vegetation characteristics, and geomorphology, have been shown to affect trends and distributions of marsh soil C stocks. One observation that has been made is a generally negative trend between halinity and soil C stocks (Loomis and Craft, 2010; Hansen et al., 2017; Gorham et al., 2020). It is believed that this is primarily due to the greater concentration of SO_4^{2-} in salt marshes (Craft, 2007; Loomis and Craft, 2010; Wang et al., 2011). Sulfate reduction is the dominant metabolic pathway for anaerobic respiration in salt marshes (Craft, 2007). Sulfate enriched waters allow sulfur reducing bacteria to decompose organic matter, thereby decreasing the overall C stocks of the soils (Craft, 2007; Tiner, 2013). Because of this, C accumulation rates also tend to decrease as halinity increases (Craft, 2007; Baustian et al., 2017). Another reason for the negative trend between halinity and C stocks is that Na^+ induces soil dispersion (Wang et al., 2011). Higher concentrations of Na^+ in saltwater marshes could aid in microbial decomposition since greater quantities of organic matter will no longer be protected within aggregates (Wang et al., 2011). Halinity may further contribute to decreased C stocks because brackish waters in coastal areas contain ocean derived nutrients (Gorham et al., 2020). The rise in nutrient concentration may decrease plant root production, and therefore decrease autochthonous C inputs (Gorham et al., 2020). However, data surrounding this interaction are mixed. Researchers found that intentionally increasing the amount of nutrient input to a *Spartina alterniflora* community did not produce a significant change in belowground production, decomposition, or C stocks (Anisfeld and Hill, 2012).

The impacts of marsh vegetation type on tidal marsh C stocks are not as clear and identifiable as the impacts of halinity. In particular, differences in biomass production among plant communities can have somewhat irregular effects on C stocks (Van de Broek et al., 2016, 2018). In tidal marsh areas where primary production is greater, autochthonous C inputs might increase. One may expect C stocks to follow suit in this scenario. However, some studies have not shown anticipated relationships between primary production and C stocks (Van de Broek et al., 2016, 2018). Research in the Scheldt Estuary in Belgium and the Netherlands surprisingly showed lower C stocks in areas of greater plant productivity, leading the authors to suggest that the influences of biomass production on tidal marsh C were not closely linked (Van de Broek et al., 2016, 2018). Therefore, plant productivity may not be as reliable an indicator of C stock patterns as one might anticipate (Van de Broek et al., 2016). However, it has been shown that some invasive species, such as *Phragmites australis*, apparently can increase C stocks (Gu et al., 2020). *P. australis* is an invasive and extensive grass that displaces native species and can alter their habitats (Chambers et al., 1999). Due to *Phragmites's* rapid growth and thick rhizomes, C stocks in *Phragmites* dominant habitats can be significantly larger (Gu et al., 2020). These growth characteristics of *Phragmites* also contribute large amounts of above and below ground biomass (Gu et al., 2020). As a result, older, more established stands of *Phragmites* contribute to soil volume and encourages marsh accretion after senescence (Rooth et al., 2003). It can be argued that *Phragmites* is particularly valuable to tidal marsh C stocks and the ability of the marsh to keep pace with SLR.

Tidal marsh elevation appears to be another factor contributing to differences in C stocks. Carbon stocks have been reported to increase in higher marsh elevations (Hansen et al., 2017; Kauffman et al., 2020). This trend could be due to less frequent inundation which allows for greater deposition and subsequent accumulation of organic matter (Hansen et al., 2017). Further, minimal flooding of the high marsh will reduce the amount of plant litter that is swept away by tides (Hansen et al., 2017).

The geomorphology of some marshes has also been reported to impact C stocks. van Ardenne et al. (2018) examined how C stocks varied in tidal marshes found behind sand spit barrier islands. Researchers divided these “back barrier” marshes into two informal classifications: the interior marsh (marshes that developed out and away from mainland edge opposite of the sand spit) and the spit marsh (located immediately behind the sand bar). Since spit marshes developed out and away from the mainland, the age of spit marsh soils decreases with distance from the mainland (Redfield, 1972; van Ardenne et al., 2018). Consequently, van Ardenne et al. (2018) found spit marsh soil depth to be shallower than that of the interior marsh, and, since soil depth is a fundamental component of C stock calculations, the measured C stocks for these marshes was also smaller. The development and history of a tidal marsh requires attention and acknowledgement, as these factors are integral to the formation of marsh soils.

1.6 CONCLUSION

Although tidal marshes cover only a small fraction of the Earth’s surface, these highly anaerobic wetlands store disproportionately large quantities of C due to reduced microbial decomposition and regular burying of organic materials. Therefore, Mid-Atlantic tidal marshes are a crucial part of regional blue C accounting. To date, there is in general a paucity of tidal marsh soil data needed to reliably estimate soil C stocks in these areas. For example, resources like the NCSS Soil Characterization Database often lack bulk density or C content data for many tidal marsh pedons, a circumstance which impedes some “work from home” quantification of C stocks. In addition to the lack of data, there are uncertainties surrounding the acquisition of soil samples for use in C stock measurements. Numerous studies reporting data only sample to shallow depths, thereby underestimating C stock values; this may be the most significant factor affecting C stock measurements. Furthermore, certain tools used for sampling have been shown to give imprecise measures of bulk density, a key component of C stock calculations. While they do not impact the acquisition and measurement of C stocks, biotic and abiotic factors, such as porewater halinity, vegetation, and geomorphology, influence the amount of C stored in the soil system.

Attempts to consider these uncertainties have led some researchers to suggest that the use of a fixed C density value is the best way to estimate tidal marsh C stocks in the continental United States (Holmquist et al., 2018). However, soils are heterogeneous. The use of a single C density value for C stock quantification may simply ignore the variations in tidal marsh soil horizons, thickness, and SOC content. Therefore, there is a need to improve our estimations of C stocks in Mid-Atlantic tidal marshes.

Chapter 2: Carbon stocks in Mid-Atlantic tidal marshes

2.1 INTRODUCTION

Tidal marshes comprise approximately four million ha, or 0.4%, of land in the United States (Tiner, 2013). Despite their small areal extent, marshes store a disproportionately high amount of C in their soils. Large quantities of organic and mineral input, coupled with highly anaerobic conditions, help tidal marshes accrete vertically to keep pace with sea level rise. This process of constant deposition and entrapment of C rich soil materials gives tidal marshes a much greater potential for C storage compared to terrestrial ecosystems. Some estimates of C burial in tidal marshes have shown that these coastal wetlands sequester 40 to 50 times more C than temperate and tropical forests (Mcleod et al., 2011).

In the Mid-Atlantic region (herein understood as Maryland, Delaware, and New Jersey) tidal marshes comprise approximately 4% of land. Marshes in the region can be differentiated from one another based on the geomorphic setting in which they are found. Each geomorphic setting is distinct with respect to its location, geomorphology, and processes of soil formation. These pedogenic factors have resulted in distinctive marsh soil characteristics among the settings. Because these pedogenic and geomorphological factors influence marsh soil formation and properties, we refer to these distinct settings as “pedogeomorphic units” (PGUs).

In the Mid-Atlantic region, Darmody and Foss (1979) first identified several marsh types (what we call PGUs) within the state of Maryland, each with distinct soil characteristics: 1) submerged upland; 2) estuarine; 3) coastal. The submerged upland marshes formed as a result of terrestrial land becoming inundated during sea level rise over the past several thousand years (Rabenhorst and Needelman, 2016). Unable to withstand the constant saturation and brackish water, the upland vegetation died back and was eventually replaced by marsh hydrophytes. Underlying the O horizon, the soils of submerged upland marshes retain much of their upland morphology including the presence of argillic horizons (Stolt and Rabenhorst, 1991) and redoximorphic features in Bt and Btg horizons. The estuarine marshes formed in tidally influenced river or stream channels that were filled with mineral and organic sediment. The low energy environment of low gradient rivers allowed silts and clays to settle during marsh formation. Since material was deposited at approximately sea level, the soils have never dried in place; they have a low bulk density and a high degree of fluidity (Darmody and Foss, 1979; Rabenhorst and Needelman, 2016). Coastal marshes are located along the perimeter of barrier island lagoons (e.g., Chincoteague Bay, Maryland). The variation in geomorphic settings and soil properties in Maryland tidal marshes alone is considerable. Recognizing the pedogeomorphic setting of marshes provides important insight into the processes of their formation and to understanding the types and sequences of soil horizons typically present. Therefore, the differences in geomorphic setting must be recognized.

Historically, the value of tidal marshes was not appreciated and these areas were often perceived as wastelands (Darmody and Foss, 1978). Further, the dense vegetation, unstable footing, and rising tides in tidal marshes can create an unforgiving environment for wetland and soil scientists wishing to conduct research in these wetlands. Together, these factors have contributed to a paucity of both research and data surrounding these valuable wetlands, but we now understand the wealth of ecosystems services marshes provide, with C storage being one. Much research has highlighted the importance of coastal ecosystems as C sinks, and, as a result of these efforts, scientists have assembled broad soil datasets (Smithsonian Environmental Research Center, 2018; National Cooperative Soil Survey, 2021). Even so, missing data plagues some of these sources making it difficult to accurately calculate soil C stocks, that is, C stored in the soil system (Equation 1).

Equation 1. Carbon stocks (kg C m^{-2}) = Bulk density (g cm^{-3}) x Soil organic C (SOC) content (%) x Horizon thickness (cm) x 10 (unit conversion)

For example, a review of the Kellogg Soil Survey Laboratory (KSSL) Soil Characterization Database conducted in 2022 revealed that there were only 35 characterized tidal marsh pedons for the entirety of the Mid-Atlantic region. Of these 35 pedons, 17 contained bulk density data to 100 cm, and only 11 had bulk density data to 200 cm (National Cooperative Soil Survey, 2021). Nine pedons contained no bulk density at all, making C stock calculations impossible. Tidal marsh C stocks have also been reported in the literature (Craft, 2007; Loomis and Craft, 2010; Van de

Broek et al., 2016; Kauffman et al., 2020; Gorham et al., 2020; Gu et al., 2020). However, there is no standard depth to which marsh soils are sampled for C calculations, a circumstance that has led to sampling depths ranging between 30 and 300 cm (Craft, 2007; Kauffman et al., 2020). Holmquist et al. (2018) assembled a large soil-core database (n = 1959), but they found that most pedons were obtained from shallow coring efforts (e.g., 24 cm). Shallow sampling depth is perhaps the most significant limitation in current data sets on tidal marsh C stocks, as this may lead to gross underestimation of C stocks. Underestimations may be more severe in tidal marsh histosols that may have several meters of organic soil materials overlying C rich mineral horizons (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2022a); shallow sampling in these soils would capture just a small fraction of stored C.

Several recent research efforts have estimated tidal wetland C stocks at a broad scale (Hinson et al., 2017; Holmquist et al., 2018; Wardrup, 2021), but each has some limitations. For example, Holmquist et al. (2018), utilizing data from past field studies in an attempt to identify the most accurate and reliable method of estimating soil C stocks in tidal wetlands of the conterminous United States (CONUS), concluded that using a fixed C density value of 0.0270 g C cm^{-3} was the best performing strategy. Following this approach, they estimated a CONUS C stock of 0.72 Pg in the upper meter (Holmquist et al., 2018). However, assuming all soils to have the same C density seems to be a gross oversimplification and neglects the dramatic heterogeneity in tidal marshes reflected in the soil morphology, which changes with particular geomorphic settings (Darmody and Foss, 1979; Rabenhorst and Needelman, 2016). Holmquist et al. (2018) did state that geomorphic drivers could have a large influence on soil C, so incorporating knowledge of regional geomorphology in the estimations of C stocks would be beneficial.

A study by Hinson et al. (2017) delineated the distribution of SOC among CONUS tidal wetlands, estimating that there were approximately 1.2 Pg of C over the same extent. In contrast to Holmquist et al (2018), bulk density and SOC data were derived from the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO). Although the SSURGO database may represent the best available knowledge of the soils at the time of mapping, the data for "ground-truthing" the maps are quite limited (as described above for the characterized pedons in the KSSL database). As a result, data from a few selected characterized pedons, are deemed representative of landscape units and applied on a very broad scale.

Wardrup (2021) also utilized digital soil mapping to model the spatial distribution of C stocks in Northeast and Mid-Atlantic tidal marshes among eight cover types and four depth intervals at a finer resolution (3 m) than Holmquist et al. (2018) and Hinson et al. (2017). Soil profile point-data sourced from multiple publicly available datasets served as training data to model C stocks. However, this training dataset was limited in that relatively few points (n = 49) contained data at the deepest depth interval (0 – 200 cm); the total was even smaller for the Mid-Atlantic region alone. Therefore, these estimations of C stocks at greater depths could be less accurate compared to those in the upper part of the profile. At such large scales, it is understandable and necessary to generalize certain kinds of data. Nonetheless, we must recognize that this concession will ultimately lead to inaccuracies in C stock estimations, especially given the various geomorphic settings in which tidal marshes and their soils have formed.

In this study, our objectives were: 1) to measure C stocks in selected marshes among the various PGUs representative of the Mid-Atlantic region; and 2) to determine the effect of deeper sampling (to 2 – 3 m depth) on the quantification of tidal marsh soil C stocks. We hypothesize that certain PGUs will store greater amounts of C due to fundamental differences in soil genesis processes and soil morphology.

2.2 METHODS AND MATERIALS

2.2.1 Identification of Pedogeomorphic Units

In order to identify tidal marsh PGUs representative of the Mid-Atlantic region, we used the three classes identified by Darmody and Foss (1979) (submerged upland, estuarine, and coastal) as a starting point. Their class of estuarine marshes did not consider the halinity of the river. However, we thought differences in biogeochemical processes and plant communities in fresh and brackish reaches of rivers warranted distinguishing estuarine fresh marshes from non-fresh. Darmody and

Foss (1979) also included all marshes surrounding coastal lagoons into a single class of coastal marshes. We expected considerable differences in soils between marshes on the mainland side and barrier island side of coastal lagoons due to differences in proximity to barrier island processes. Therefore, coastal marshes were divided into two separate PGUs, the coastal barrier and coastal mainland. Thus, a total of five distinct PGUs representative of Mid-Atlantic tidal marshes were recognized: 1) submerged upland; 2) estuarine fresh; 3) estuarine non-fresh; 4) coastal barrier; 5) coastal mainland (Table 2-1).

Table 2-1. Description and general locations of Mid-Atlantic PGUs. Some PGUs contain unique soil series that are not mapped elsewhere. Areal extent is in relation to the Mid-Atlantic region.
* The soil series observed in the estuarine non-fresh and coastal mainland PGUs were not distinctive or diagnostic as they were mapped in other PGUs.

PGU	**Description and location**	**Soil series unique to PGU**	**Areal extent (ha)** ***(Percent of total area)***
Submerged upland	The submerged upland marshes formed as a result of terrestrial land becoming inundated by sea level rise over the past several thousand years. Unable to withstand the constant saturation and brackish water, the upland vegetation died back and was eventually replaced by marsh hydrophytes. Submerged uplands are located mainly in MD in low-elevation areas that have been most susceptible to sea level rise.	Sunken, Honga	58,000 *(27%)*
Estuarine fresh	The estuarine fresh marshes formed from the deposition of sediment in the	Nanticoke, Mannington	24,000 *(11%)*

	freshwater reaches of tidally influenced river or stream channels. They are located along large rivers and their major tributaries, such as the Patuxent, Choptank, and Nanticoke Rivers.		
Estuarine non-fresh	The estuarine non-fresh marshes formed from the deposition of sediment in the brackish reaches of tidally influenced river or stream channels. They are located along large rivers and their major tributaries, such as the Patuxent, Choptank, and Nanticoke Rivers. Estuarine non-fresh marshes are also present along the coasts of the Delaware Bay.	None*	95,000 *(44%)*
Coastal barrier	Coastal barrier marshes formed in association with the deposition of sand blown or washed over from the beaches and dunes during high-energy storm events. They are located on the landward side of barrier islands such as Assateague Island, MD.	Purnell, Saltpond, Fox Hill	8,800 *(4%)*
Coastal mainland	Coastal mainland marshes formed from low energy alluvial deposits carried to and in the lagoonal waters and have similar characteristics to estuarine marshes. These marshes are located on the mainland side of barrier island lagoons (opposite of the barrier island marshes).	None*	28,000 *(13%)*

2.2.2 Delineating soil map units

Tidal marshes in the region have been mapped within units named for eighteen soil series (Table 2-2). Using ArcGIS (version 10.6) and the SSURGO database, we delineated all marsh map units (which contained one or more of these 18 series as a major component) into one of the five PGUs. The Sunken and Honga soil series, which have organic horizons less than 130 cm thick, are mapped exclusively in the submerged upland PGU. Thus, any map unit containing these “diagnostic” series were delineated as submerged upland marshes. When other series (such as Transquaking, which has an O horizons >130 cm thick) were mapped adjacent to submerged uplands, these areas were also included in submerged upland marshes.

Table 2-2. Tidal marsh soil series mapped in the Mid-Atlantic region. Taxonomic classification is given at the subgroup level. Information on pedon data were obtained from the KSSL Soil Characterization Database (National Cooperative Soil Survey, 2021) and the University of California, Davis Series Extent Explorer (UC Davis California Soil Resource Lab, 2020). Useable pedons in the KSSL database are those that contained both SOC content and bulk density data needed for calculating C stocks. Some useable pedons had bulk density data past 100 cm, but few had data past 200 cm. The total number of characterized pedons for the series (whether or not they had SOC and bulk density data) are also given.

*Legacy: only in old mapping of Kent County, MD. Mostly mapped in New England

		Number of Pedons					
Series	**Taxonomic classification**	**Usable pedons**	**With bulk density data below 100 cm**	**With bulk density data below 200 cm**	**Total pedons**	**Extent (ha)**	**Percent of total area**
Transquaking	Typic Sulfihemist	2	2	1	2	66,457	31.19%
Mispillion	Terric Sulfihemist	6	6	6	7	27,659	12.98%
Honga	Terric Sulfihemist	1	1	0	2	21,320	10.01%
Appoquinimink	Thapto-Histic Sulfaquents	0	0	0	0	18,735	8.79%
Sunken	Typic Endoaqualfs	0	0	0	2	17,303	8.12%
Broadkill	Typic Sulfaquents	2	1	0	2	13,662	6.41%
Puckum	Typic Haplosaprists	0	0	0	2	10,460	4.91%
Pawcatuck	Terric Sulfihemist	1	0	0	1	7,099	3.33%
Bestpitch	Terric Sulfihemist	6	5	4	8	5,971	2.80%
Nanticoke	Typic Hydraquents	0	0	0	0	5,741	2.69%
Mannington	Thapto-Histic Hydraquents	0	0	0	0	5,554	2.61%

Westbrook*	Terric Sulfihemist	3	2	0	3	3,091	1.45%
Tangier	Typic Endoaqualfs	1	0	0	2	2,448	1.15%
Purnell	Histic Sulfaquents	1	0	0	1	2,086	0.98%
Boxiron	Histic Sulfaquents	0	0	0	0	2,077	0.97%
Ipswich*	Typic Sulfihemist	0	0	0	0	1,671	0.78%
Fox Hill	Sodic Psammaquents	2	0	0	2	1,114	0.52%
Saltpond	Haplic Sulfaquents	0	0	0	0	592	0.28%
TOTALS		**25**	**17**	**11**	**34**	**213,040**	**100%**

The Nanticoke and Mannington soil series were mapped in the upper reaches of estuarine streams and were diagnostic for the estuarine fresh PGU. There were no soil series directly unique to (and thus diagnostic for) estuarine non-fresh marshes. To delineate this PGU, we used the US Fish and Wildlife Service’s National Wetland Inventory (NWI) Wetlands Mapper (United States Fish and Wildlife Service, 2018) to identify at what point along a river the estuarine marshes would transition from fresh to non-fresh. In general, the estuarine fresh PGU corresponded with “Freshwater Emergent Wetland” polygons in the NWI (United States Fish and Wildlife Service, 2018). Those map units further downstream were assigned to the non-fresh PGU. In some instances, the SSURGO map units for estuarine fresh marshes (Nanticoke and Mannington) did not directly align with the NWI freshwater emergent polygons. In those cases, we also attempted to utilize available water halinity data to assist in identifying the transition between estuarine fresh and non-fresh PGUs (Maryland Department of Natural Resources, 2022). The soil series mapped in coastal mainland marshes also occurred in other settings, but the marshes in this PGU were relatively simple to delineate as these occurred on the mainland side of barrier island lagoons. Similarly, marshes in the coastal barrier PGU were also straightforward to identify as they exist only behind barrier islands. Coastal barrier marshes were mostly mapped as Fox Hill, Saltpond, or Purnell soil series (which did not occur in other PGUs). Once we had compiled a draft map delineating all regional tidal marshes among the five PGUs, we consulted with several experienced soil scientists for their review and feedback. The outcome of these efforts is the map shown in Figure 2-1 which shows the extent of each PGU in the Mid-Atlantic region.

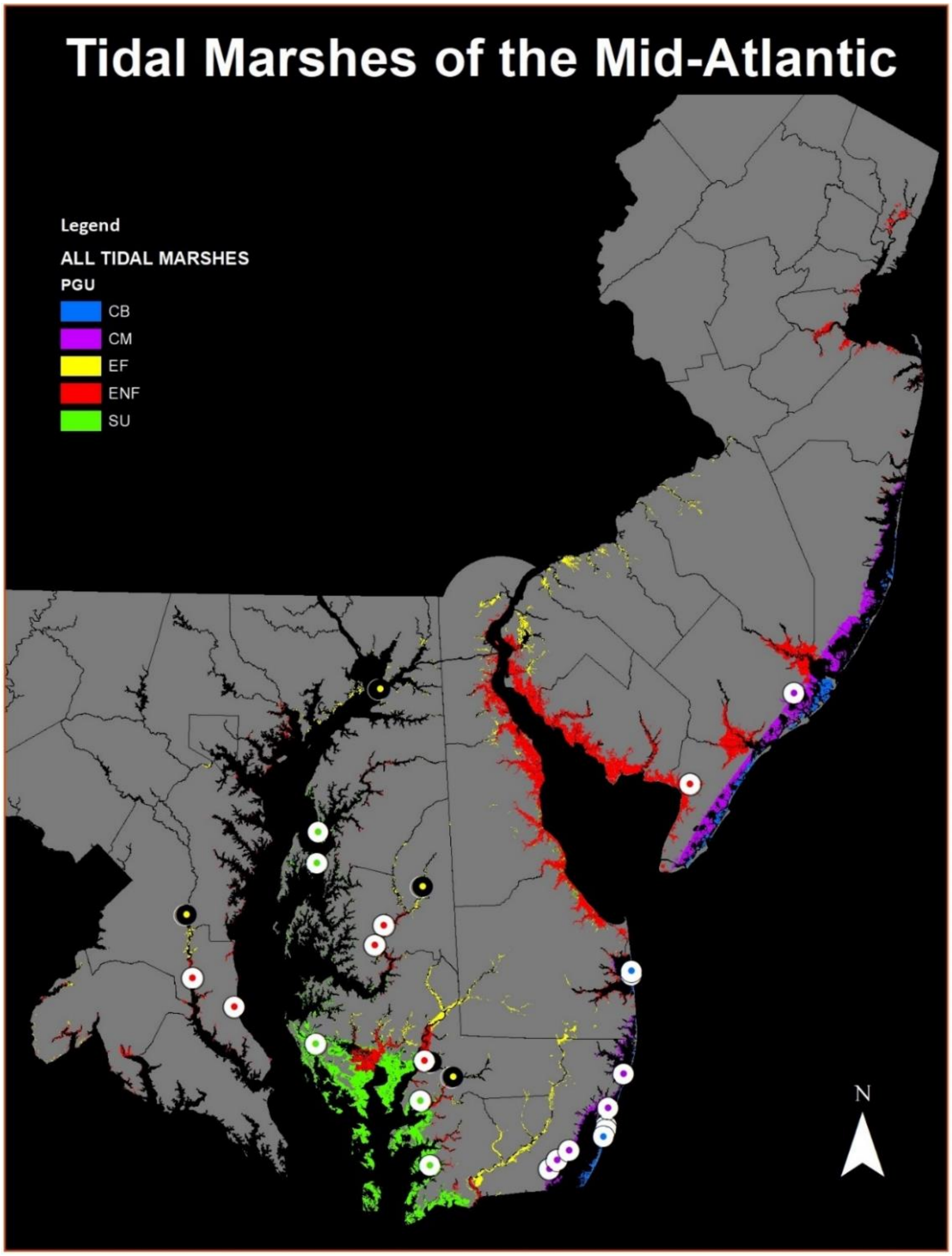


Figure 2-1. The distribution of tidal marshes among five pedogeomorphic units in the Mid-Atlantic region and transect locations where marshes were examined and sampled (Environmental Systems Research Institute, Inc., 2018; Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2022b).

2.2.3 Site selection

Within in each PGU we identified five to six transects for examination and sampling. Transect locations were selected 1) to be representative; 2) to provide geographical distribution; and 3) to be accessible. Most transects were accessible by land (by driving and walking) but others were only accessible by boat. Each marsh transect extended from the upland boundary to the edge of open water (river, major tidal creek, or bay) and ran roughly normal to the adjacent upland boundary. Transects were selectively placed such that they avoided large, degraded areas (e.g., pools or unvegetated zones). Depending on the length of the transect (which ranged from 92 to 757 meters), three to five points were chosen along each transect for morphological descriptions and sampling, with the distance between points in a given transect being roughly equal. Description points were also chosen to be representative of the surrounding marsh landscape (i.e., similar microtopography and vegetation). In total, we examined 28 transects across the five tidal marsh PGUs in Maryland, Delaware, and New Jersey (Table 2-3).

Table 2-3. Twenty-eight tidal marsh transects examined within the Mid-Atlantic study area.

Transect	PGU	Length (m)	Latitude	Longitude	Pedons described
DE CB01	Coastal barrier	259	38.63412°	-75.06974°	4
DE CB02	Coastal barrier	359	38.64551°	-75.07170 °	5
MD CB01	Coastal barrier	255	38.17009°	-75.17043°	4
MD CB02	Coastal barrier	213	38.17824°	-75.16814°	4
MD CB03	Coastal barrier	331	38.18809°	-75.16425°	5
MD CB04	Coastal barrier	241	38.20048°	-75.15910°	4
MD CM02	Coastal mainland	147	38.07523°	-75.36610°	4
MD CM03	Coastal mainland	203	38.10090°	-75.33819°	4
MD CM04	Coastal mainland	149	38.25103°	-75.15378°	4
MD CM07	Coastal mainland	109	38.34961°	-75.09708°	4
MD CM09	Coastal mainland	93	38.12886°	-75.29471°	5
NJ CM01	Coastal mainland	368	39.44406°	-74.46447°	5
MD EF01	Estuarine fresh	222	38.79498°	-76.70565°	4
MD EF04	Estuarine fresh	103	38.42849°	-76.22522°	4
MD EF09	Estuarine fresh	124	38.95081°	-76.22807°	4
MD EF11	Estuarine fresh	92	38.88585°	-75.83849°	3
MD EF12	Estuarine fresh	211	39.45216°	-76.00085°	4
MD ENF02	Estuarine non-fresh	319	38.38256°	-75.79890°	4
MD ENF04	Estuarine non-fresh	268	38.34037°	-75.71883°	4
MD ENF06	Estuarine non-fresh	266	38.38578°	-75.82635°	4
MD ENF09	Estuarine non-fresh	244	38.71550°	-76.00982°	5
MD ENF10	Estuarine non-fresh	376	38.53314°	-76.52344°	5
NJ ENF01	Estuarine non-fresh	406	39.18154°	-74.85235°	4
MD SU01	Submerged upland	757	38.61275°	-76.67738°	5
MD SU04	Submerged upland	267	38.77110°	-75.97814°	4

MD SU11	Submerged upland	112	38.08028°	-75.80317°	4
MD SU13	Submerged upland	268	38.26932°	-75.83886°	4
MD SU15	Submerged upland	110	39.03929°	-76.22465°	4

2.2.4 Field methods

Field efforts were conducted from May – August 2021. At each transect point, a detailed soil morphological description was made to a depth of 2 – 3 m following standard protocols (Schoeneberger et al., 2012). This included such characteristics as horizon name, horizon depth, texture, and Munsell color. For organic horizons, percent rubbed fiber was estimated (Soil Survey Staff, 2014) and degree of decomposition was further assessed using the von Post scale of humification (Rokus, 2020). We also documented the soil's reaction with 3% and 30% hydrogen peroxide to test for the presence of Fe-sulfide minerals (Schoeneberger et al., 2012; Wessel and Rabenhorst, 2017; Duball et al., 2020). Where sufficiently soft and fluid, soils were examined using a Macaulay sampler, which removes an undisturbed half-core of known volume. Where the soils were too dense for use of a Macaulay sampler, a bucket auger was used. We also employed a serrated hand-coring device (of known volume) to obtain samples from fibrous surface O horizons. At approximately half of the points where descriptions were made, the soils were sampled for bulk density and SOC analysis. Samples were collected from each pedogenic horizon in the same core used for the morphological description, and a total of 455 samples were collected.

2.2.5 Laboratory methods

Soil organic C was measured in duplicate for every sample using high temperature, dry combustion with a LECO CN628 carbon analyzer. Prior to analysis, samples were tested using 10% HCl to determine if inorganic C was present in the form of $CaCO_3$. Because no reaction with HCl was observed, no additional treatment was used to remove carbonates prior to combustion. If samples were collected using a device of known volume (Macaulay sampler or serrated corer), bulk density was determined from sample weights after oven drying to a constant mass.

2.2.6 Estimations of bulk density

In some instances, direct measurement of bulk density was not possible. Mostly these occurred in sandy or dense subsoils where the Macaulay sampler could not be used. In these cases, bulk densities were estimated using pedotransfer functions derived from local or regional data that were based mainly upon soils with similar morphology, texture (particle size), and SOC content. This was done for approximately 30% of the samples collected, which mainly occurred deeper in the profile and where OC values were low. The source of information for the derivation of the pedotransfer functions, and the pedotransfer functions themselves, are available in Appendix A.

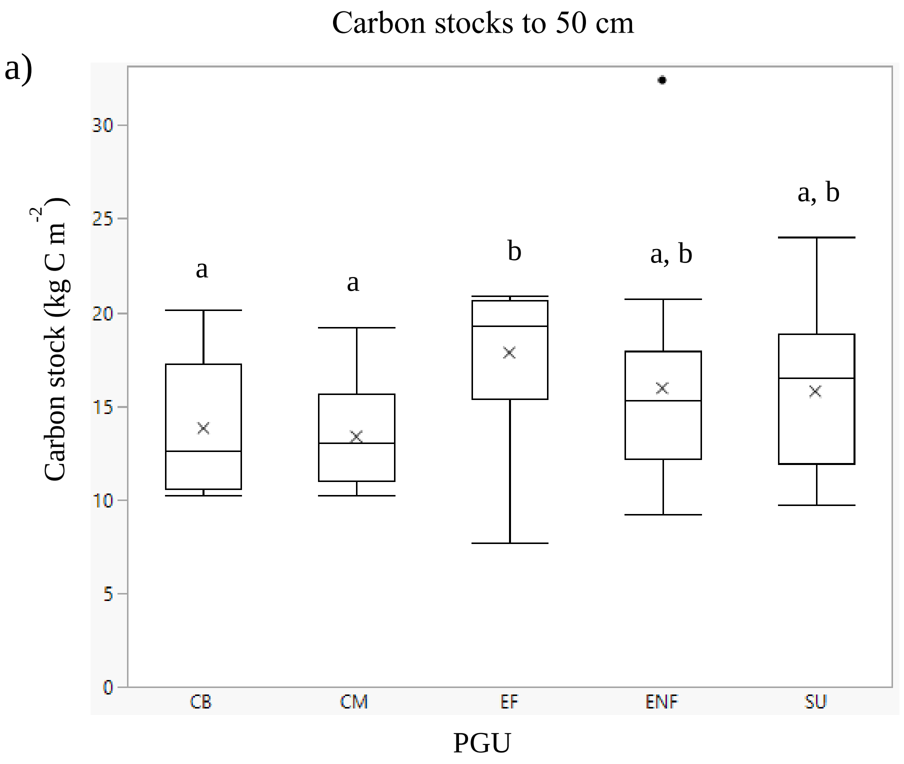
2.2.7 Data analysis

Data were analyzed using JMP Pro version 15.2. Analysis of variance (ANOVA) was used to determine if there were significant differences among the mean C stocks of the PGUs. A students t-test was used to locate the significant differences among the mean C stocks of the five PGUs. R studio (version 1.3.1073) and Microsoft Excel (version 18.2210.1203.0) were also used to illustrate some figures.

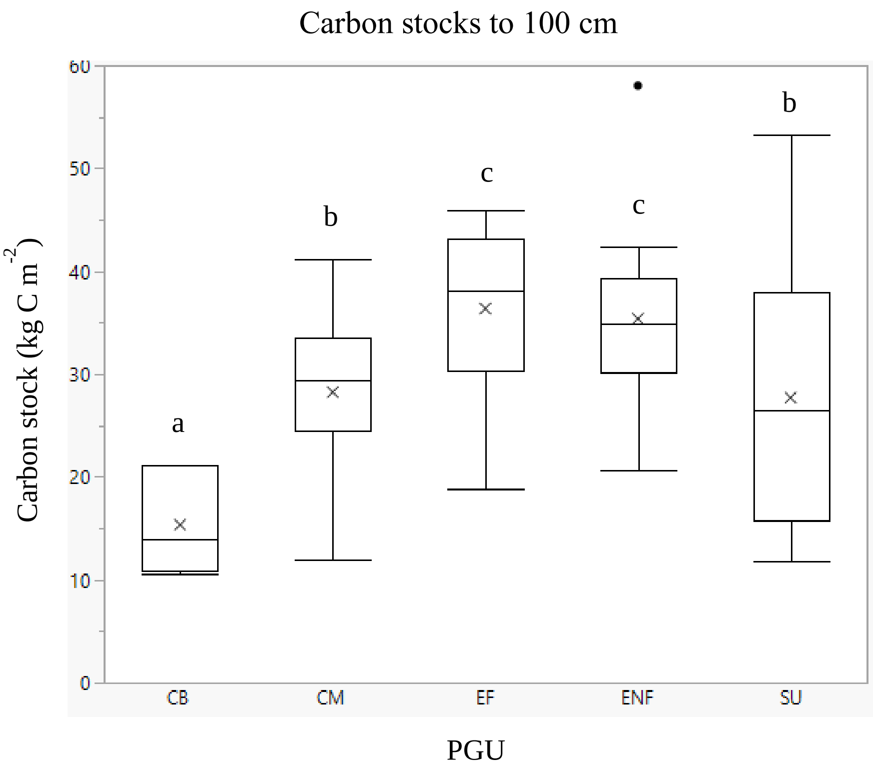
2.3 RESULTS AND DISCUSSION

2.3.1 Carbon stocks among the five pedogeomorphic units

Carbon stocks for each pedon were calculated to depths of 50 cm, 100 cm, and 200 cm (Figure 2-2). When calculated to a depth of 50 cm (Figure 2-2 a) the mean C stocks were largely similar among the five PGUs, ranging between 7 and 32 kg C m^{-2}. Only the coastal mainland and coastal barrier PGUs had means that were significantly different from that of the estuarine fresh PGU. More pronounced differences among the PGUs emerged when C stocks were calculated to a depth of 100 cm (Figure 2-2 b). The smallest mean C stocks were found in the coastal barrier PGU (15 kg C m^{-2}) and the highest in the estuarine fresh and non-fresh PGUs (35 to 38 kg C m^{-2}, respectively). The coastal mainland and submerged upland marshes stored an intermediate amount of C. When calculated to a depth of 200 cm, differences in C stocks among the PGUs became most obvious (Figure 2-2 c). The estuarine marshes continued to show the greatest mean C stocks which ranged as high as 90 kg C m^{-2}. Coastal mainland marshes, which shared many characteristics with the estuarine marshes, had mean C stocks that were nearly as high, and were significantly greater than those of the submerged upland soils. When calculated to a depth of 200 cm, C storage in the coastal barrier PGU remained lowest among all the PGUs with a maximum of just 22 kg C m^{-2}.



b)


Carbon stocks to 100 cm
Carbon stock (kg C m^{-2})
60
50
40
30
20
10
0
a
b
c
c
b
CB
CM
EF
ENF
SU
PGU

c)

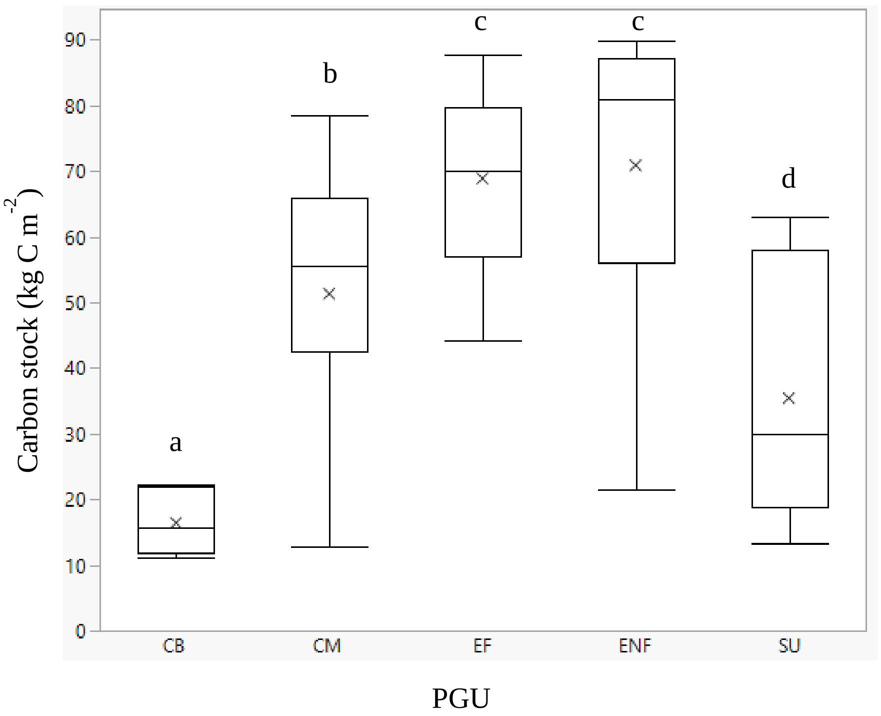

Carbon stocks to 200 cm

Figure 2-2 a – c. Carbon stocks of sampled tidal marsh pedons calculated to depths of a) 50 cm; b) 100 cm; and c) 200 cm among the five pedogeomorphic units. Bars designated with different letters have means that are significantly different at the 0.05 level. Means are represented by the X within the boxes. The top and bottom of the box show the 25th and 75th percentiles of the data with the median at the midline. Whiskers represent 1.5 times the interquartile range (IQR – the distance between the 25th and 75th percentiles). If the data extend past 1.5 times the IQR, then they are plotted as points and are considered outliers. If the data do not extend to 1.5 times the IQR, then the whiskers represent the range in values, excluding outliers.
CB: coastal barrier; CM: coastal mainland; EF: estuarine fresh; ENF: estuarine non-fresh; SU: submerged upland.

The differences in C stocks among the PGUs were related to differences in the geomorphology and soil morphology in each setting. The estuarine marshes were comprised of deep, organic-rich, sedimentary deposits that extended many meters before encountering a dense, low-carbon base (typically far deeper than our maximum sampling depth of roughly 350 cm). Additionally, the soils largely consisted of materials with high C densities (Equation 2), whether as O horizons or as C-rich mineral horizons. Thus, soils in these systems may have actually stored an enormous amount of C. The coastal mainland marshes were similar in nature to the estuarine marshes in having similar soil materials with high C density, but the depth to the base of these marshes was not as deep. We frequently observed soil texture becoming sandier (coupled with a decrease in C density) at depths approaching 150 – 250 cm, indicating we were nearing the contact with the sandy base material. In pedons described closest to the upland interface, the depth to a sandy base was much shallower (as little as 35 cm), but in contrast to the submerged upland soils, the slope of the contact was steeper, and the thickness of the C-rich marsh soil increased quickly to approximately 150 – 250 cm where it stabilized. Therefore, when calculated to 200 cm, coastal mainland marshes had average C stocks that were usually close to, but not as high as, those in the estuarine marshes. The submerged upland marshes had O horizons that gradually thickened towards the estuary. Close to the upland edge, we observed thin O and A horizons overlying Bt or Btg horizons; these pedons had smaller C stocks. Moving away from the upland-marsh edge, the O horizons thickened, and C stocks correspondingly increased toward the open water. The contrast in the magnitude of C stocks at either end of submerged upland transects resulted in a wide range in total C stocks across these marshes, so C stocks in this PGU were highly spatially dependent. The dynamic nature of barrier islands has produced the youngest marsh soils with O horizons that were typically less than 30 cm. Beneath the O horizon are low-C, sandy C horizons; these materials mostly had a SOC content less than 0.2% by weight and a mean C density of 0.0029 g C cm^{-3}. As a result, these marshes consistently had the smallest C stocks.

Equation 2. Carbon density (g cm^{-3}) = Bulk density (g cm^{-3}) x SOC content (%)

Another factor that affected differences in mean C stocks among soils was the depth to which C stocks were calculated. The morphology of marsh soils among all PGUs were more alike in the upper 50 cm (where soils were dominated by O horizons or more C-rich mineral materials). Thus, the soils had similar C densities nearer the surface, and calculated C stocks were more alike to 50 cm. However, at greater depths, soil morphology, and therefore C density, differed dramatically among PGUs. Soils in some PGUs remained more similar at depth while others (predictably) changed drastically lower in the profile, which impacted calculations of C stocks at greater depths. For instance, in the coastal barrier PGU or along the upland edges of submerged upland PGU, most of the C in the soil occurred within the upper 100 cm (and often the upper 50 cm). Deeper sampling yields little additional stored C. On the other hand, the O horizons and C-rich mineral horizons of the estuarine PGUs often extended well past 200 cm (Beckett, 2012). Thus, deeper sampling would yield much additional stored C.

The differences in C stocks among the five PGUs illustrates the value and necessity of differentiating tidal marshes by their geomorphic setting, rather than considering them without distinction (Holmquist et al., 2018). These data also emphasize the importance of collecting measured data. Hinson (2017) used the SSURGO dataset to map C distribution, but these maps currently utilize very few measured data upon which C stock data can be based. Based on SSURGO data and the associated limited database, Hinson et al. (2017) estimated the C density at 100 cm in CONUS tidal marshes to be 0.042 and 0.043 g cm^{-3} (for estuarine emergent and freshwater tidal, respectively). In all tidal wetlands of the Chesapeake Bay Watershed, they estimated the C density at 100 cm to be 0.048 g cm^{-3}. These values would appear to be significant overestimates for all marshes compared to the data obtained in this project. For marshes in the coastal barrier and submerged upland PGUs, measured mean C densities at 100 cm were 0.001 and 0.016 g cm^{-3}, respectively.

2.3.2 Impacts of shallow sampling depth

Figure 2-3 further elucidates the implications of shallow sampling on C stocks among the PGUs. With reliable C stock data to 200 cm, we determined what proportion of that C stored to 200 cm would be accounted for if soils were sampled to shallower depths: 50 and 100 cm. In barrier island marshes, over 75% of the C stored to 200 cm would be accounted for if we only sampled the upper 50 cm. Sampling to 100 cm would raise that C captured to over 88%. However, in the coastal mainland and estuarine PGUs, only one-quarter to one-third of the C stored to 200 cm would be captured if soils were sampled to 50 cm. If sampling went to 100 cm, the proportion accounted for would roughly double. However, this still represents only 53 – 59% of the C stored in the upper 200 cm; this might actually represent an even smaller portion when considering the great depths to which some estuarine marsh soils may extend (Beckett, 2012). The upper 50 cm of submerged upland soils accounted for anywhere between 22% to 82% of the C in the upper two meters. The large range in the proportion of C captured is explained by the increasing thickness of the O horizon as one moves away from the upland in these settings. Pedons near the upland edge had thin O horizons, so the majority of C would be captured under a 50 cm sampling protocol. Close to open water, organic horizons were thicker, where sampling the upper 50 cm would capture only a fraction of the total C stored in the upper 200 cm. In the upper 100 cm, submerged upland soils contain 60 – 91% of the C stocks to 200 cm.

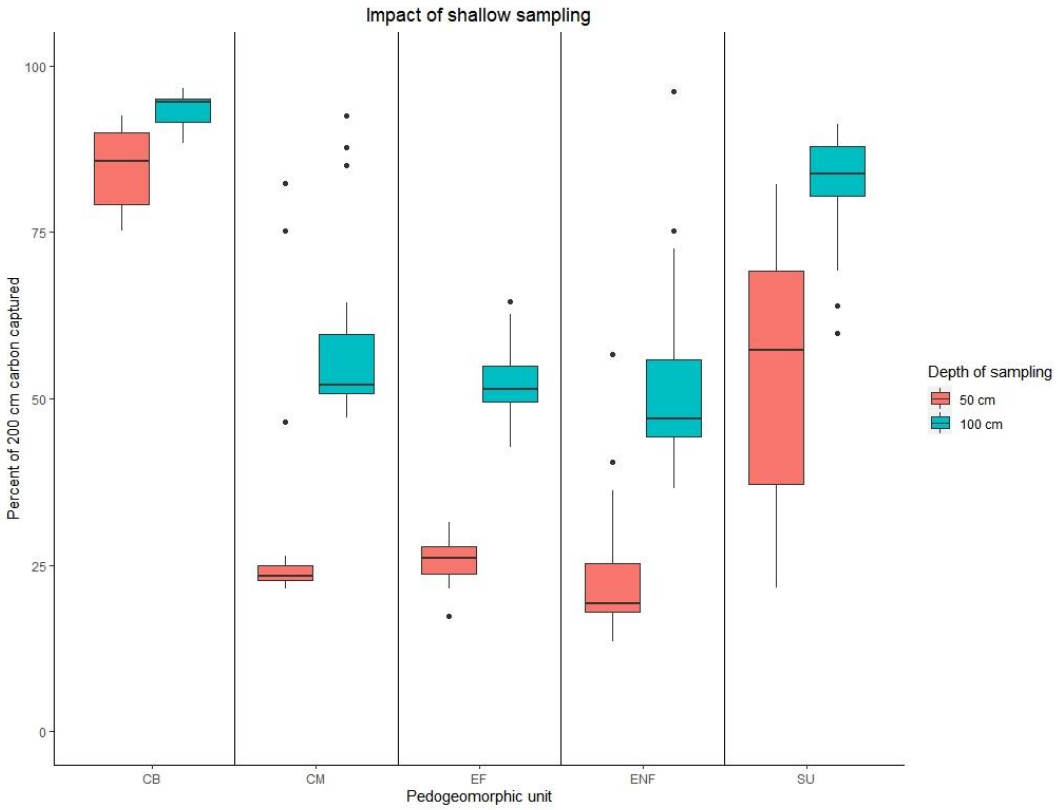
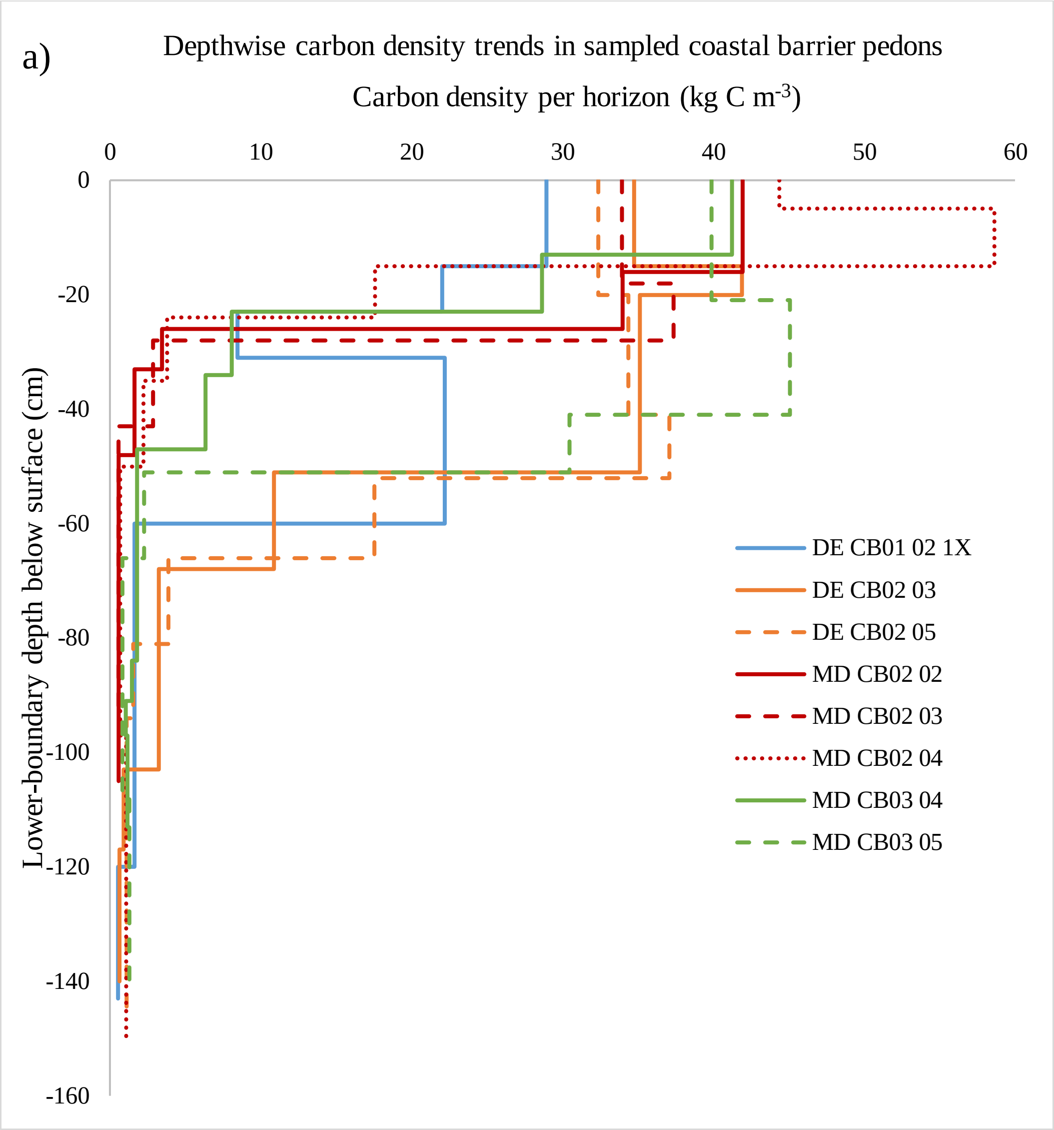


Figure 2-3. The percent of C stored in the upper 200 cm that would be captured if pedons were sampled to 50 cm (red) and 100 cm (blue). CB: coastal barrier; CM: coastal mainland; EF: estuarine fresh; ENF: estuarine non-fresh; SU: submerged upland. Whiskers represent 1.5 times the interquartile range (IQR – the distance between the 25th and 75th percentiles). If the data extend past 1.5 times the IQR, then they are plotted as points and are considered outliers. If the data do not extend to 1.5 times the IQR, then the whiskers represent the range in values, excluding outliers.

These findings suggest that deep sampling is less critical in certain PGUs. In the coastal barrier marshes, for instance, the C density declined sharply below 40 – 50 cm (Figure 2-4 a), so a 100 cm (or perhaps even a 50 cm) sampling protocol for determining C stocks would be sufficient. Sampling soils to 50 or 100 cm is also sufficient in the landward portions of submerged upland marshes where the O horizon is thin.

a)
Depthwise carbon density trends in sampled coastal barrier pedons
Carbon density per horizon (kg C m-3)
0
10
20
30
40
50
60
0
-20
-40
-60
-80
-100
-120
-140
-160
Lower-boundary depth below surface (cm)
DE CB01 02 1X
DE CB02 03
DE CB02 05
MD CB02 02
MD CB02 03
MD CB02 04
MD CB03 04
MD CB03 05

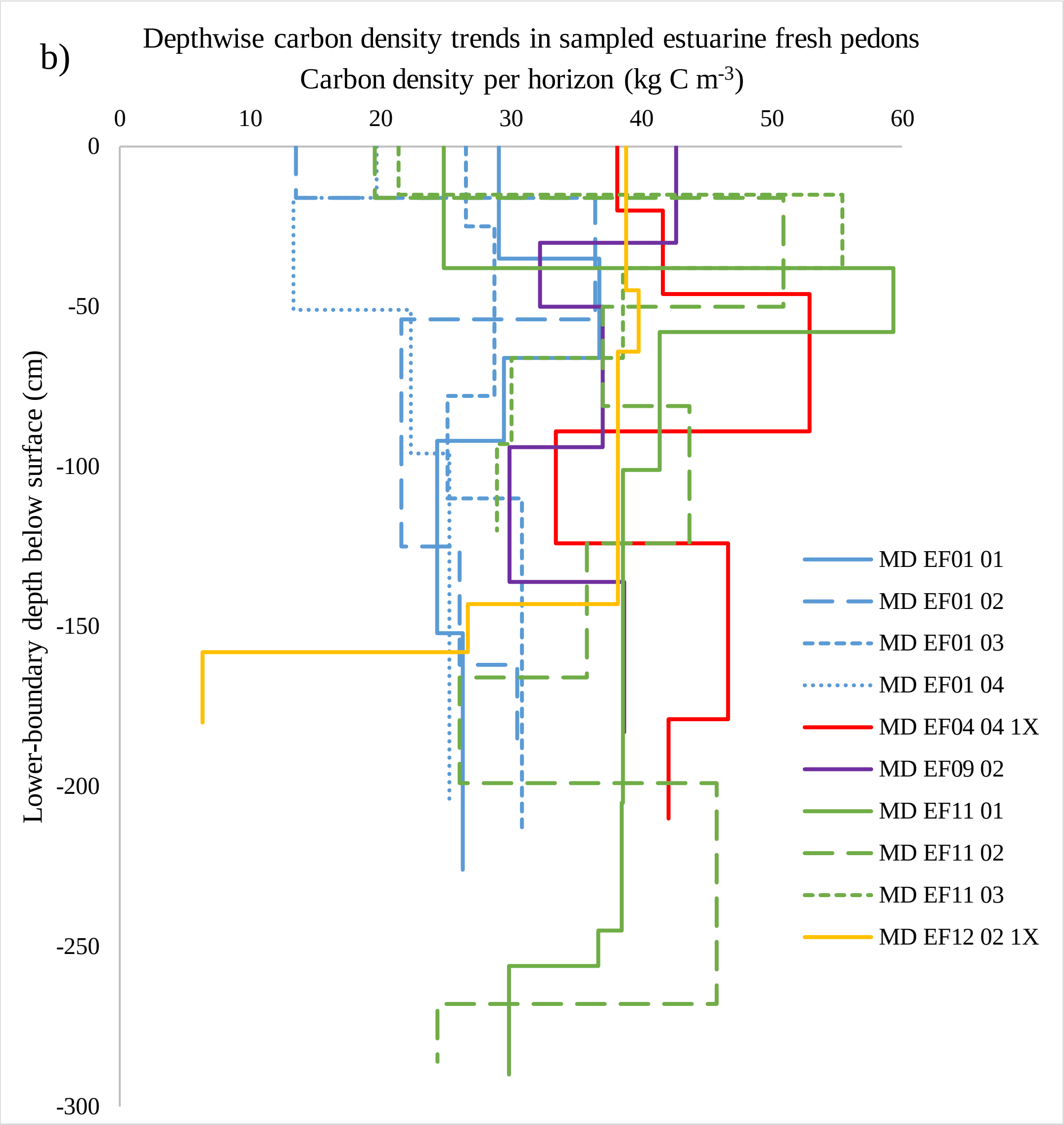


Figure 2-4 a – b. Carbon density depth functions (by soil horizon) in (a) sampled coastal barrier pedons and (b) estuarine fresh pedons. Carbon stocks are represented by the area to the left of each curve. In the coastal barrier PGU, C stocks were greater near the surface due to the presence of O and A horizons but drop quickly once low-carbon C horizons were encountered in the profile. In the estuarine fresh PGU, C density remained high throughout the profile, which was comprised of O horizons and C-rich mineral horizons. Pedons from the same transect are indicated by the same color and different pattern.

In other settings, such as the estuarine PGUs, shallow sampling would result in a gross underestimation of C storage. We described many estuarine marsh pedons to 200 – 300 cm, but Beckett (2012) analyzed a number of cores from an estuarine non-fresh marsh along the Nanticoke River, MD that ranged in depth from 600 – 800 cm; one core was 1500 cm deep. In a separate field exercise, we documented over 6 m of organic and high-C fluid mineral material in an estuarine non-fresh marsh along the Blackwater River, MD (data were not included in this study). Since estuarine marsh soils maintained uniformly high C densities throughout the profile (Figure 2-4 b), C stock calculations in these settings were largely a function of sampling depth. This explains the dramatic increase in C captured when sampling deeper in these marshes (Figure 2-3). Some studies that have measured and calculated C stocks have reported shallow sampling protocols (Craft, 2007; Hansen et al., 2017), and not surprisingly, those studies have reported lower magnitudes of C stocks than those that have sampled deeper (Hansen et al., 2017; Kauffman et al., 2020; Gorham et al., 2020). Shallow sampling in an estuarine (or even a coastal mainland) PGU would encounter just a fraction of total stored C. Thus, the accurate accounting of C stocks in PGUs where high C density materials are deeper will require sampling as deep as is feasible.

2.3.3 Bulk density sensitivity analysis

We quantified the potential error in total pedon C stocks that may have been introduced as a result of bulk density estimations by carrying out a sensitivity analysis. To do this, for each horizon for which bulk density had been estimated (using one of the pedotransfer functions), the estimated BD value was increased either by the root mean square error (RMSE) of the model or by the standard deviation (as appropriate for the particular pedotransfer function used for each sample; Appendix A). Then, C stocks for each pedon (for which estimated bulk densities were used for one or more horizons) were recalculated and compared to the C stocks originally determined, and the magnitude of the change and the relative increase was calculated (Figure 2-5).

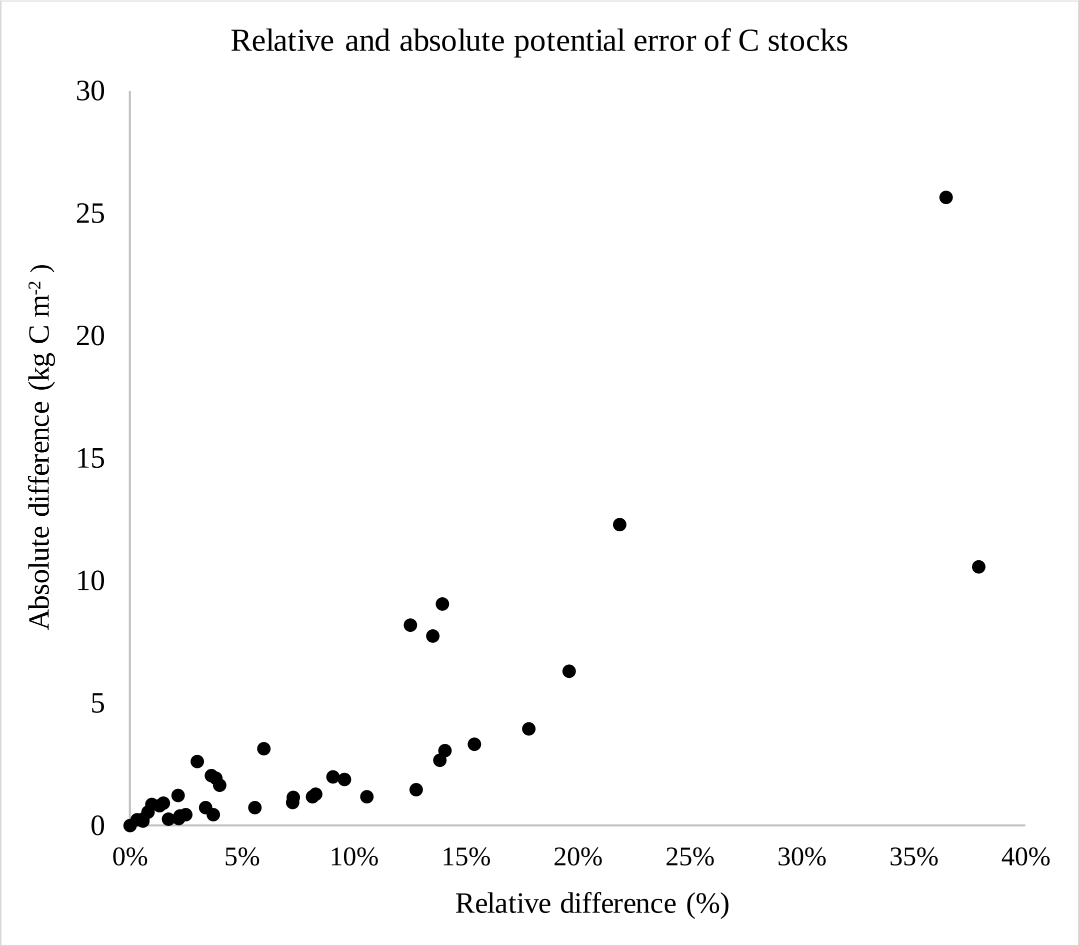


Figure 2-5. The relative percent difference (X-axis) and the absolute value difference (Y-axis) of C stocks (to 200 cm) in pedons containing horizons with estimated bulk densities after changing their bulk densities by one RMSE or standard deviation.

Nearly all (38 of 40) of the pedons containing horizons with estimated bulk densities had a potential error of less than 24%, and two-thirds of the pedons had a potential error of 10% or less (Figure 2-6). Only two of 40 pedons showed relative differences that were substantial (36% to 38%). In one of these instances, all five horizons in the profile required bulk density estimations, and four of them were classified as O horizons (a very unusual situation). In the second instance, most of the potential error introduced came from an O horizon. The pedotransfer function for these materials had a wide prediction range due to the range in possible SOC values in O horizons. In most cases where BD estimates were needed (i.e., sandy coastal barrier soils or submerged upland argillic horizons that were too dense to retrieve with a Macaulay sampler) those horizons also had extremely low SOC contents. Thus, even if errors were introduced in bulk density estimations, the overall impact on C stock calculations generally were minimal.

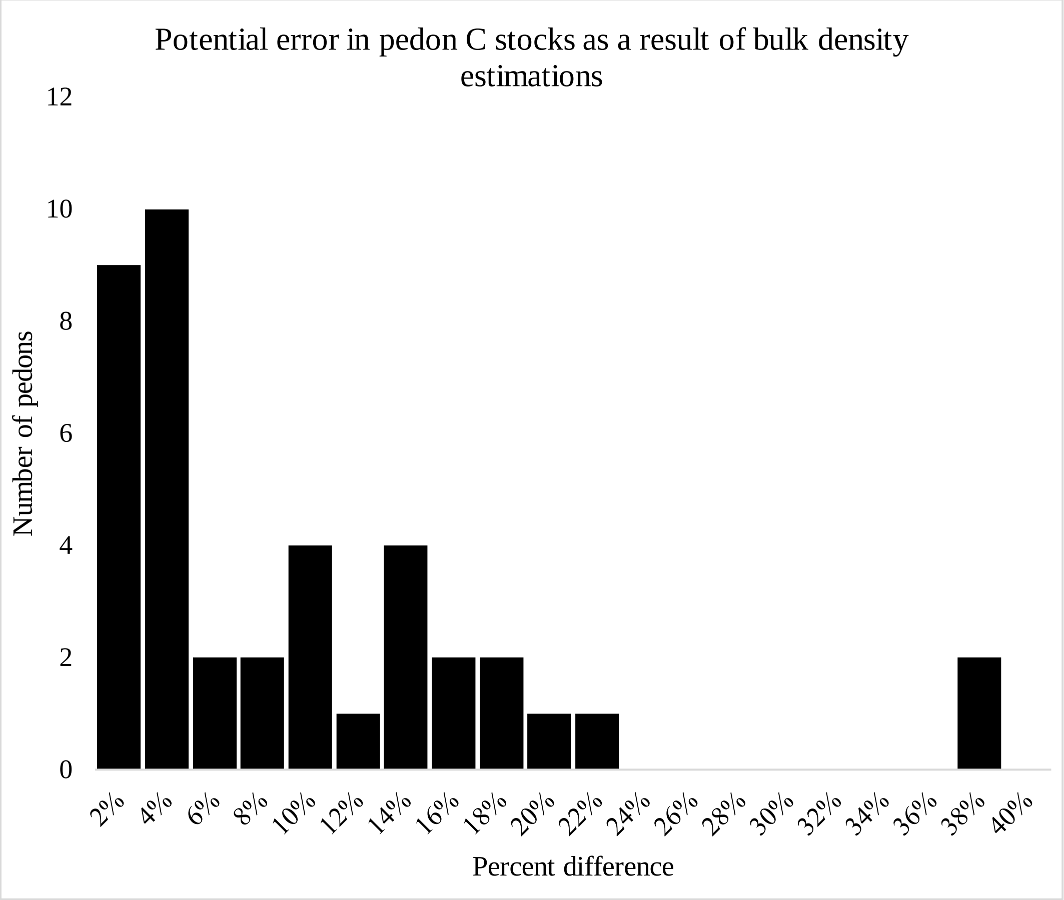


Figure 2-6. Histogram showing the frequency at which error estimates of various magnitudes occurred in those pedons where bulk densities were estimated using pedotransfer functions. The percent difference between originally calculated C stocks to and C stocks calculated from modified (± 1 RMSE or standard deviation) bulk densities is shown on the X-axis. Carbon stocks were calculated to 200 cm in both the original and the modified calculation. The number of pedons with estimated bulk densities with a given level of error is represented on the Y-axis.

2.4 CONCLUSION

Tidal marshes in the Mid-Atlantic region were classified into five PGUs. We examined soils along 28 transects among these five PGUs, and measured C stocks in 72 pedons. This effort essentially tripled the number of pedons for which any detailed data are currently available in the KSSL database. In considering the number of pedons for which carbon stocks could be calculated to 100 cm or 200 cm, it increased the number of pedons by five-fold and seven-fold, respectively. Carbon storage differed significantly among marshes in various PGUs. Marshes in the estuarine fresh and non-fresh PGUs consistently stored the most C to 200 cm, whereas those in the coastal barrier PGU stored the least. These differences in C stocks were due to different sedimentary and pedological processes at work among the PGUs causing soils to form with contrasting morphologies and with associated differences in the C densities, impacting C stocks.

Carbon density trends with depth (depth functions) changed dramatically throughout the soil profile and differed among PGUs. In the coastal barrier or landward portions of the submerged upland PGUs, C density was high in the upper part of the soil, where thin O horizons overlayed low-C subsoil materials such as Bt or sandy C horizons. Contrastingly, C densities remained high throughout the profiles of estuarine marshes, which can extend to depths of many meters. In these settings, calculating C stocks to shallow depths (i.e., less than 100 cm) will dramatically underestimate the magnitude of stored C. In general, deeper sampling will provide more accurate quantifications of C stocks, but sampling effort (time and energy) increases with sampling depth. Therefore, optimal sampling strategies for C stocks should be tied to an understanding of the pedology and geomorphology of the marsh system (i.e., PGU) so that most of the C can be efficiently accounted for and with minimal sampling effort.

Chapter 3: The utility of carbon density, soil morphology, and geomorphic setting for improved estimations of carbon stocks in Mid-Atlantic tidal marshes

3.1 INTRODUCTION

The United States contains four million ha of tidal marsh wetlands (Tiner, 2013). Although tidal marshes only comprise 0.4% of the land, they store a disproportionately high amount of C compared to terrestrial wetlands. Sufficient quantities of C rich inputs paired with highly anaerobic conditions allow tidal marshes to accrete vertically to keep pace with sea level rise. Due to the continual deposition and burial of C, tidal marshes may sequester C at rates 40 to 50 greater than terrestrial forests (Mcleod et al., 2011). The considerable C storing capacity of marshes, which were once perceived as wastelands, has reinforced the need for their preservation as well as the need for accurate estimations of C in these wetlands.

Tidal marshes in the Mid-Atlantic region (Maryland, Delaware, and New Jersey) occupy approximately 214,000 ha (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2022b). Marshes in this region can be differentiated based on the geomorphic setting in which they are found, which are distinctive with respect to their pedogenic processes resulting in particular soil morphologies within each setting. Due to the differences in pedological and geomorphological processes, we can recognize these various areas as "pedogeomorphic units" (PGU). In Maryland, Darmody and Foss (1979) investigated the soil-landscape relationships of tidal marshes and identified three distinct geomorphic settings (what we now recognize as PGUs): 1) submerged upland; 2) estuarine; 3) coastal.

Submerged upland marshes formed as terrestrial land became inundated during sea level rise over the past several thousand years (Rabenhorst and Needelman, 2016). The existing upland vegetation (e.g., *Pinus taeda* forest) died due to osmotic stress (Hussein et al., 2004) and increased periods of inundation and was replaced by marsh hydrophytes. Soils in this setting have O horizons that gradually thicken in the direction of open water; they also retain typical upland morphological characteristics including argillic horizons (Stolt and Rabenhorst, 1991) and redoximorphic features. Estuarine marshes have formed in tidally influenced river channels that were filled with fine-textured mineral sediment such as silts and clays. Since mineral material was deposited at approximately sea level, these fine textured soils have always been saturated giving them a high degree of fluidity and a low bulk density (Darmody and Foss, 1979; Rabenhorst and Needelman, 2016). Finally, the coastal marshes have formed along the perimeter of barrier island lagoons (e.g., Chincoteague Bay, Maryland) (Darmody and Foss, 1979). Marshes behind the barrier island formed as sand was deposited in shallow area of the lagoon following wash-over events from the beaches and dunes. Marshes along the mainland side of the lagoon formed from alluvial deposition of silts and clays. In Maryland alone, there is great variation in the geomorphologies and soil properties of tidal marshes. The differences among these PGUs must be acknowledged because it provides crucial insight into their processes of formation and to the soil morphologies present.

The recognition of the importance of tidal wetlands has given rise to recent studies attempting to estimate their C stocks (a measure of C storage) at a broad scale (Hinson et al., 2017; Holmquist et al., 2018). Holmquist et al. (2018) attempted to identify the most accurate and precise method of estimating C stocks in tidal wetland soils of the conterminous United States (CONUS). They concluded that using a fixed C density value of 0.027 g C cm^{-3} for all marshes was the optimal strategy compared to other methods (including more spatially-explicit methods like using soil survey maps) (Holmquist et al., 2018). Perhaps such an approach could be justified for nation-wide estimates of blue C, but it neglects the dramatic variations in tidal marsh soil morphology known to occur in certain geomorphic settings of the Mid-Atlantic region (Darmody and Foss, 1979; Rabenhorst and Needelman, 2016). Holmquist et al. (2018) did acknowledge that geomorphic variables may greatly impact soil organic matter, so incorporating knowledge of the pedogeomorphic setting could aid in estimations of C stocks. Variations in soil morphology and their impacts were evident in a preliminary analysis of characterized Mid-Atlantic tidal marsh pedons in the United States Department of Agriculture (USDA) Kellogg Soil Survey (KSSL) Soil Characterization Database, which revealed that there were significant differences among the mean C densities of various soil materials present in marsh soils (Figure 3-

1). Others have also shown that C density increases deeper in the profile (Sapkota and White, 2021), so one cannot reasonably assume that all tidal marsh soils have a uniform C density with depth. So, although some generalizations may be required at large scales, they may be excessively broad when estimating C stocks at a regional scale.

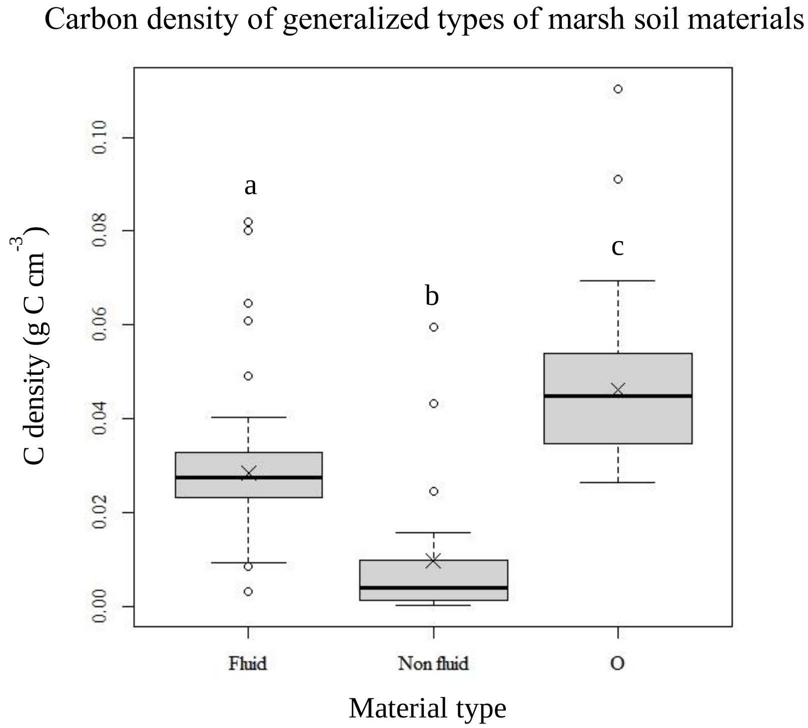


Figure 3-1. Carbon density among three generalized marsh material types. Fluid materials are fine or loamy-textured mineral horizons and have a fluidity class of moderately or very fluid (Schoeneberger et al., 2012). Non-fluid materials are comprised of sandy textures or Bt/Btg horizons of submerged uplands; O horizons include Oi, Oe, and Oa horizons (National Cooperative Soil Survey, 2021). Materials designated with different letters have means that are significantly different at the 0.05 level. Means are represented by the X within the boxes. The top and bottom of the box show the 25th and 75th percentiles of the data with the median at the midline. Whiskers represent 1.5 times the interquartile range (IQR – the distance between the 25th and 75th percentiles). If the data extend past 1.5 times the IQR, then they are plotted as points and are considered outliers. If the data do not extend to 1.5 times the IQR, then the whiskers represent the range in values, excluding outliers.

Work by Hinson et al. (2017) mapped the quantity and distribution of SOC in CONUS tidal wetlands on a watershed scale. The regional focus in this work may have improved on the efforts by Holmquist et al. (2018) because it relied on soil data for each particular watershed, thereby accounting for the differences in the soils. The soil data used for this study came from a spatial dataset of the USDA Soil Survey Geographic Database (SSURGO) rather than from tidal marsh soil data reported in the literature. The SSURGO dataset is perhaps the best available spatial soils information at broad scales, and their use of this database to quantify C storage at a similar scale is appropriate. However, the parameters and characteristics associated with the spatial units that comprise SSURGO are often derived from a limited number of observed data; pedons representative of a particular landscape are described and characterized, and those data are applied to similar landscapes expected to contain the same soils (i.e., soil map units). So, the use of SSURGO data as a means to estimate the magnitude of C stocks at a finer scale are likely too generalized. This may be especially true in tidal marshes where relatively few data have been collected. For the Mid-Atlantic region, 34 marsh pedons have been characterized (over an area of 214,000 ha), and only 24 contain the data necessary for C stock calculations (National Cooperative Soil Survey, 2021). We found that, compared to measured data gathered in a previous study (Chapter 2), Hinson et al. (2017) overestimated the C density at 100 cm of all tidal marsh PGUs—a circumstance that would lead to overestimates of C stocks. Thus, more measured data are necessary for better regional or local estimates of C stocks.

Howard et al. (2014) provided guidance for obtaining measured data in tidal marsh soils for the purposes of C stock calculations. They suggested sampling in 5 cm increments in the upper 50 cm and using a 50 cm and a 100 cm increment thereafter (rather than by pedogenic horizon). They reason that SOC content varies most in the upper part of the profile calling for a finer sampling scheme (Howard et al., 2014). While this strategy may be justified in terrestrial soils, some marsh soils may show not only pronounced decreases (which are typical of terrestrial soils), but also increases in C density or C stocks at greater depths (Kauffman et al., 2020; Sapkota and White, 2021). Additionally, their fixed depth-interval approach may be burdensome compared to sampling by pedogenic horizon. In the upper 50 cm of a typical marsh soil, it is unlikely that one would identify 10 horizons. Further, the fluid soils and dense vegetation common in many Mid-Atlantic marshes can make such detailed sampling in these environments arduous work. A more efficient manner of acquiring soil data (without sacrificing accuracy) would be beneficial for those conducting work in tidal marshes.

Attempting to inventory tidal marsh C storage at large scales requires generalizations of certain types of data. We must recognize, however, that these concessions may lead to limitations especially among the diverse geomorphic settings in which tidal marsh soils form. Thus, accurate estimations of C stocks should be based on more localized generalizations derived from measured data in order to account for regional differences in soils. In this study, our objectives were to: 1) identify the common types of tidal marsh soil materials observed in the Mid-Atlantic region and to measure and compare their mean C densities; and 2) to assess the feasibility of joining the mean C densities of distinctive marsh soil material types with standard soil descriptions to reliably estimate C stocks in the absence of site specific lab data (i.e., bulk density and SOC content).

3.2 METHODS AND MATERIALS

3.2.1 Overview, Strategy, and Site Selection

A previous study was undertaken to quantify C stocks in Mid-Atlantic tidal marshes by sampling 72 pedons along 28 marsh transects distributed across the Mid-Atlantic region (Chapter 2). Transects were distributed among the five groups of marshes (or PGUs) that were recognized in the region. These five PGUs represented marshes with distinctive geomorphic settings and pedological processes of formation and included: 1) submerged upland; 2) estuarine fresh; 3) estuarine non-fresh; 4) coastal barrier; 5) coastal mainland.

Five to six transects were established in each PGU. We described and sampled soils at three to five evenly spaced points along the transects depending on its length (ranging between 92 and 757 m). Transects were selected to be representative of the PGU, to have geographic distribution over the larger study area, and extended from the marsh-upland boundary to the open water. They were also strategically placed to avoid non-representative areas within the marsh such as degraded areas that contained no vegetation. We also ensured that description points were representative of the surrounding marsh (i.e., similar microtopography and vegetation).

3.2.2 Field methods

At each transect point we made detailed soil morphological descriptions following standard procedures (Schoeneberger et al., 2012). Documented characteristics included horizon names and depths, textural class, Munsell color, fluidity class for mineral horizons, and estimates of percent rubbed fiber for organic horizons (Soil Survey Staff, 2014). The degree of decomposition of O horizons was further documented using the von Post scale of humification (Rokus, 2020). To test for the presence of Fe-sulfide minerals (i.e., pyrite or metastable Fe-monosulfides), the reaction with 3% and 30% H_2O_2 was documented (Schoeneberger et al., 2012; Wessel and Rabenhorst, 2017; Duball et al., 2020). Soft soils, such as O horizons and fluid mineral horizons, were examined using a Macaulay peat sampler, which removes an undisturbed half-core of known volume. Dense soils, including sands and argillic horizons, were excavated with a bucket auger. We used a serrated hand-coring device (of known volume) to obtain samples from surface O horizons. Sampling was conducted at approximately half of the pedons where morphological descriptions were made, and samples were obtained from each pedogenic horizon (from the same core used for descriptions). At selected locations, we collected triplicate samples from three individual cores spaced closely together (approximately within a 1 m radius) in order to assess the variability of C stocks in a single pedon.

3.2.3 Laboratory methods

Samples were analyzed for SOC by high temperature, dry combustion with a LECO CN628 carbon analyzer. We tested for the presence of $CaCO_3$ before analysis by using 10% HCl. Since no effervescence was observed in any of the samples, we concluded that inorganic C was not present, and no further treatment was necessary prior to combustion. Total C was thus equal to SOC. Bulk density was calculated by repeatedly weighing samples of known volume (i.e., those collected with a Macaulay sampler or serrated corer) until they reached a constant mass during drying.

Measurement of bulk density was not possible for some horizons because samples of known volume could not be obtained. These were mostly in sandy or dense subsoil materials that could not be collected with the Macaulay sampler. For those samples (approximately 30%), we estimated the bulk density using pedotransfer functions (Appendix A). Carbon stocks were then calculated to 50, 100, and 200 cm for sampled pedons.

3.2.4 Identification of the types of tidal marsh soil materials

Marsh soil materials were differentiated into nine types based on their basic morphological characteristics, including degree of organic material decomposition (Oi, Oe, or Oa), and texture, color, and fluidity for mineral materials. Some material types were tied to specific PGUs. Further explanation for differentiating these classes is given in Appendix B. Based on SOC content and bulk density, the mean C density was calculated for samples of each material type. Using the mean C densities calculated for each soil material type, C stocks were estimated (horizon by horizon) for those pedons that were described in the field but not sampled.

3.2.5 Jackknifing

In order to evaluate the reliability of this method to estimate C stocks using mean C densities and soil morphological descriptions, this approach was also applied to those pedons for which C stocks had been measured. These comparisons were made using a jackknifing methodology (Efron, 1982). For each of the 72 pedons in this data set, the C stocks were estimated using soil morphology and mean carbon densities, while the data from that particular pedon being estimated had been removed from the data set used to calculate mean C densities for the nine material types. In this way, the data from a given pedon were selectively removed and excluded from the dataset used to develop the estimation model that was applied to that pedon. Carbon stocks were modeled for each pedon to depths of 50, 100, and 200 cm. The modeled C stocks acquired for each pedon from the jackknifing procedure were then compared with the actual (measured) C stocks.

3.2.6 Data analysis

JMP Pro (version 15.2) was used to analyze data. ANOVA was used to determine if there were statistically significant differences among the means of the C densities of the types of soil materials. To locate these differences, a student’s t-test was used. R studio (version 1.3.1073), and Microsoft Excel (version 18.2210.1203.0) were also used to illustrate some figures.

3.3 RESULTS AND DISCUSSION

3.3.1 Soil material types

Nine types of soil materials were distinguished using soil morphology alone (Table 3-1; Figure 3-2).

Table 3-1. The nine material types found in Mid-Atlantic tidal marsh soils. Certain materials are tied to a particular PGU while others are common in multiple PGUs.

Material type	**Definition**	**Typical location**
Oa	Highly decomposed organic soil-material[1]; muck.	O horizons are common in all tidal marsh PGUs.
Oe	Moderately decomposed organic soil-material[1]; mucky peat.	
Oi	Slightly decomposed organic soil-material[1]; peat.	
Fluid dark	Mineral soil material that flows freely between fingers when squeezed (degree of fluidity is moderately or very fluid[1]). **The matrix color must have a Munsell value of 4 or less.** Master horizon designation is usually A, AC, CA, or C.	Fluid mineral soil materials are ubiquitous in estuarine fresh and non-fresh PGUs and in the coastal mainland PGU.
Fluid light	Mineral soil material that flows freely between fingers when squeezed (degree of fluidity is moderately or very fluid[1]).	

	The matrix color must have a Munsell value greater than 4. Master horizon designation is usually C, CA, AC, or A.	
Sandy dark	Mineral soil material with a texture of sand or loamy sand. **The matrix color must have a Munsell value less than 4.**	Sandy mineral soil materials are most commonly found in coastal barrier marshes. They also can occur at the base of tidal marsh soil profiles (i.e., transition to sandy coastal-plain sediment parent material) in other settings.
Sandy light	Mineral soil material with a texture of sand or loamy sand. **The matrix color must have a Munsell value of 4 or more.**	
Submerged upland A/E	A or E horizons of a submerged upland soil profile. This is the former upland mineral soil surface that existed prior to marsh formation.	These soil materials are specific to the submerged upland PGU.
Submerged upland Bt	Bt or Btg horizons of a submerged upland soil.	

[1] These distinctions were based primarily upon the quantity of fibers that remained identifiable following rubbing, as described in Schoenberger et al. (2012).

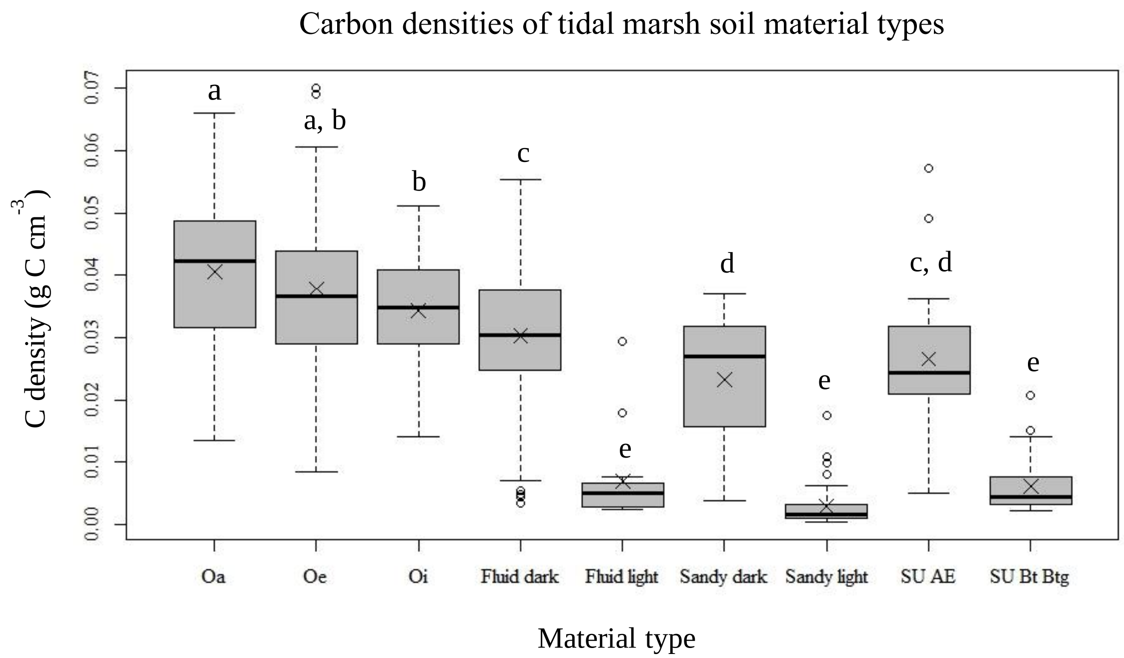


Figure 3-2. Carbon densities of 455 soil horizons sampled and grouped among the nine marsh soil material types. Materials designated with different letters have means that are significantly different at the 0.05 level. Means are represented by the X within the boxes. The top and bottom of the box show the 25th and 75th percentiles of the data with the median at the midline. Whiskers represent 1.5 times the interquartile range (IQR – the distance between the 25th and 75th percentiles). If the data extend past 1.5 times the IQR, then they are plotted as points and are considered outliers. If the data do not extend to 1.5 times the IQR, then the whiskers represent the range in values, excluding outliers.

Organic soil-materials, or O horizons, were found in all tidal marsh PGUs. They are differentiated by the degree of decomposition as determined by the percent of identifiable plant fibers remaining after the sample is rubbed (Soil Survey Staff, 2014). Although organic soil-materials are technically defined as having 12% or more

SOC by weight[2], these materials were, in most cases, easily distinguishable by their dark brown to black colors and the abundance of decomposing plant materials. Some horizons were more difficult to recognize as organic soil-materials as they did not exhibit these typical properties (e.g., having many plant fibers that would contribute to a higher SOC content, but a lighter matrix color). Our data show that samples with a Munsell value greater than 3 were virtually always mineral horizons (i.e., having less than 12% SOC by weight) (Figure 3-3). This observation would be useful in helping to recognize mineral materials.

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[2] A proposal to change the definition of organic soil material to those materials with ≥ 12% SOC regardless of clay content or saturation frequency was approved at the 2022 Northeast Regional National Cooperative Soil Survey Conference.

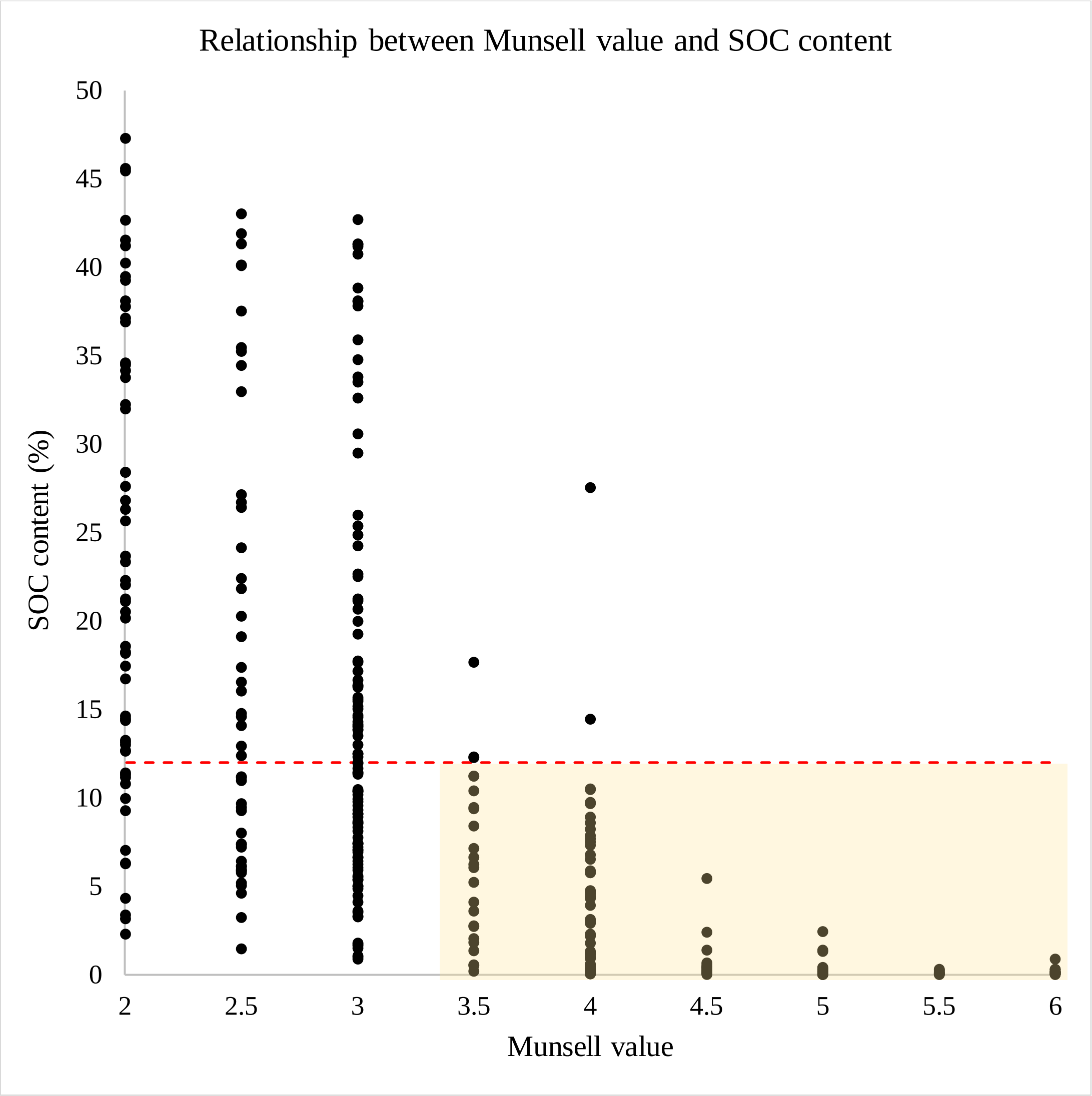


Figure 3-3. Munsell value can be a useful indicator of the nature of tidal marsh soil materials. Essentially all samples with a Munsell value > 3 were mineral (highlighted in yellow). Horizons with values of three or less could be either mineral or organic. The red dashed line indicates the cutoff between mineral and organic soil materials (12% SOC).

Fluid dark and fluid light materials were ubiquitous in estuarine and coastal mainland marsh PGUs. Pedogenically, they are essentially the same, having been deposited under low energy sedimentary environments, and are mainly differentiated by the amount of organic matter contained within. When darker in color, they were often designated as A horizons, but in various situations they were described as C horizons or as transitional horizons (AC or CA). Commonly, there is subjectivity in assigning master horizon designations, which reflects the soil scientist's interpretation. However, describing the Munsell color is more objective and was used here to identify and define the type of soil material. When distinguishing among fluid mineral soil materials in estuarine or coastal mainland settings, this approach removes any ambiguity related to which master horizon may have been used. Similarly, Munsell value was also used to differentiate between two groups of sandy materials, chiefly present in coastal barrier marshes.

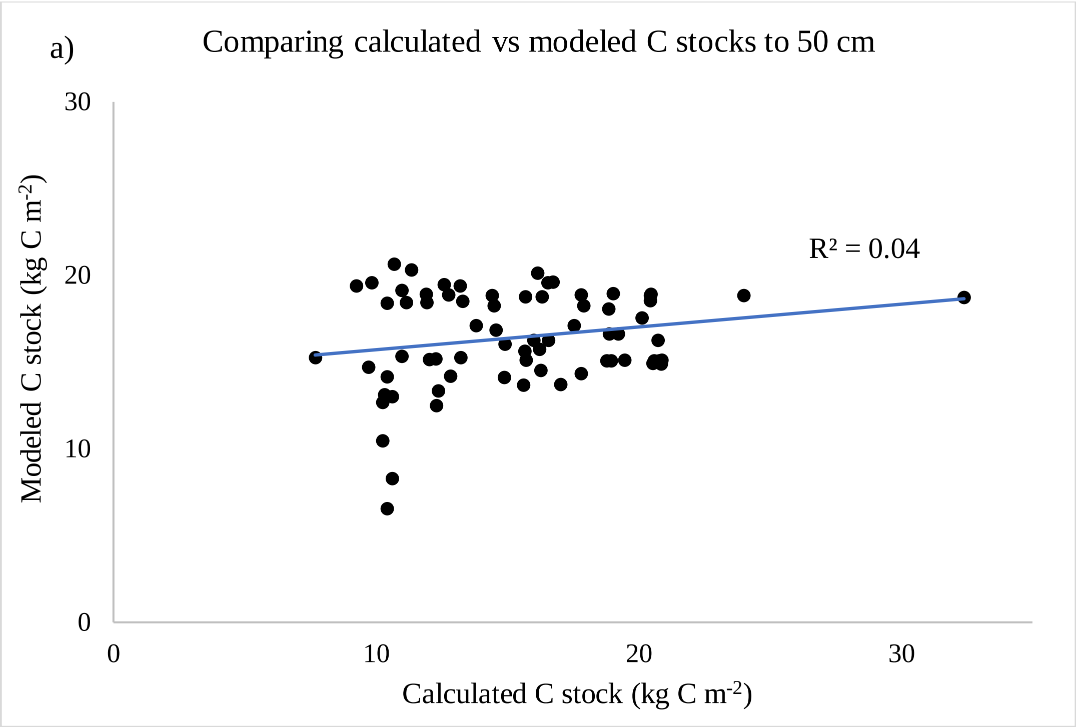
In the submerged upland PGU, distinguishing between A and E horizons was sometimes challenging as the mineral surface horizons tended to be thin and could be disturbed if excavated with a bucket auger. In contrast, the Bt or Btg materials in submerged upland soils were easily identified by their higher density, increase in clay content, depleted matrix colors, and concentrations of Fe-oxide minerals. Pedologists experienced in describing hydric soils would be proficient in recognizing the nine marsh material types with little to no additional training.

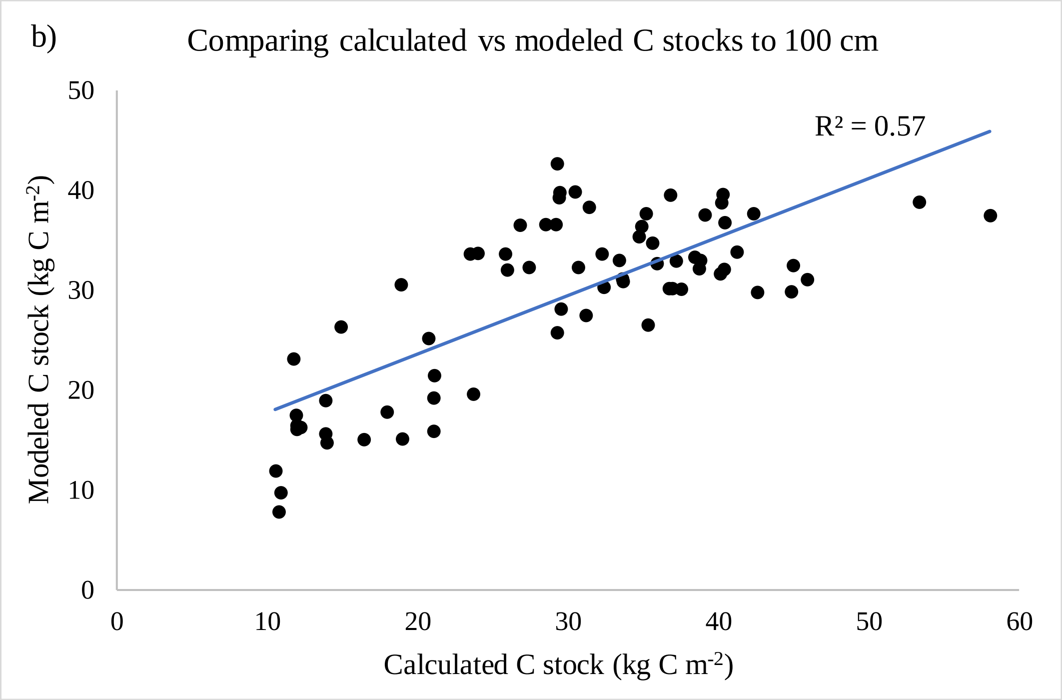
3.3.2 Reliability and utility of carbon stock estimates

When the modeled C stocks were compared with measured stocks to a depth of 50 cm, no significant relationship was observed ($p=0.08$; $R^2=0.04$) (Figure 3-4 a).

When modeled and measured C stocks to a depth of 100 cm were compared, the strength of the relationship improved significantly (R^2=0.57; p<0.0001) (Figure 3-4 b). The relationship between measured and modeled C stocks to a depth of 200 cm was even stronger (R^2=0.79; p<0.0001) (Figure 3-4 c).

As one examines marsh soils to greater depths, it is more likely that different types of materials with different C densities will be encountered. Materials with especially low C densities (sandy light materials and submerged upland Bt horizons) did occur within 50 cm of the soil surface but were more likely to be encountered at greater depths (within 100 – 200 cm). Materials with higher C densities, like organic horizons and fluid dark materials, often occurred at or near the marsh surface in all PGUs. They invariably extended to depths beyond 100 or even 200 cm in the coastal mainland and estuarine PGUs. The strength of prediction to 50 cm was weak likely because that part of the profile was commonly dominated by O horizons. They have a wide range in possible SOC contents (12 – 47% in this dataset), which results in a wider range in C densities and C stocks. On the other hand, the predictions of C stocks improved when calculated to greater depths due to the greater variety of soil materials encountered, including those with lower C densities. Because many tidal marshes contained high SOC contents (and therefore high C densities) to great depths, C stocks should be calculated or estimated to at least 100 cm and perhaps to 200 cm or more. Carbon stock estimates to shallow depths (30 cm or 50 cm) would be expected to provide little useful information.


a)
Comparing calculated vs modeled C stocks to 50 cm
Modeled C stock (kg C m-2)
0
10
20
30
Calculated C stock (kg C m-2)
0
10
20
30
R² = 0.04


b)
Comparing calculated vs modeled C stocks to 100 cm
Modeled C stock (kg C m-2)
0
10
20
30
40
50
Calculated C stock (kg C m-2)
0
10
20
30
40
50
60
R² = 0.57

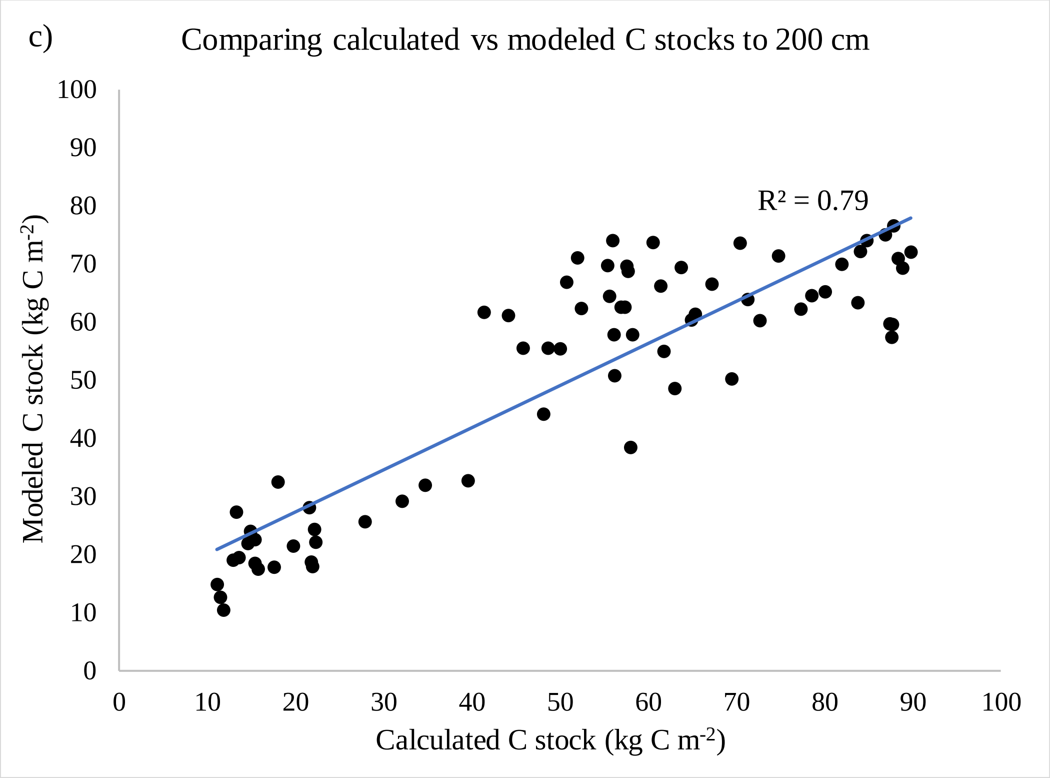
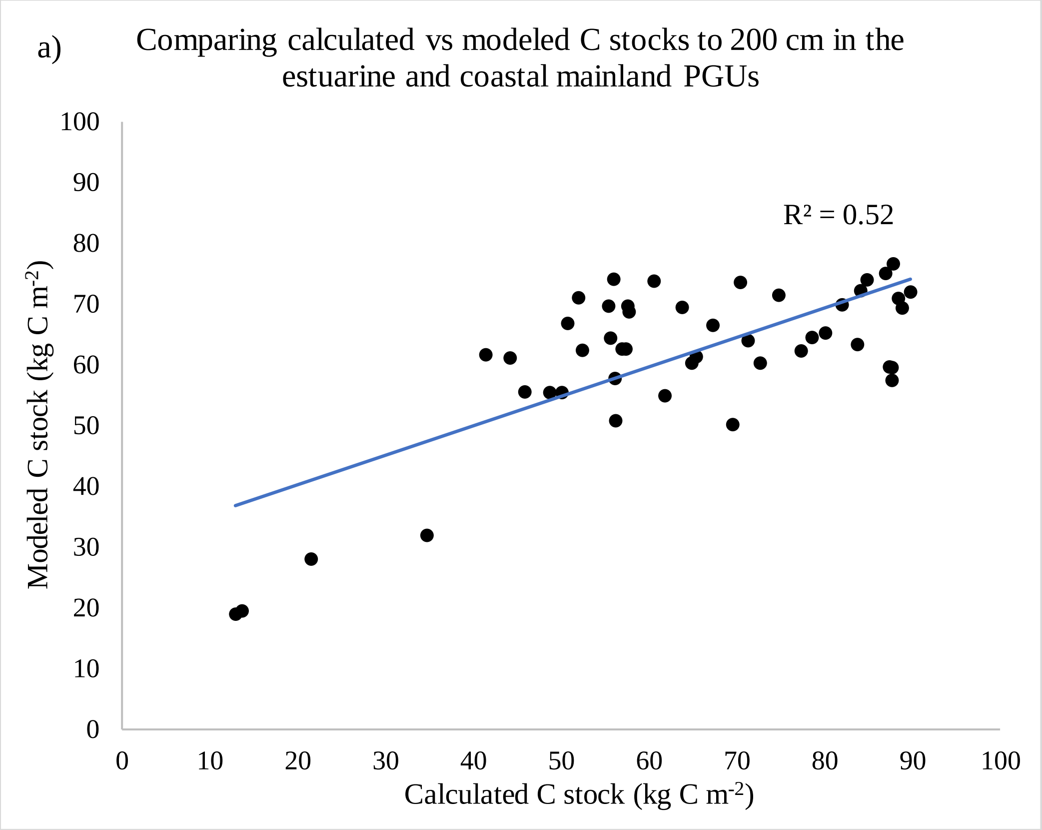


Figure 3-4 a – c. A comparison between C stocks calculated using laboratory data and those modeled using the jackknifing approach. a) C stocks to 50 cm, p=0.08; b) C stocks to 100 cm, p<0.0001; c) C stocks to 200 cm, p<0.0001.

When examined separately, the marshes in submerged upland and coastal barrier PGUs demonstrated a stronger relationship between calculated and modeled C stocks (R^2=0.82, p<0.001), while the relationship in estuarine and coastal mainland marshes was weaker (R^2=0.52) but still highly significant (p<0.0001) (Figure 3-5 a – b). This would suggest that using the C density approach to estimate C stocks in the coastal mainland and estuarine PGUs is less robust, but even among these marshes, modeled estimates of C stocks (to 200 cm) for 75% of the pedons ranged between 0.01% to 27% of the measured values. We found the variability in measured C stocks within a pedon to be similar. Triplicate sampling and analysis within each of seven selected pedons showed that the mean deviation in C stocks to 200 cm was 14% but could be as large as 35% in a given pedon; the minimum difference was 7%. Since the relative differences between modeled and calculated C stocks were similar in magnitude to the inherent variability within a pedon, estimations of C stocks in the coastal mainland and estuarine PGUs were deemed to be reliable.

It was hypothesized that some materials (specifically Oa, Oe, and fluid mineral materials) might be more compacted when located deeper in the soil profile, which would increase bulk density and C density (Oi materials were not included because they mostly occurred near the soil surface). When this (depth versus C density) relationship was examined, for these three material types, statistically significant relationships ($p < 0.05$) were observed. However, there were little to no visually observable trends in the data, and the R^2 values were extremely low (ranging from 0.04 to 0.24). Therefore, we concluded that the depth of an O horizon or fluid mineral horizon was not a useful predictor of C density and would not justify incorporation into the overall process of C stock estimations.

The results of the jackknife modeling (and subsequent comparison to measured C stocks) suggested that the reliability of using the mean C density of material types to calculate C stocks increases with the depth to which C stocks are calculated. Thus, in the absence of laboratory data, joining the mean C densities of particular marsh materials with a soil morphological description generates a reasonable estimation of C stocks to 200 cm across all Mid-Atlantic PGUs.



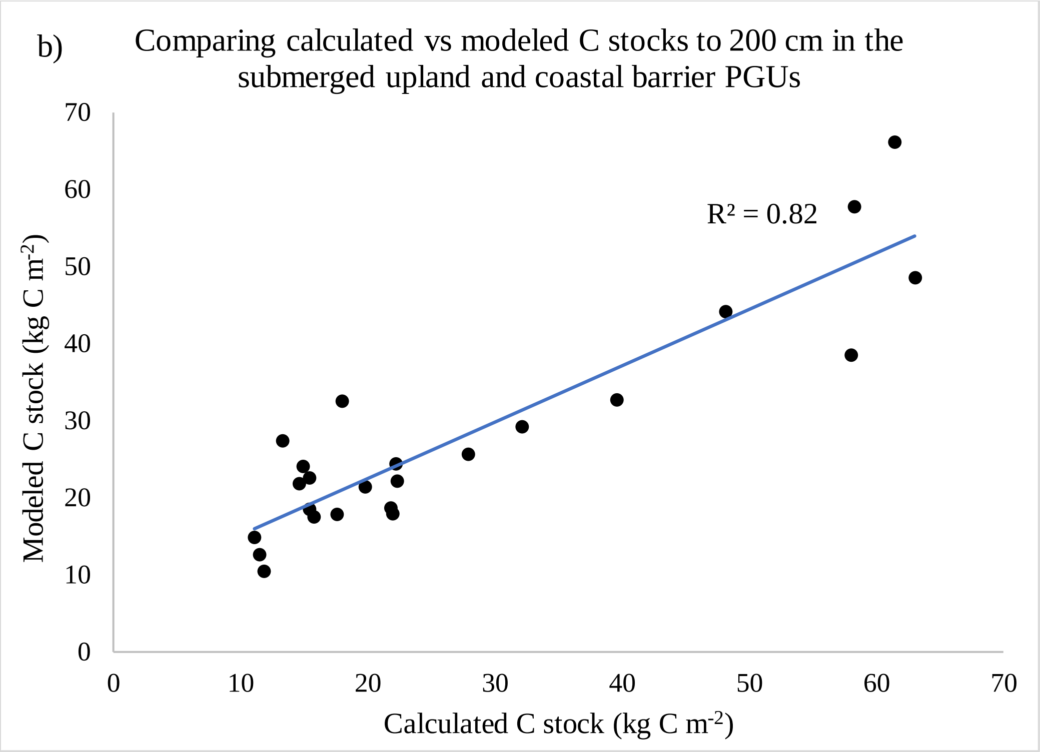


Figure 3-5 a – b. A comparison between C stocks calculated (to 200 cm) using laboratory data and those modeled using the jackknifing approach in marshes from a) estuarine fresh, non-fresh, and coastal mainland PGUs; b) submerged upland and coastal barrier PGUs. For both relationships $p<0.0001$.

This estimation approach offers distinct advantages to those who wish to document and inventory C pools in Mid-Atlantic tidal marshes. The primary advantage is the simplicity with which C stocks can be estimated. Compared to terrestrial wetlands, tidal marshes are challenging environments to work in due to unstable footing, dense vegetation, rising tides, and difficult accessibility. The work is made more time consuming and challenging if soils must be sampled in addition to being described, especially if adhering to the guidance suggested by Howard et al. (2014) who suggested sampling 5 cm increments in the upper 50 cm. This approach to estimation only requires that one obtain a good morphological description (which is unlikely to contain 10 horizons in the upper 50 cm) and to utilize the mean C densities reported here. One must also understand the pedogeomorphic setting in which they are working, but this can be easily distinguished from geographic context or by using a GIS-based map (Chapter 2). Previously gathered or historical morphological data could also be used to estimate C stocks. This method lessens the burden of field reconnaissance without greatly compromising the accuracy of C stock estimations.

Additionally, our methodology is an improvement over suggestions that a single C density value (of 0.0270 g C cm^{-3}) is the best strategy for estimating C stocks (Holmquist et al., 2018). We have shown that, in Mid-Atlantic tidal marshes, there are a wide range of C densities which are associated with particular soil horizons or material types. Using the nine C densities reported here, our approach would avoid the hazard of significant over or underestimations of C stocks that might occur when using a single C density value across the Mid-Atlantic region.

Finally, while this approach would be, admittedly, easier for those with experience making soil descriptions, we believe that one could still estimate C stocks effectively using this methodology even without a strong pedological background. The classes of marsh soil materials have been defined based on basic morphological characteristics, and, therefore, relatively little training would be required to gain the needed proficiency to identify the material type. Nonetheless, one must ensure that the morphology of the soil is documented accurately (and by pedogenic horizon rather than fixed depth interval) to avoid misidentifying the types of materials found in the profile.

3.4 CONCLUSION

Nine types of tidal marsh soil materials were distinguished based upon their morphological characteristics and pedogeomorphic setting, and mean C density varied by an order of magnitude among these classes (between 0.0029 – 0.0409 g C cm^{-3}). We propose an approach to estimating C stocks in tidal marsh soils by joining mean C densities of distinctive soil material types with information obtained from a detailed morphological description. Using this approach, we have demonstrated that the strength of prediction increased with the depth to which C stocks were calculated across all PGUs. Further, the accuracy of estimations was greater in the coastal barrier and submerged upland PGUs, but also reasonable and reliable in the estuarine and coastal mainland PGUs. Future work could apply this method to additional marshes in the Mid-Atlantic region in order to obtain a better regional approximation of stored marsh C. This approach should also be tested, and possibly modified and adapted, in other regions such as New England, the Southeast, or the Gulf Coast of the United States. Given the critical role of tidal wetlands in C storage and sequestration, reliable and rapid methods of estimating C stocks must be employed.

Chapter 4: Conceptual models of the properties of Mid-Atlantic tidal marshes and their soils

4.1 INTRODUCTION

Tidal marsh wetlands occupy a small fraction of the total land in the United States—approximately 0.4% (Tiner, 2013). Even so, they provide a number of ecosystem services including wildlife habitat, nutrient cycling, and public recreation (Barbier et al., 2011). One important service is C storage and sequestration. Inputs of biomass and C rich sediment paired with virtually constant anaerobic conditions, results in the accumulation of C at rates far greater than those in terrestrial ecosystems. Carbon sequestration has been estimated to be 40 – 50 times greater in tidal marshes than in terrestrial forests (Mcleod et al., 2011).

The Mid-Atlantic region (Maryland, Delaware, and New Jersey) contains approximately 214,000 ha of tidal marshes (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2022b). The marshes in this region have been grouped based on the various geomorphic settings in which they have formed (Darmody and Foss, 1979). The position in the landscape, processes of formation, and geomorphic setting and have resulted in distinctive soil morphologies (combinations of soil horizons and properties) among the settings. Therefore, we have recognized these various settings as “pedogeomorphic units” (PGUs).

Although they didn’t use the term PGU, Darmody and Foss (1979) identified three tidal marsh PGUs in Maryland (also found throughout the Mid-Atlantic region): submerged upland, estuarine, and coastal. Submerged upland marshes formed on previously terrestrial land that has been inundated by rising tidal water over the past several thousand years (Rabenhorst and Needelman, 2016). Estuarine marshes became established in major river channels that were filled in with fine-textured alluvial materials as tidal waters rose. Coastal marshes are located around the perimeter of barrier island lagoons. Although marshes on either side of the lagoon formed from drastically different processes, they were grouped within a single unit (Darmody and Foss, 1979).

For the three landscape settings they recognized, Darmody and Foss (1979) characterized the nature of the surrounding uplands, including typical soils, plant communities, and the overall geomorphology (especially of the upland-marsh transition). They also described the types of pedogenic horizons in the marshes, and they proposed new soil series, some of which have been mapped throughout Maryland’s tidal region (Darmody and Foss, 1978; Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2022b).

Although the work of Darmody and Foss (1979) generated improved understanding and concepts of tidal marshes in Maryland, their efforts were, in some ways, limited. Quantitative information about the transitional zones between the upland and marsh (such as elevation and slope) were not reported, and thus were unavailable to further differentiate each setting. As was common in marsh investigations of 50 years ago, information on C stocks was also omitted. This is a critical metric that more recent research has emphasized (Rabenhorst, 1995; Chmura et al., 2003; Mcleod et al., 2011; Van de Broek et al., 2016; Hinson et al., 2017; Holmquist et al., 2018; van Ardenne et al., 2018; Kauffman et al., 2020; Wardrup, 2021) because of the increased emphasis on blue C storage and climate change. Our efforts have demonstrated that soils of some PGUs store significantly greater amounts of C than others, which is reflected in the soil morphological characteristics and is a product of the pedogeomorphic setting in which the marsh has formed (Chapter 2). Nevertheless, little has been reported on how C stocks may vary *within or across* individual marshes of a given PGU.

Examining three marshes in a single geomorphic setting (or PGU) within Canada and the Northeast United States, van Ardenne et al. (2018) reported that in barrier island marshes, soil depth changed systematically along marsh landscapes. In their study, marsh soil depth was assumed to correlate to the depth at which plant materials ceased to be observed; based on data reported for bulk density and organic matter content throughout the profile, the authors are likely referring to O horizons and fluid, dark-colored mineral horizons (that contained plant materials) when discussing soil depth. Following this concept, the authors reported that C density remained relatively constant through the soil profile, and thus the depth of the marsh deposits alone is a reliable estimator of C stocks in those settings. Therefore, they observed that C stocks were spatially dependent within individual marshes and were largest in those portions of the sites where the marsh soils were deepest. However, little information was provided regarding the nature of the surrounding terrestrial soils or the transitions into the marsh (van Ardenne et al., 2018).

In the present study, we aimed to augment the conceptual models developed by Darmody and Foss (1979). Although their ideas were novel and offered new insight into the nature of tidal marsh landscapes in Maryland (and by extension, the Mid-Atlantic region), some refinements are needed to better elucidate characteristics among Mid-Atlantic marshes—especially the spatial variation in C stocks across marsh landscapes. Our objectives were to 1) create revised conceptual pedogeomorphic models of tidal marshes in the Mid-Atlantic region that reflect the nature of the surrounding upland and transitions into the marsh; and 2) to document systematic spatial variation of C stocks within individual marshes that were representative of PGUs in the Mid-Atlantic region.

4.2 METHODS AND MATERIALS

4.2.1 Overview, strategy, and site selection

A previous study was conducted to measure C stocks in Mid-Atlantic tidal marshes (Chapter 2). This was accomplished through sampling along 28 transects distributed across the five PGUs that have been recognized in the region: 1) submerged upland; 2) estuarine fresh; 3) estuarine non-fresh; 4) coastal barrier; 5) coastal mainland. In each PGU, five to six transects were examined that extended from the upland boundary to open water. Transects were intended to be representative of the PGU and were geographically distributed over the study area. Depending on the length of the transect, which ranged from 92 and 757 m, three to five evenly spaced pedons were described.

4.2.2 Field methods

Detailed soil morphological descriptions were made at every point following procedures in Schoeneberger et al. (2012). Most marsh soils consisted of soft and fluid materials that were observed using a Macaulay sampler, which collects an undisturbed half-core of known volume. For dense soils where a Macaulay sampler was unsuitable, a bucket auger was used, and surface O horizons were examined using a handheld serrated corer (also of known volume). Approximately half of the pedons described were also sampled by pedogenic horizon for bulk density and soil organic carbon (SOC) determination.

4.2.3 Laboratory methods

Samples were analyzed for SOC by high temperature combustion using a LECO CN628 carbon analyzer. To test for the presence of inorganic C ($CaCO_3$), 10% HCl was dropped on the samples. Since no reaction was observed under a stereo microscope, it was concluded that the soils did not require further treatment before analysis, and total C was assumed to be equal to organic C. Bulk density was calculated by oven drying samples of known volume to a constant mass and then weighing. In cases where subsoils were too dense or sandy for use of the Macaulay sampler (e.g., submerged upland argillic horizons or sandy C horizons in the coastal barrier PGU), bulk density samples could not be obtained (roughly 30% of the sampled horizons). In those horizons the bulk density was estimated using pedotransfer functions (Chapter 2) developed using data from soils similar to those in our study (Appendix A).

4.2.4 Carbon stock calculations

For the sampled pedons, C stocks were calculated to 200 cm using bulk density and SOC data. For the pedons that were described but not sampled, C stocks were estimated (to 200 cm) by using C density estimates and soil morphological characteristics (as detailed in Chapter 3).

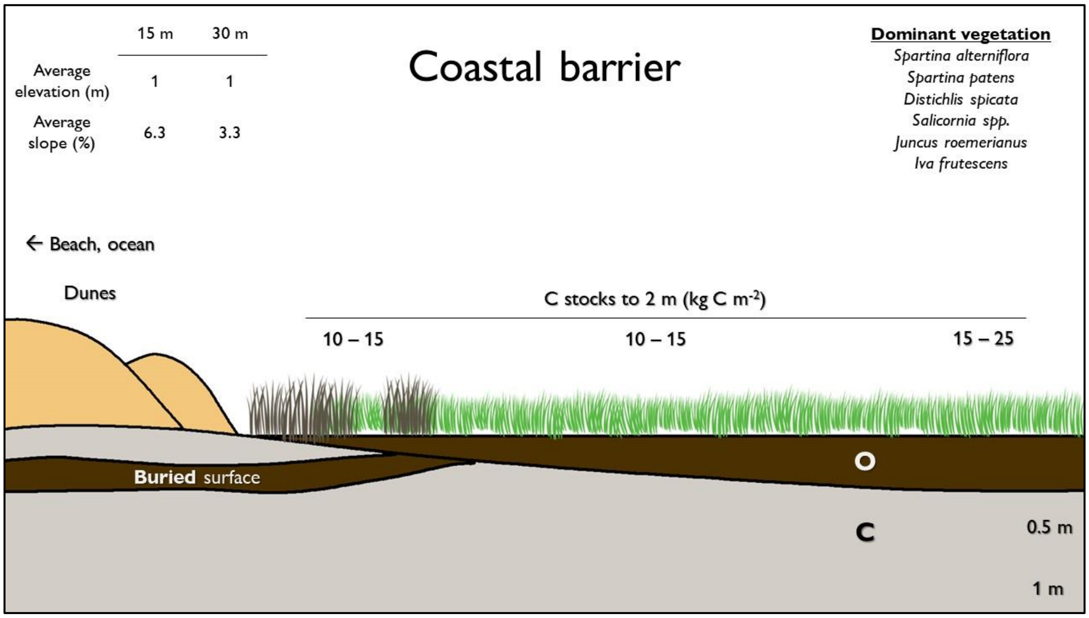
4.2.5 Properties at the marsh-upland transition

Properties at the transition areas were examined starting at the marsh-upland boundary. The land elevations at distances of 15 and 30 m inland were determined using Google Earth, and slopes along these gradients were estimated. Using SSURGO data, the dominant soil series and their drainage classes were identified within these transition areas.

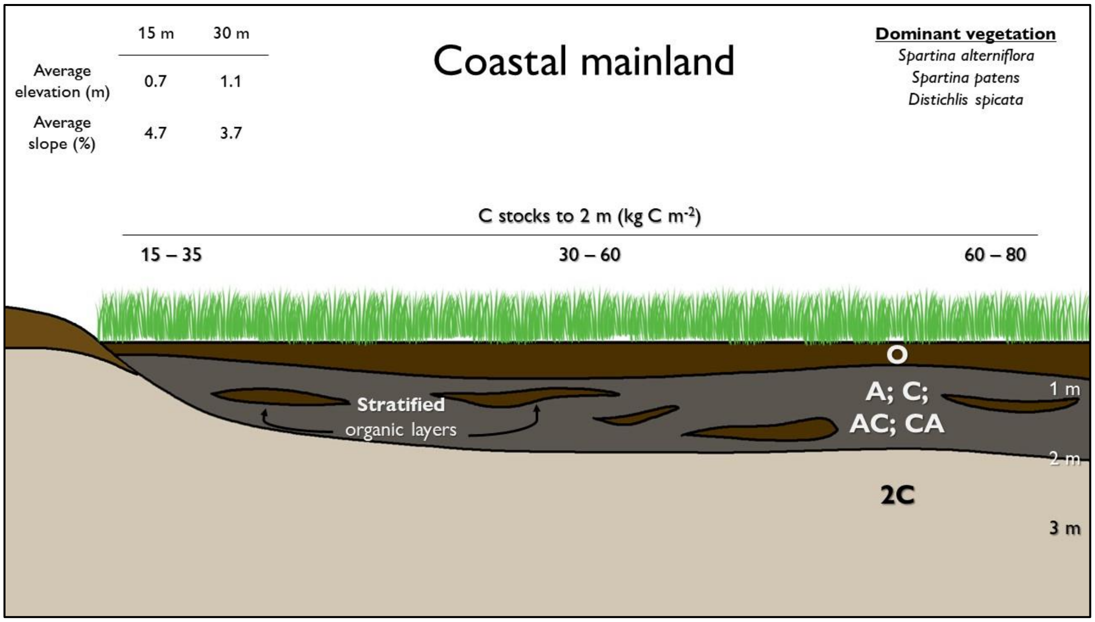
4.3 RESULTS AND DISCUSSION

Conceptualized models of the major marsh PGUs are shown in Figure 4-1 a – d. These idealized cross sections illustrate the presence, thickness, and distribution of major soil horizons and dominant soil materials as well as common vegetation observed in each PGU. Approximations of C stocks (calculated to 200 cm) are shown for each PGU near the upland-marsh interface, within the marsh interior, and near the edge of the marsh close to open water.

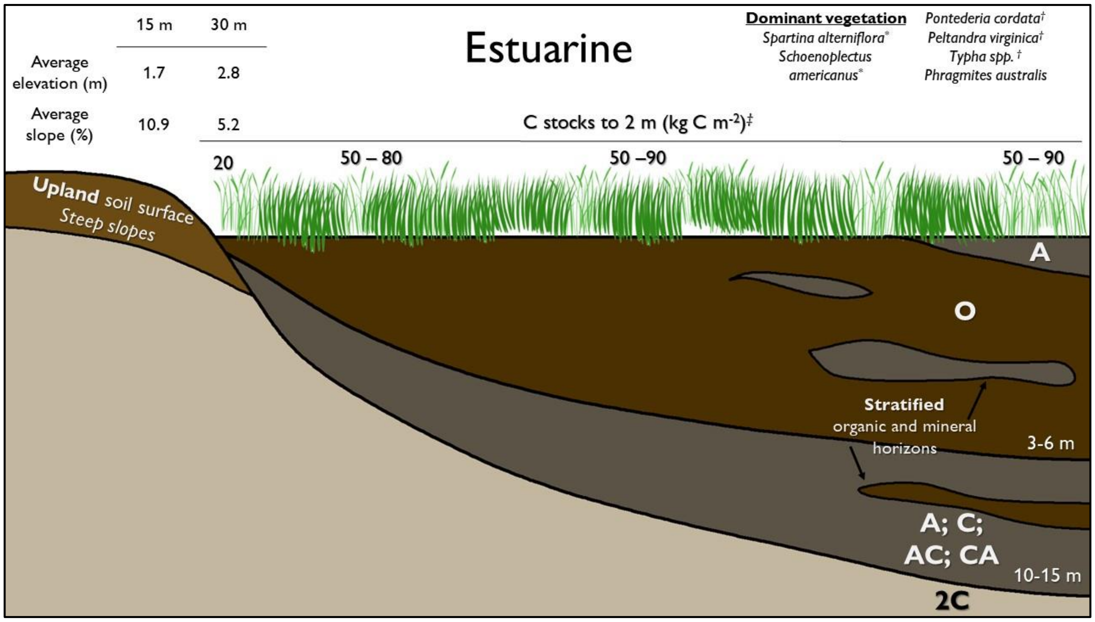
a)



b)


15 m
30 m
Average elevation (m)
0.7
1.1
Average slope (%)
4.7
3.7
Coastal mainland
Dominant vegetation
Spartina alterniflora
Spartina patens
Distichlis spicata
C stocks to 2 m (kg C m-2)
15 – 35
30 – 60
60 – 80
O
Stratified organic layers
A; C; AC; CA
1 m
2 m
2C
3 m

c)


15 m
30 m
Average elevation (m)
1.7
2.8
Average slope (%)
10.9
5.2
Estuarine
Dominant vegetation
Spartina alterniflora*
Schoenoplectus americanus*
Pontederia cordata†
Peltandra virginica†
Typha spp. †
Phragmites australis
C stocks to 2 m (kg C m-2)‡
20
50 – 80
50 –90
50 – 90
Upland soil surface
Steep slopes
A
O
Stratified organic and mineral horizons
3-6 m
A; C; AC; CA
10-15 m
2C

d)

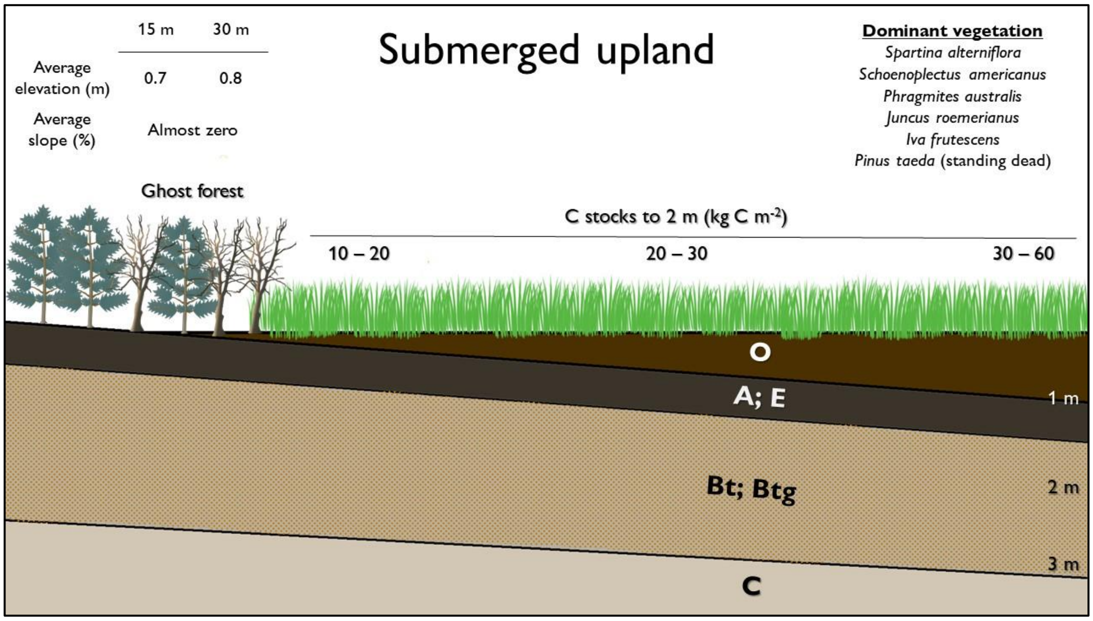


Figure 4-1 a – d. Cross sectional diagrams of the (a) coastal barrier, (b) coastal mainland, (c) estuarine fresh and non-fresh, and (d) submerged upland PGUs. The elevation of the upland within 15 and 30 m of the marsh-upland transition was calculated and averaged. Similarly, the slope within 15 and 30 m of the transition was also calculated and averaged. Typical sequences of horizons found in each PGU are listed and their approximate depths are given on the right side.
*Species common in the estuarine non-fresh PGU.
†Species common in the estuarine fresh PGU.
‡ Using a C density value of 0.0356 g C cm^{-3} (the average C density of the Oa, Oe, Oi, and Fluid dark material types (Chapter 3)), C stocks to 5, 10, and 15 m would be 178 kg C m^{-2}, 356 kg C m^{-2}, and 534 kg C m^{-2}, respectively.

4.3.1 Marshes in the coastal barrier PGU

The upland soils surrounding coastal barrier marshes were sandy Entisols, with Brockatonorton (Aquic Udipsamments) and Acquango (Typic Udipsamments) being the main soil series. The Fox Hill series (Sodic Psammaquents) also bordered the marshes. These soils formed primarily in the sandy Holocene dunal and over-wash deposits of the barrier island and were situated at elevations a meter or more above the marsh surface. They were typically excessively drained to moderately well drained (Figure 4-2). Slopes leading into the marsh were mostly 3 – 6%, on average. Typically, the dune and sandy over-wash materials formed a distinctive geomorphologic boundary between the marsh and the sandy upland. Some instances where greater elevations (and therefore slopes) were observed near the transitional zones can be attributed to the height of the dunes.

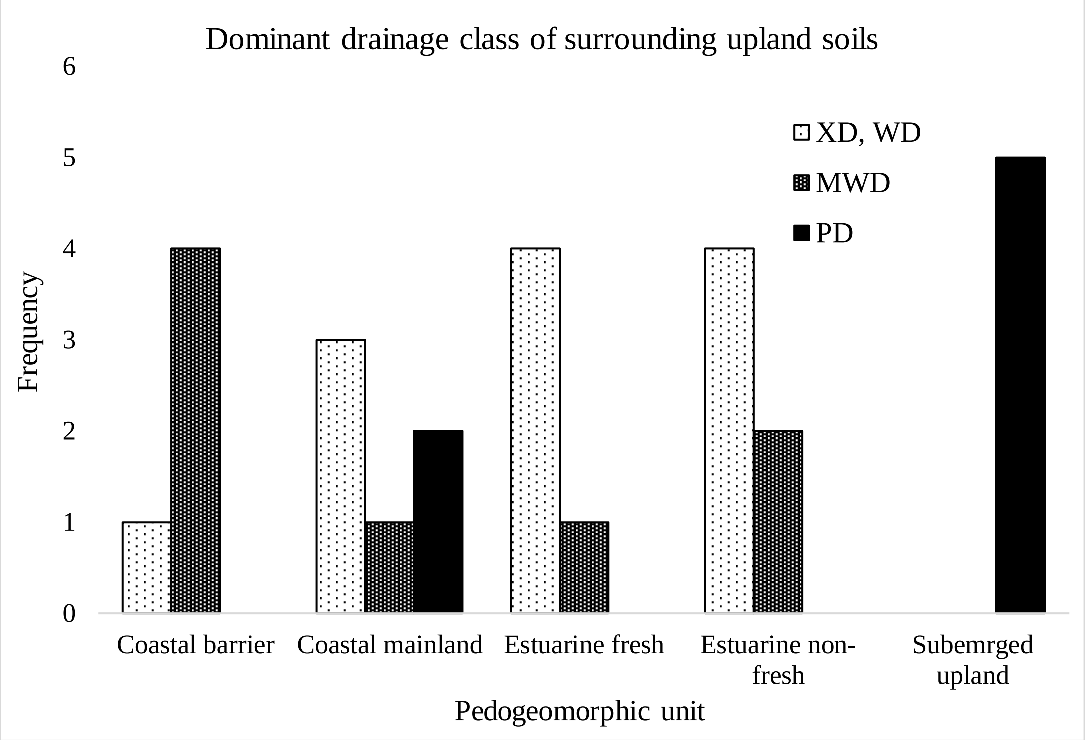


Figure 4-2. Drainage class frequency of the dominant component in the dominant upland map unit within a 100 m radius of the start of each transect. XD: excessively drained; WD: well drained; MWD: moderately well drained; PD: poorly drained.

Carbon stocks within the coastal barrier marshes remained more or less steady across the marsh at approximately 10 – 15 kg C m^{-2} (Figure 4-3). In most cases C stocks increased near open water, where, in some cases, C storage approximately doubled relative to the pedon nearest the upland. The spatial trends in C stocks in these marshes was attributed to the thickness of the O horizons, which contained nearly all of the stored C. This organic surface overlaid sandy C horizons that contained little C. In this PGU, O horizons were generally less than 30 cm thick (Figure 4-4), although in some marshes O horizons thickened substantially toward the water's edge.

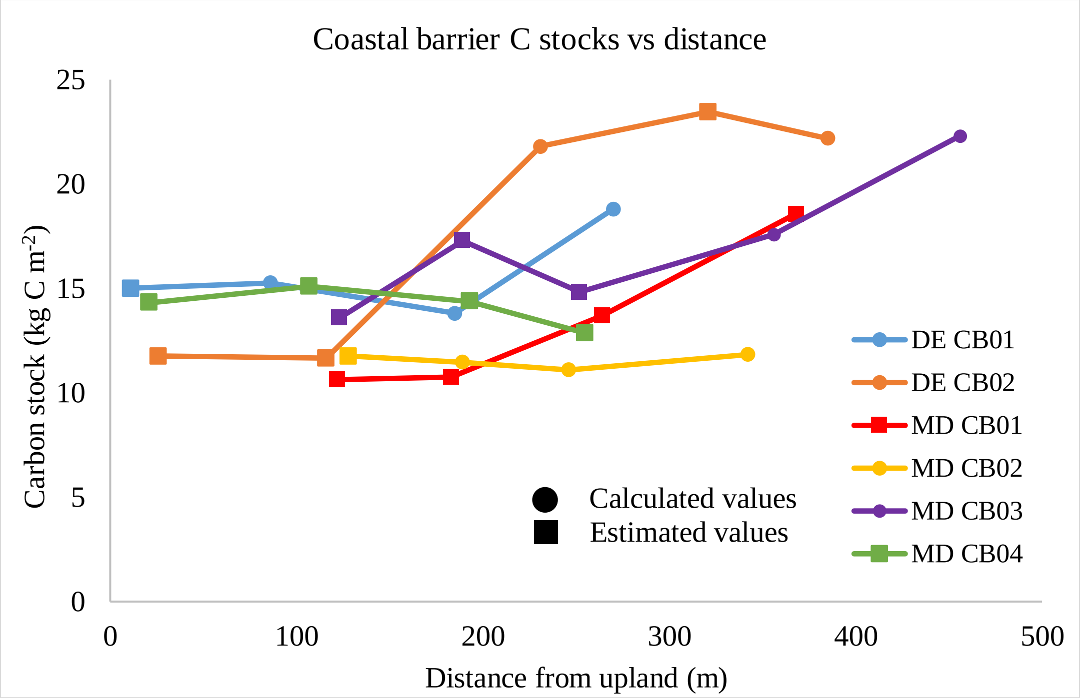


Figure 4-3. Calculated or estimated C stocks to 200 cm at each description point along every coastal barrier transect. Each line represents a different transect. Distance from upland was determined by the distance from the start of the transect to the nearest upland (non-marsh) soil map unit. Sometimes, the edge of the upland map unit did not coincide with an obvious upland landscape feature (e.g., forest edge). In these cases, the distance was measured to the upland landscape feature.

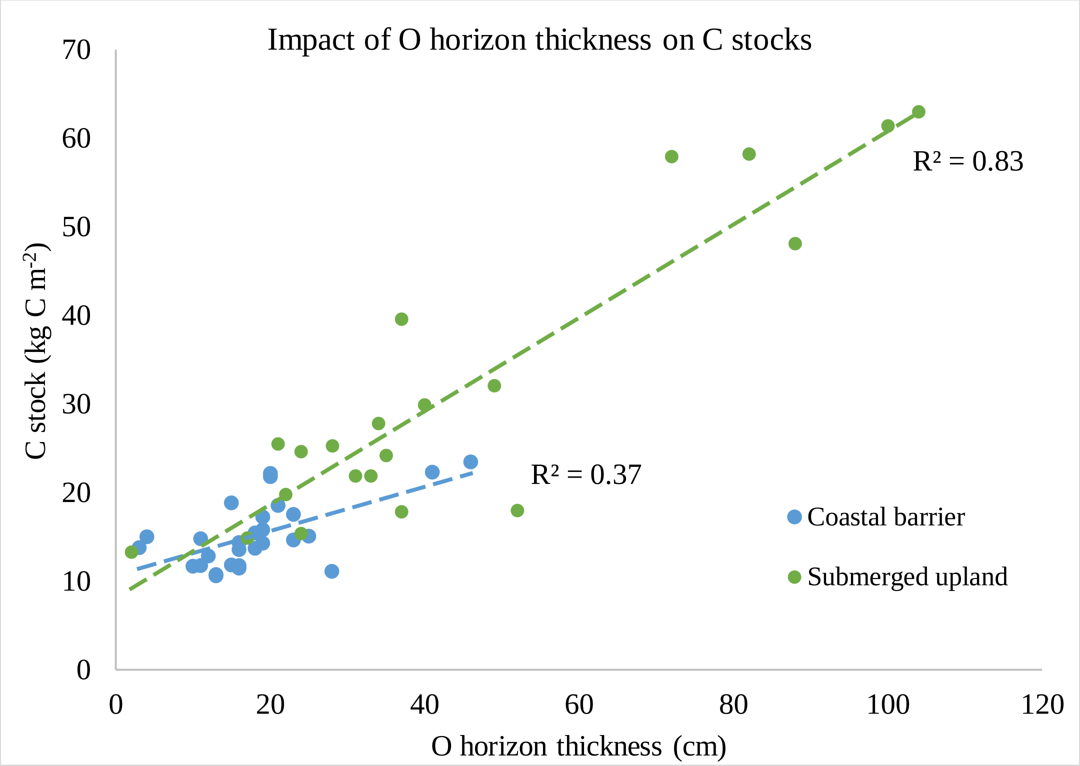


Figure 4-4. The thickness of the surface O horizon at each coastal barrier and submerged upland pedon is closely related to the C stocks to 200 cm. Coastal barrier $R^2 = 0.37$ and $p=0.0006$; submerged upland $R^2 = 0.83$ and $p<0.0001$.

4.3.2 Marshes in the submerged upland PGU

The low-lying and very gently sloping nature of the land surrounding submerged upland PGU has resulted in the dominance of poorly drained hydric soils. Soils in the Elkton or Othello series (Typic Endoaquults) border this PGU almost exclusively. These well-developed soils with argillic horizons have generally formed in late Pleistocene aged silty deposits (often thought to be loess), which overlaid sandy fluviomarine deposits (USDA Natural Resources Conservation Service, 1998). Additionally, the upland landscapes had a characteristically gentle, and nearly imperceptible, downward slope from the upland into the marsh. Detailed work by Hussein et al. (2004) showed that the former terrestrial land surface in two submerged upland marshes had slopes of roughly 0.03% to 0.07% over a lateral distance of approximately 1500 – 2000 m. The progression from upland to marsh was so gradual that the surrounding pine forests, which typically border these marshes, slowly transitioned from a healthy community to a "ghost forest"—a zone of dying trees suffering from osmotic stress (Hussein et al., 2004) (Figure 4-5). Eventually, the conditions were such that all upland species became replaced by salt-tolerant marsh hydrophytes.

Figure 4-5. A typical "ghost forest" bordering a submerged upland marsh at Blackwater National Wildlife Refuge in Cambridge, MD. Trees near the upland-marsh border suffer from osmotic stress and inundation, resulting in an increasing quantity of dead and dying trees grading into the marsh.

O horizon formation in submerged uplands has been driven by sea level encroaching on these gently sloping landscapes. Points along the landscape that were once above tidal influence became situated at mean high water as sea level rose (Rabenhorst, 1997). Marsh vegetation established in these zones and has generally kept pace with sea level rise, which has permitted the vertical accretion of the O horizon over the former upland surface (Rabenhorst, 1997; Rabenhorst and Needelman, 2016). However, due to climate change, some marshes have lost the ability to keep pace with the accelerated rate of sea level rise, owing to factors such as reduced sediment and plant inputs or greater subsidence (Cahoon et al., 2018). Nevertheless, submerged upland soils were much the same as the those found in the adjacent upland but now had a thickened organic surface layer. Additionally, their chemical properties, including base saturation and exchangeable sodium percentage, have become altered due to the influence of brackish tidal water (Stolt and Rabenhorst, 1991; Hussein and Rabenhorst, 2001a; b). Due to the transgression of the marsh upwards along the landscape, O horizons were thinner in upland direction (where the marsh is younger) and gradually thickened toward the estuary (where the marsh is older) (Figure 4-4). However, the increase may not be linear. One study showed that the depth to the former upland surface (i.e., the thickness of the O horizon) in two submerged upland marshes remained relatively stable, but closer to open water, the thickness of the O horizon increased suddenly (Hussein et al., 2004).

Soils here were likely influenced by estuarine deposition, as the organic materials were underlain by fluid mineral materials (Hussein et al., 2004).

Similar to the coastal barrier setting, C stocks in the submerged upland were largely controlled by the thickness of the O horizon (which also overlayed a subsoil containing low C-density materials). That is to say, submerged upland marshes had C stocks that gradually increased with distance from the upland interface (Figure 4-6). Carbon stocks were small near the upland—roughly 10 – 30 kg C m^{-2}. The C stocks along each transect did not always increase in the same manner, and sometimes showed irregularities that could be attributed to variations in the microtopography of the former upland surface prior to inundation. Despite some variations, submerged upland C stocks tended to increase across the marsh and reached a maximum of approximately 50 – 60 kg C m^{-2} at most sites.

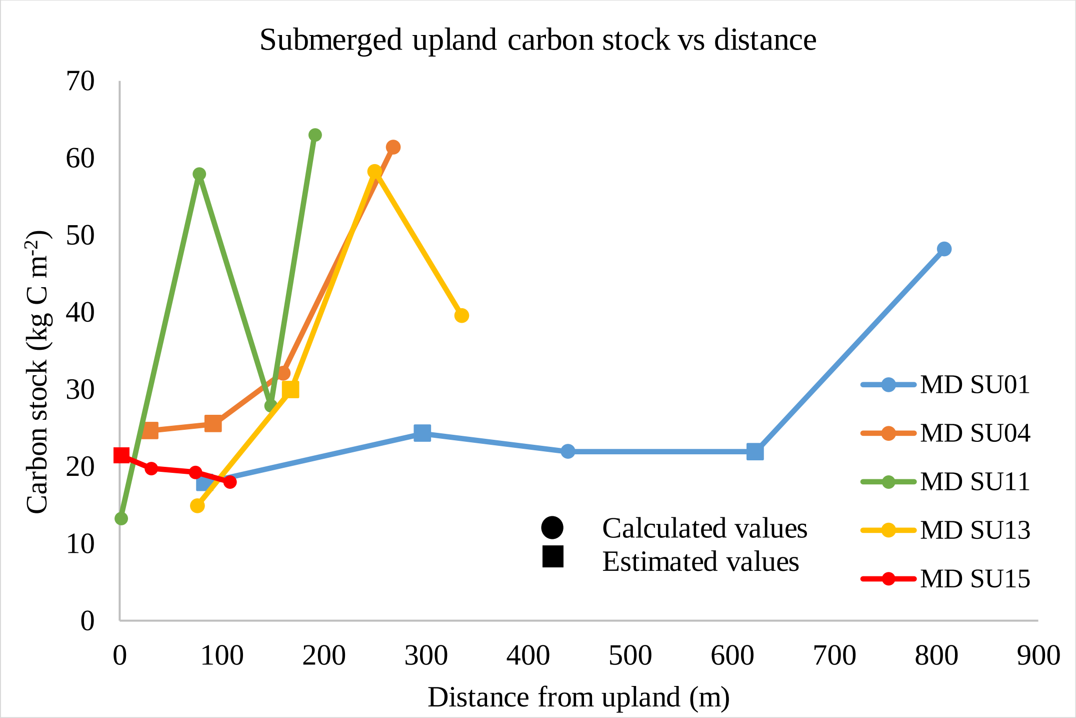


Figure 4-6. Calculated or estimated C stocks to 200 cm at each description point along every submerged upland transect. The variations in MD SU11 are attributed to the fluctuating thickness of the O horizon, impacting C stocks at each pedon. The estimated C stock in MD SU15 was derived from the mean C density of the materials found in the remainder of that particular transect.

4.3.3 Marshes in the coastal mainland PGU

Coastal mainland marshes were surrounded by a range of soil series that were Entisols and Ultisols. The Entisols were sandy (Quartzipsamments), yet, unlike the coastal barrier, some were poorly drained; wet conditions were also present in the Ultisols (Figure 4-2). Typical of many Mid-Atlantic coastal plain soils, these soils predominantly formed in sandy or loamy fluviomarine deposits during the late Pleistocene (USDA Natural Resources Conservation Service, 2004). The surrounding upland soils were generally situated on more steeply sloping (roughly 4 to 5%) land.

Marsh soils of the coastal mainland PGU were comprised of alluvially deposited silt and clay. Although these mineral materials had a high degree of fluidity, their bearing capacity seemed to be greater than those in some marshes of the estuarine PGUs. O horizons generally overlaid the fluid mineral horizons, sometimes in quantities thick enough to be considered Histosols. Organic materials were also commonly found interstratified within the profile. In most pedons, we observed coarser (sandy) textures toward the bottom of the profile, indicating the profile was transitioning into the sandy material that underlies the marsh.

By documenting these depths at which sandy textures were encountered along the transects, we could approximately outline the base of the marsh. There was not a clear relationship between the surrounding upland slope and the slope of the contact with the sandy base. In most cases (all but one) the slope of the upland was steeper than the slope of the sandy base. However, we did observe that the contact with the base seemed to have a greater slope at the upland interface (where the upland began to grade into and below the marsh) relative to the remainder of the transect; this was most apparent at transects MD CM02, 04, and 09 (Figure 4-7). This slope tended to become less steep closer to open water, suggesting that the base of the marsh became more level as the marsh extended further into the lagoon. In transect MD CM03, the depth to contact with a sandy base decreased linearly throughout. The sandy base was not encountered at the transect point closest to open water in MD CM07 and NJ CM01. Based on the changes in soil morphology, we determined that the depth of marsh deposits in the coastal mainland PGU was approximately 150 – 250 cm, which may roughly correspond to the depth of the lagoon.

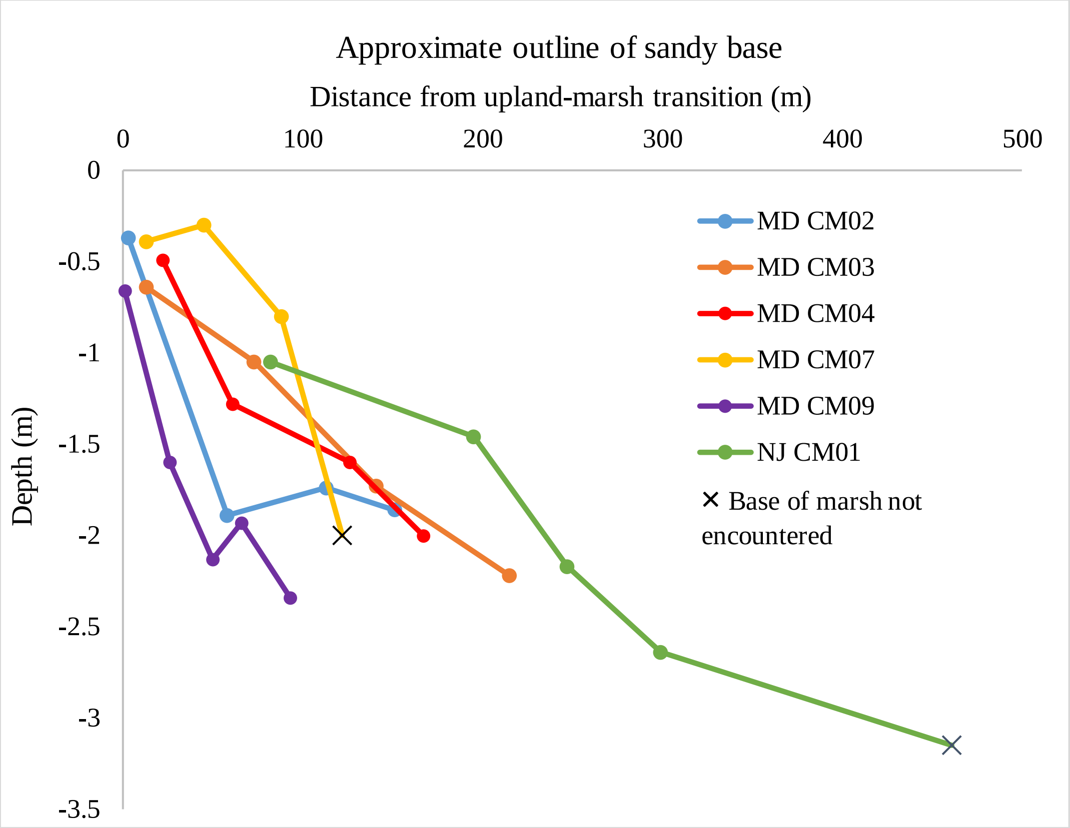


Figure 4-7. The depths at which sandier textures were described at each point along all coastal mainland transects. Coarser textures indicated that the soil was transitioning to sandy base material. Horizons overlying these points were fine textured (silt loams, silty clay loams, and silty clays). The soil surface is represented by 0 cm depth.

Not surprisingly, the geomorphology of the sandy base seemed to be related to observed trends in C stocks. Carbon stocks in all coastal mainland transects were small near the upland interface due to the shallow depth at which low C density soil materials were encountered (sometimes as shallow as 35 cm) (Figure 4-8). Moving away from the terrestrial border, C stocks increased quickly, to approximately 80 kg C m^{-2}, as a result of organic-rich material becoming deeper (more suddenly in some transects than in others). Thus, from the middle and toward the end of the transects where the thickness of the marsh soil increased more slowly, C stocks tended to level off.

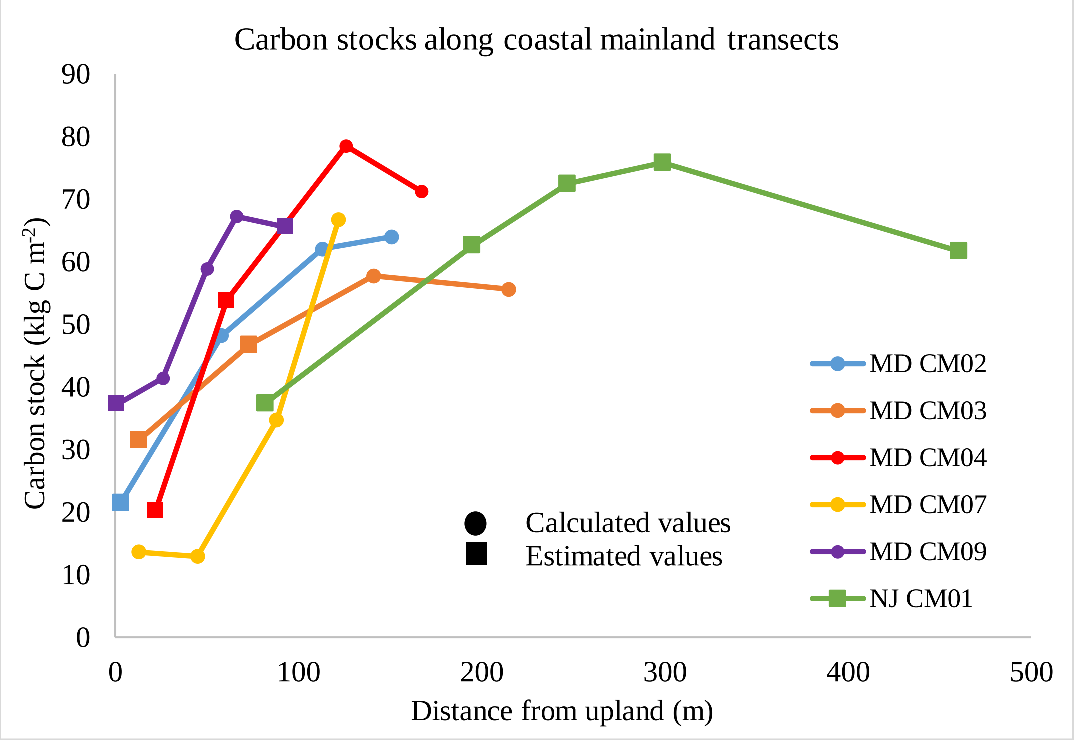


Figure 4-8. Calculated or estimated C stocks to 200 cm at each description point along every coastal mainland transect.

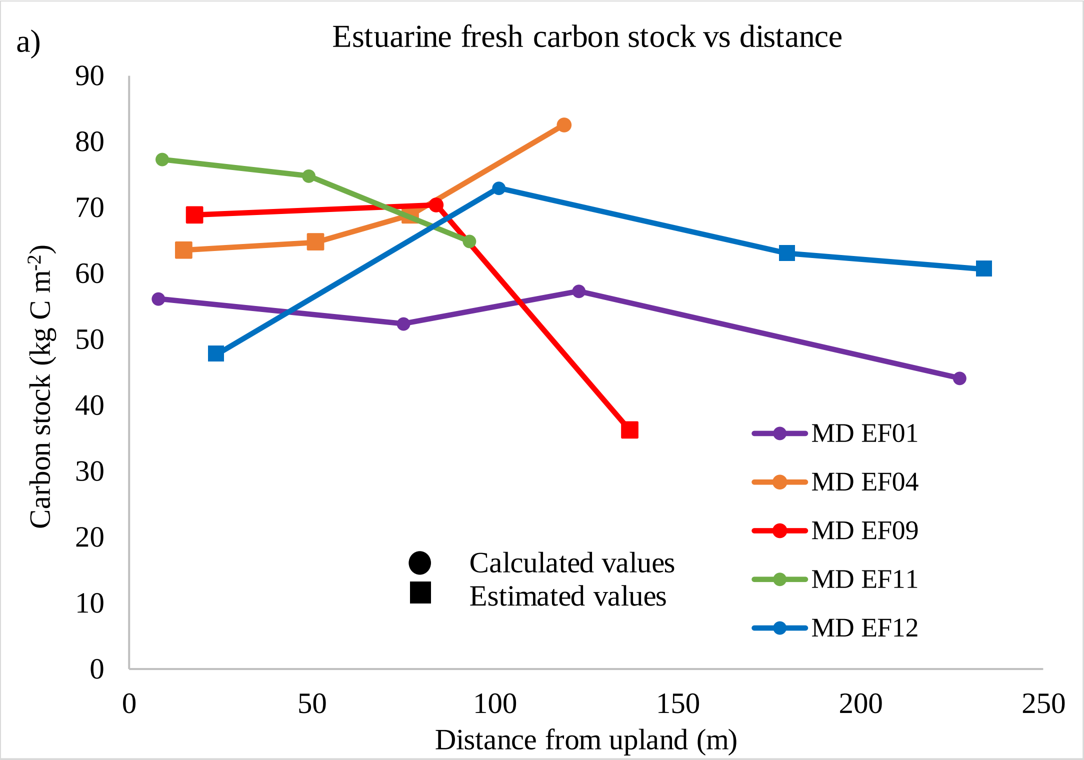
4.3.4 Marshes in the estuarine fresh and non-fresh PGUs

Tidal marshes in the estuarine fresh and non-fresh PGUs were largely surrounded by Ultisols and Entisols. Similar to the coastal mainland PGU, these terrestrial soils were formed in sandy or loamy fluviomarine sediments (USDA

Natural Resources Conservation Service, 1998). Some of the upland soils west of the Chesapeake Bay have formed from glauconitic fluviomarine sediments (USDA Natural Resources Conservation Service, 1973). The estuarine marshes themselves were formed as both organic and fine textured mineral material was deposited in low-energy stream and river channels that have become relatively incised within the surrounding landscape (Darmody and Foss, 1979). The deepening of the channels has resulted in dramatic elevational differences from the marsh to the surrounding uplands, which was partly reflected in the drier drainage classes of the adjacent terrestrial soils (Figure 4-2). Further, the significant changes in elevation meant that the slopes at the transitional zone were quite steep compared to those in other PGUs. Slopes near the transition were generally in the range of 5 to 11% with some as high as 30%—the steepest among all PGUs. It appeared that these steep gradients continued, or perhaps even increased, into and below the marsh soils, as the vast majority of pedons described in the estuarine fresh and non-fresh PGUs showed no indication of sandy textures near the bottom of the profile to the depth described. Therefore, we could not trace the base of the estuarine marshes as we did in the coastal mainland PGU, even in points closest to the upland edge. This suggests that the contact with the bottom of the marsh deepens rapidly moving away from the upland interface. Therefore, the thickness of marsh soil materials was probably many meters in depth across the estuarine PGUs. One study along the Nanticoke River in

MD documented the marsh thickness at several locations to be between 6 and 8 m deep, and at one location it was 15 m deep (Beckett, 2012).

Carbon stocks to 2 m across marshes in the estuarine fresh and non-fresh PGUs remained relatively even and did not reveal any systematic spatial variation (Figure 4-9 a – b). Carbon stocks (to 2 m) were large and ranged between approximately 50 – 90 kg C m^{-2} regardless of the distance from the upland interface. These deep soils consisted of stratified O horizons and fluid dark mineral horizons (i.e., soft A and C horizons with high SOC contents), and we have found that these soil materials have the greatest C densities among the materials documented in marshes (Chapter 3). The C density also appeared to remain relatively constant (mostly between 0.030 and 0.040 g C cm^{-3}) throughout the soil profile, suggesting that the magnitude of C stocks in these settings was largely a function of the depth of the marsh materials.


Estuarine fresh carbon stock vs distance

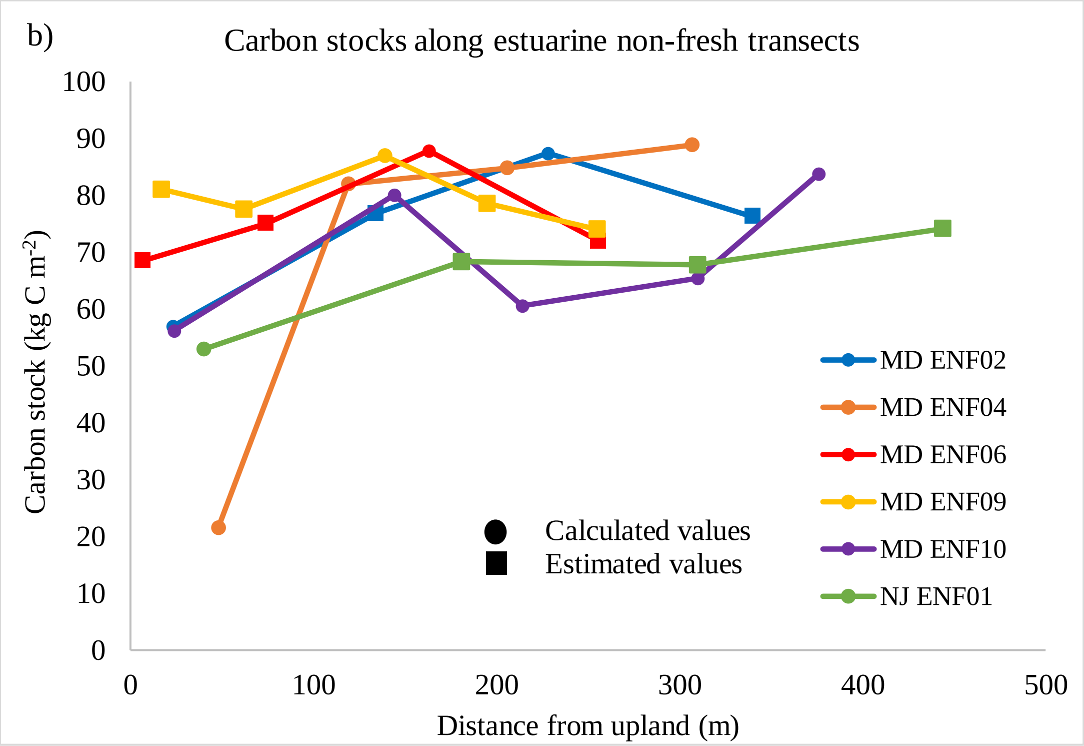

Carbon stocks along estuarine non-fresh transects

Figure 4-9 a – b. Calculated or estimated C stocks to 200 cm at each description point along every (a) estuarine fresh and (b) estuarine non-fresh transect. In MD EF09, the decrease in C stocks at the water's edge is because low-C sandy material was encountered starting at 99 cm below the soil surface, whereas in the rest of the transect, sandy materials were not encountered at all.

4.4 CONCLUSION

We previously determined that there were significant differences in C stocks to 200 cm among the five PGUs in which Mid-Atlantic tidal marshes occur. This chapter describes and explains how and why C stocks in some PGUs vary spatially. Coastal barrier marshes mainly consist of thin O horizons accumulated over sandy over-wash deposits that increase slightly in thickness towards open water. Marshes in this PGU stored a consistently small amount of C throughout most of the marsh with a small increase near the water's edge (where the O horizons thickened). Submerged upland marshes had O horizons that gradually thickened in the direction of the estuary; little C was stored below the organic surface in the dense Bt and Btg horizons. Therefore, C stocks also increased toward open water. In these two PGUs, the thickness of the O horizon was the primary driver of the spatial variations in C stocks. In the coastal mainland PGU, C stocks mainly exhibited spatial trends close to the upland boundary where the thickness of marsh sediments changed concomitant with the relatively steep slopes of the sandy, underlying upland-soil materials. In the estuarine fresh and non-fresh PGUs, marshes have formed in incised river and stream channels; the slope of the underlying sandy base increased at a much greater rate than even that of the coastal mainland, and the base was likely many meters deep in nearly all locations in the marsh. Thus, C stocks to 200 cm did not appear to present any spatial trend and were high in magnitude in most locations along any given transect.

More robust conceptual models can help inform the identification and recognition of marshes among the five PGUs in the Mid-Atlantic region. We have previously established that knowledge of the pedogeomorphic setting is a critical component in the estimation of pedon-scale C stocks (Chapter 3). Further, knowledge of the spatial variation in C stocks will be crucial if estimating region-wide quantities of C storage. Applying an average value to each of the five PGUs would provide a first approximation, but we also understand this would oversimplify in some PGUs that tend to have systematic differences in C stocks across the marsh (such as submerged uplands). Finally, these conceptual models can guide best practices for C stock sampling. Where soils are deeper and are comprised of high C density materials (the estuarine PGUs), sampling as deep as is feasible would be needed in order to obtain more accurate estimations of C storage. Although the coastal mainland PGU has similar C-rich materials, we now know that soils in this setting may only extend to a couple of meters. For pedogeomorphic units in which the majority of C is stored near the soil surface (e.g., the coastal barrier or landward areas of submerged upland marshes), a shallow sampling protocol could be sufficient. Future work should continue to focus on fine-scale transect sampling to further elucidate these ideas and to refine these conceptual models.

Thesis Summary and Conclusions

Tidal marshes in the Mid-Atlantic region were grouped into five PGUs based upon geomorphic setting and soil morphology: submerged upland, estuarine fresh, estuarine non-fresh, coastal barrier, and coastal mainland. Twenty-eight transects were established across these five PGUs. Pedons were described and sampled along these transects, and we acquired measured values of C stocks to depths of 50, 100, and 200 cm.

Marsh soil C stocks to 200 cm differed significantly among some of the PGUs. Soils in the two estuarine PGUs, which are rich in C and may extend many meters, stored the most C. The coastal mainland PGU had soils that were similar in nature to the estuarine marshes but were not as deep. Therefore, they had C stocks that were close to, but generally less than, those in the estuarine marshes. The submerged upland PGU had soil C stocks that were more variable across the marsh, with areas near the upland storing less, and areas near open water storing more. The coastal barrier marshes had the smallest soil C stocks as most of the C is stored in thin O horizons that overlaid low-C sand. These differences among the five settings were related to pedological processes reflected in soil morphology and the associated differences in C density. Carbon was distributed differently throughout the soil profile in various PGUs, so effective sampling strategies should incorporate knowledge of geomorphic context and soil morphology.

We classified marsh soil materials and horizons present in the region into nine types. Using the mean C densities of these materials joined with soil morphological descriptions, we have demonstrated that one can reliably estimate C stocks to 200 cm in the absence of laboratory data (i.e., bulk density and SOC content). We think this approach represents an improvement to the recent suggestion to use a single C density value to estimate carbon stocks (Holmquist et al, 2018) as it recognizes the differences in soil properties (including C density, which varies significantly among the nine material types) in the Mid-Atlantic region. The mean C density approach would thus avoid large over or underestimations of C stocks in Mid-Atlantic tidal marshes.

Finally, we updated, revised, and augmented conceptual models of the types of tidal marshes in Maryland (and the rest of the Mid-Atlantic region) that were originally described by Darmody and Foss (1979). Quantitative data regarding the nature of the marsh-upland transition zone (including elevation and slope) were incorporated into the central concepts of each PGU. Also included were the typical magnitudes and trends in C stocks observed from the upland boundary, across the marsh, and toward open water. In the submerged upland and coastal barrier PGUs, most of the C was stored in surficial O horizons that gradually thickened toward the estuary. The coastal mainland marshes had soils with a relatively uniform (and high) C density throughout the profile. These soils deepened rapidly moving away from the marsh-upland border and then tended to stabilize in depth toward the marsh interior.

Therefore, C stocks also increased rapidly and leveled off. The estuarine fresh and non-fresh marshes had soils that were deep in all locations. They similarly had a uniform C density throughout the soil profile, so C stocks did not show any systematic spatial trends.

The pedogeomorphic settings in which Mid-Atlantic tidal marshes occur have a dramatic influence on soil morphology and the distribution of C throughout the profile; these impacts were documented with measured C stocks of representative pedons. Further, we demonstrated that regional estimations of C stocks can be greatly simplified and more rapidly assessed using the mean C density approach—a better method than the application of a single C density value. Therefore, for more efficient (yet still reliable) estimations of C stocks, we propose the following practices:

1. Describe the soil by horizon or material type, rather than by fixed depth interval.
2. Describe the soil, at a minimum, through the "C-rich zone". The work presented here has demonstrated that C is distributed differently through the profile among the five PGUs. In the coastal barrier and submerged upland, the C-rich zone is the surface O horizon, which increases in thickness in the direction of open water. The C-rich zone of the coastal mainland PGU is the entire thickness of the marsh soil. However, the marsh deposits tend to extend for only a couple of meters; the soils near the upland may be much shallower. The estuarine fresh and non-fresh PGUs have C-rich zones that extend

through the entire profile, and these soils are many meters deep in all locations throughout a given marsh (up to 15 m in some Chesapeake Bay estuaries). Thus, one must describe these soils as deep as is feasible.

3. Apply the mean C density of the particular horizon or material type in order to calculate C stocks. We estimate that using this approach, only one-fourth the time (effort) is needed to generate an estimate of C stock, as would be required for sampling, processing, and analyzing each horizon in a pedon.
4. If data (rather than estimates) are desired, we recommend that pedons be sampled for lab analyses (i.e., bulk density and SOC determination) by pedogenic horizon. This would ensure that sample are more homogeneous (avoiding mixing different material types) and will invariably result in fewer samples to analyze (especially if layers are sampled at 5 cm intervals through the upper 50 cm as per the Howard et al. (2014) protocol).

Our findings affirm that soil and wetland scientists working in Mid-Atlantic tidal marshes must acknowledge the differences in pedogeomorphic setting in order to employ effective strategies for C stock calculations and estimations.

Appendix A. Pedotransfer functions for the estimation of bulk density

Direct measurement of bulk density was not feasible in some soils. These instances were mostly in dense subsoils such as submerged upland argillic horizons and sandy barrier-island C horizons. In a few cases, bulk density samples were not available for O horizons or fluid mineral horizons.

To obtain bulk densities, we first identified the types of horizons and materials that lacked bulk density data. These materials were: 1) O horizons; 2) fluid mineral soil materials; 3) sandy A horizons; 4) sandy C horizons; 5) A and E horizons of submerged uplands; 6) Bt and Btg horizons of submerged uplands.

We then created pedotransfer functions for each of these types of materials using two main sources of data. The first was the data generated in this study. The second was data from Rossi (2014) and characterized pedons from the KSSL database that had both measured bulk density and SOC contents. Those pedons from the KSSL database were soils in the Mid-Atlantic region that belonged to the following series: Woodstown, Marshyhope, Elkton, Othello, Crosiadore, Matapeake, Pineyneck, Downer, Greenwich, Ingleside, and Hammonton.

1) O horizons

O horizons are defined as organic soil materials, which contain ≥ 12% SOC. The dataset used in this study contained 148 O horizon samples with measured bulk densities and SOC contents. We plotted the bulk densities of our sampled O horizons as a function of their SOC content. The function generated is given in Equation 1.

Equation 1. Bulk density = $0.2948 - 0.004873 \times (\mathrm{SOC})$

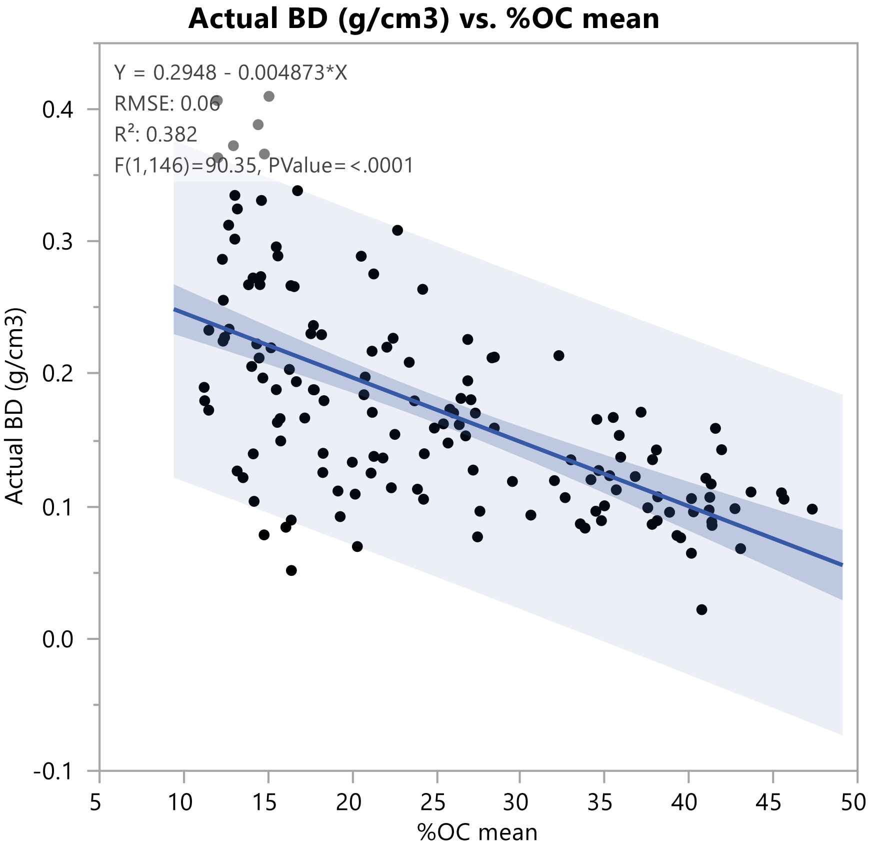
$R^2 = 0.382$; $p < 0.001$; RMSE = 0.06

Model development input range: SOC = 11.21 – 47.31

Model development output range: BD = 0.064 – 0.24

Sample Input range: SOC = 12.51 – 42.68

Sample Output range: BD = 0.089 – 0.23



2) Fluid mineral horizon

We define fluid mineral horizons as those materials with a fluidity class of very fluid or moderately fluid (Schoeneberger et al., 2012). Generally, these soils were fine textured, although some were loamy. Fluid mineral horizons are ubiquitous in the estuarine fresh, non-fresh, and coastal mainland PGUs, and were described as A, C, AC, or CA horizons. The dataset used in this study contained 158 fluid mineral horizon samples with measured bulk densities and SOC contents. We plotted the bulk densities of our sampled fluid mineral horizons as a function of their SOC content. The function generated is given in Equation 2.

Equation 2.

$$\text{Bulk density} = 1.798 - 0.4541 \times (\text{SOC}) + 0.05239 \times (\text{SOC}^2) - 0.002113 \times (\text{SOC}^3)$$

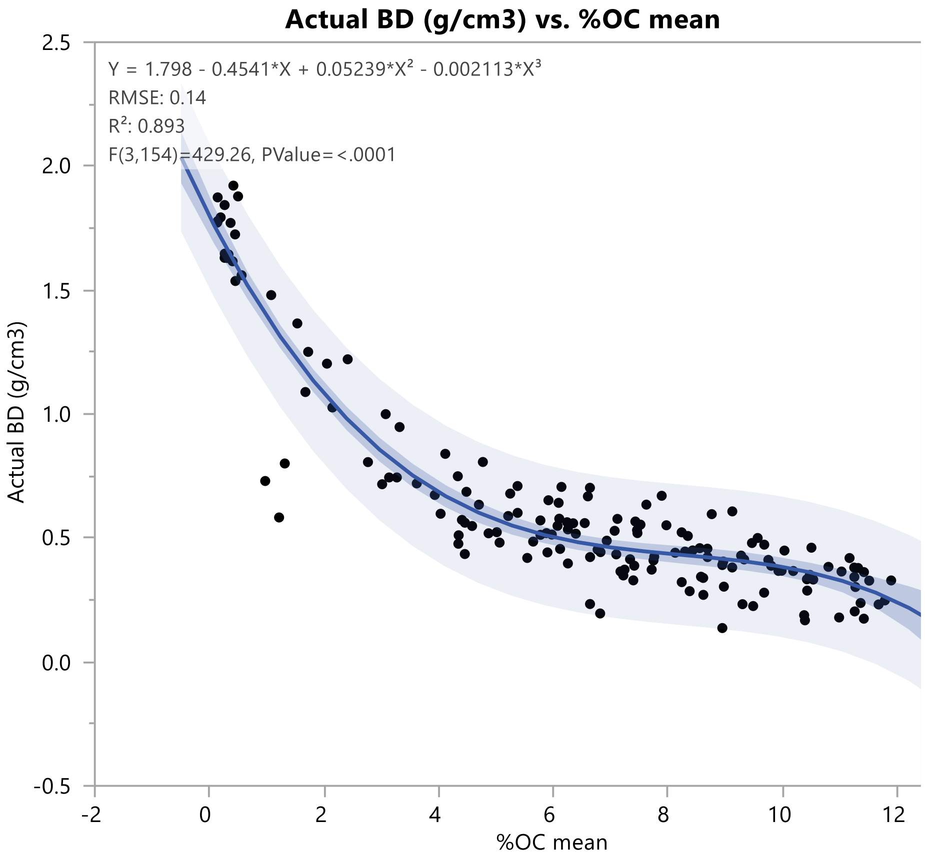
$R^2 = 0.893$; $p < 0.001$; RMSE = 0.14

Model development input range: SOC = 0.14 – 11.74

Model development output range: BD = 0.15 – 1.74

Sample Input range: SOC = 0.15 – 12.74

Sample Output range: BD = 0.29 – 1.73


Actual BD (g/cm3) vs. %OC mean
Y = 1.798 - 0.4541*X + 0.05239*X² - 0.002113*X³
RMSE: 0.14
R²: 0.893
F(3,154)=429.26, PValue=<.0001
Actual BD (g/cm3)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-2
0
2
4
6
8
10
12
%OC mean

3) Sandy A horizons

We define these soil materials as A horizons with textures of sand or loamy sand; they can also include sandy loams in the coastal barrier PGU. These materials were predominantly described in the coastal barrier PGU. We did not obtain any sandy A horizon samples with measured bulk densities and SOC contents from our study. Therefore, we used external sources with measured data for sandy A horizons. These data consisted of 41 A horizons obtained in Rossi (2014). These soils were from the dune and swale complex of barrier islands, which had soils similar in nature to the sandy A horizons that lacked bulk density (Rossi, 2014). Four sandy A horizons from the KSSL database were also extracted for use in this pedotransfer function; these were from pedons belonging to the series Evesboro, Runclint, Klej, and Askecksy that have been characterized in the Mid-Atlantic region. We plotted the bulk densities of the sandy A horizons as a function of their SOC content. The function generated is given in Equation 3.

Equation 3. Bulk density = 1.488 - 0.1428 × (SOC)

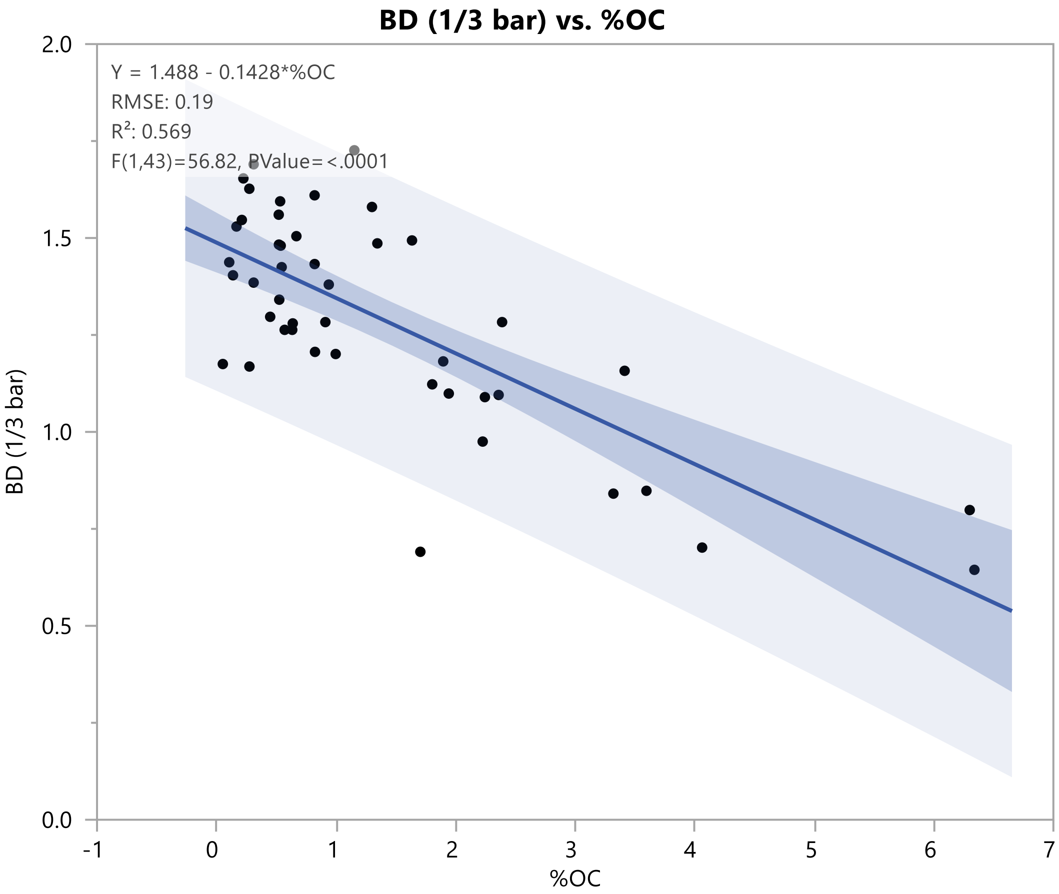
R2 = 0.569; $p < 0.001$; RMSE = 0.19

Model development input range: SOC = 0.05 – 6.34

Model development output range: BD = 0.58 – 1.48

Sample Input range: SOC = 0.09 – 7.04

Sample Output range: BD = 0.48 – 1.48

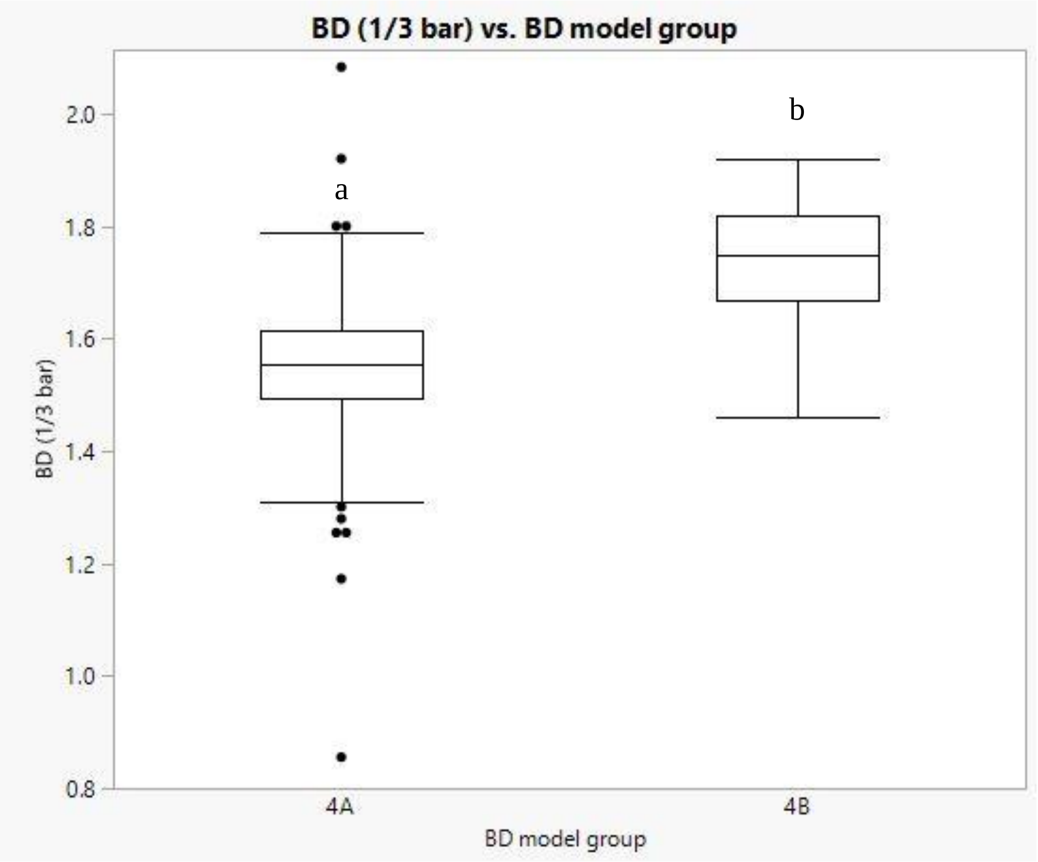

BD (1/3 bar) vs. %OC
Y = 1.488 - 0.1428*%OC
RMSE: 0.19
R²: 0.569
F(1,43)=56.82, PValue=<.0001
2.0
1.5
1.0
0.5
0.0
BD (1/3 bar)
-1
0
1
2
3
4
5
6
7
%OC

4a, 4b) Sandy C horizons

We define these soil materials as C horizons with textures of sand or loamy sand. These materials were predominantly described in the coastal barrier PGU and at the base of pedons in other PGUs. Similar to the sandy A horizon group, we did not obtain any measured bulk densities of sandy C horizons in our study, and thus external sources were used to derive the pedotransfer function. Eighty-nine sandy C horizons from Rossi (2014) and 43 from KSSL pedons were used. Those soils from the KSSL database were characterized in the Mid-Atlantic region and belonged to the following series: Greenwich, Pineyneck, Ingleside, Matapeake, Othello, Downer, Crosiadore, Askecksy, Brockatonorton, Evesboro, Fox Hill, Klej, and Runclint. When plotting the bulk density of these soils as a function of the SOC content, the data are clustered when SOC < 0.1% and show no apparent trend when greater than 0.1%. However, when plotting the bulk densities of these horizons as a function of their texture, sands had bulk densities that were significantly less than those of loamy sands and sandy loams. We therefore used one fixed bulk density value for sands (Equation 4a) and one value for loamy sands and sandy loams (Equation 4b).

Equation 4a. Bulk density = 1.55 g cm^{-3}; Standard deviation = 0.149

Equation 4b. Bulk density = 1.74 g cm^{-3}; Standard deviation = 0.103



5) Submerged upland A and E horizons

These materials are defined as A and E horizons in the submerged upland PGU; their textures are generally loamy. The horizons in this group that lacked bulk density had measured SOC contents up to 11.9%. In order to estimate their bulk densities, we used the samples in our dataset that had SOC contents in the same range (as well as measured bulk densities). We plotted the bulk densities of our sampled horizons as a function of their SOC contents. The equation is given in Equation 5.

Equation 5. $\text{Bulk density} = 1.834 - 0.4688 \times (\text{SOC}) + 0.0558 \times (\text{SOC}^2) - 0.002349 \times (\text{SOC}^3)$

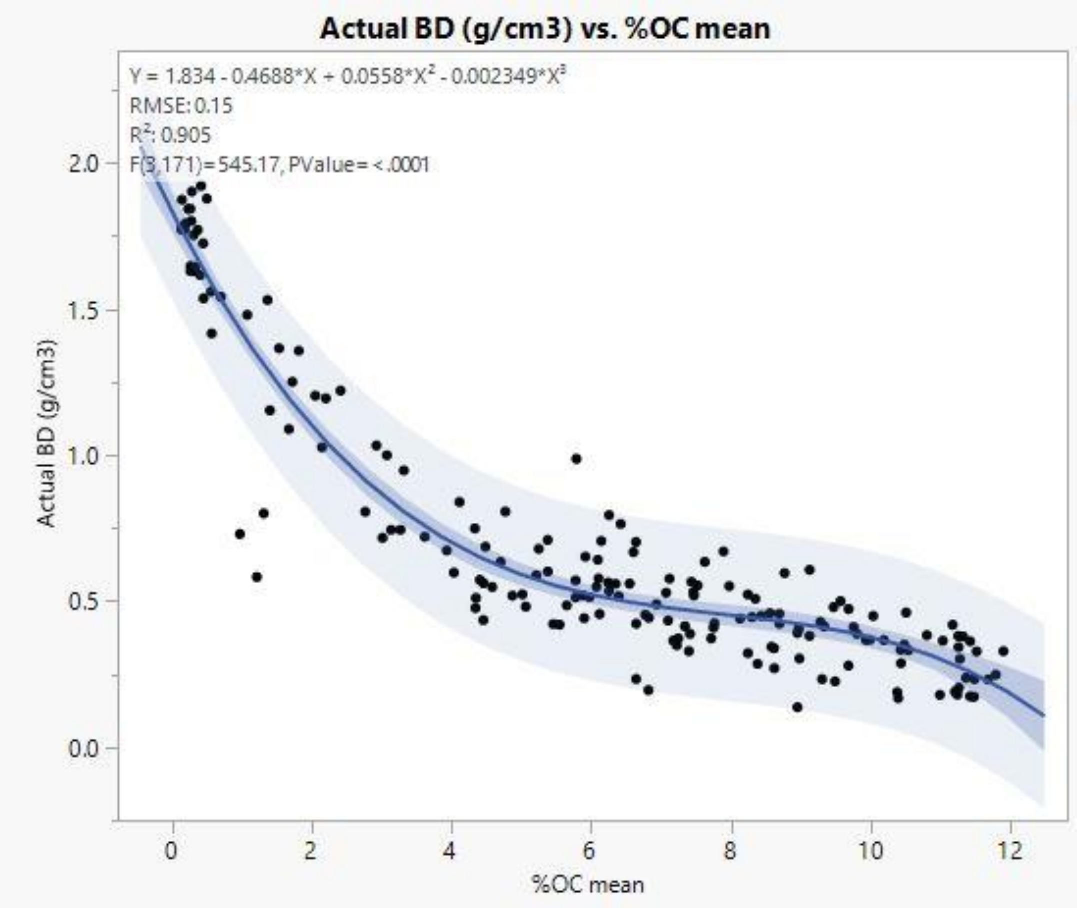
$R^2 = 0.905$; $p < 0.001$; RMSE = 0.15

Model development input range: SOC = 0.14 – 11.90

Model development output range: BD = 0.20 – 1.77

Sample Input range: SOC = 0.30 – 11.19

Sample Output range: BD = 0.28 – 1.70

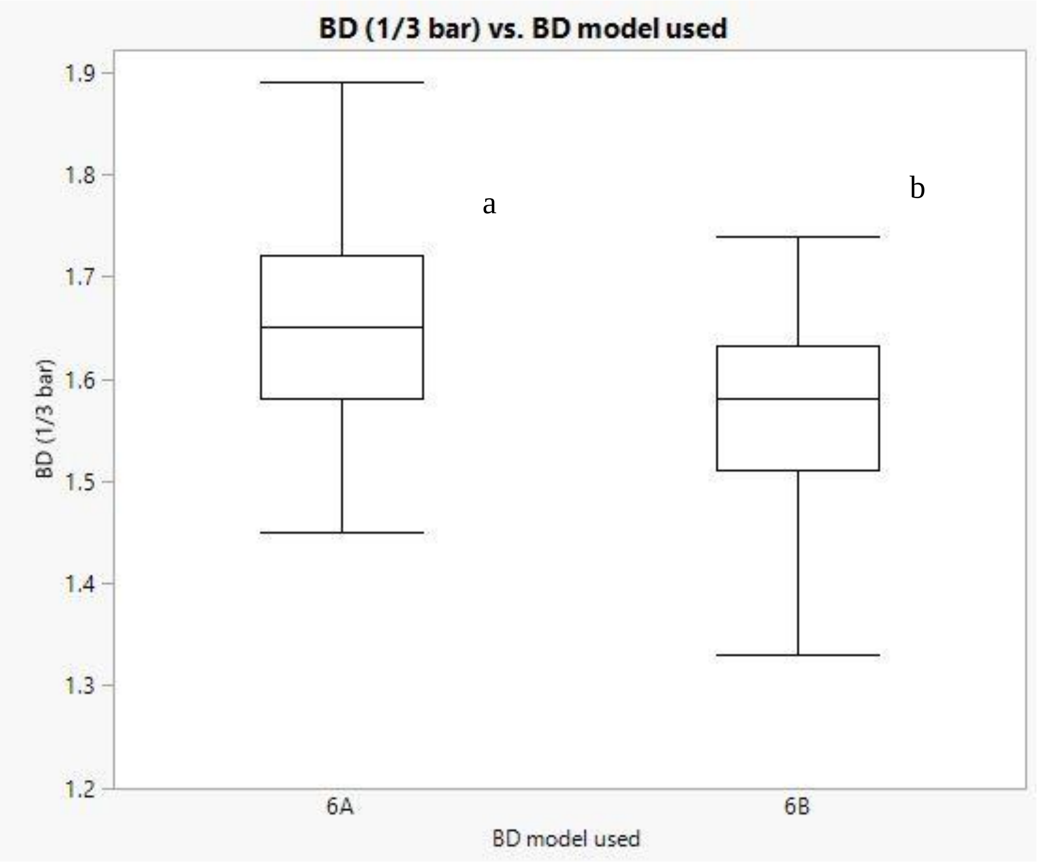


6a, 6b) Submerged upland Bt and Btg horizons

We define these soil materials as Bt or Btg in the submerged upland PGU. Textures were variable and could be silty (silt loams and silty clay loams) or loamy. We obtained a few measured bulk densities of Bt or Btg horizons, however these samples may have been subjected to compaction during removal. Therefore, Bt and Btg horizons from the KSSL database were used to derive this pedotransfer function; these horizons also had variable textures that included sand, loamy sand, loam, clay loam, sandy loam, silt loam, and silty clay loam. The soils from the KSSL database were characterized in the Mid-Atlantic region and belonged to the following series: Woodstown, Marshyhope, Elkton, Othello, Crosiadore, Matapeake, Pineyneck, Downer, Greeenwich, Ingleside, and Hammonton. When plotting the bulk densities as a function of SOC content, a weak trend was observed. However, when plotting the bulk densities of these horizons as a function of their texture, two groups emerged: loamy sands, sandy loams, and loams (Function 6a); silt loams, silty clay loams, and clay loams (Function 6b). Bulk densities were not significantly different within the groups, but they were among the groups. Therefore, we used a single bulk density value for each group. Sands were not significantly different from either group and were included with Equation 6a.

Equation 6a. Bulk density = 1.65 g cm^{-3}; Standard deviation = 0.097

Equation 6b. Bulk density = 1.57 g cm^{-3}; Standard deviation = 0.087


BD (1/3 bar) vs. BD model used
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
BD (1/3 bar)
a
b
6A
6B
BD model used

Appendix B. Differentiating the types of marsh soil materials

We classified the types of soil materials that comprised our sample dataset. First, generalized groups of materials were identified: organic soil materials (O horizons), fluid mineral horizons, sandy (non-fluid) horizons, and submerged upland horizons. Each of these groups was analyzed to further differentiate material types.

Oa, Oe, Oi

The O horizons were described in the field based on their degree of decomposition (i.e., Oi, Oe, and Oa). When these horizons were analyzed together, Carbon densities of Oa horizons were significantly greater than for Oi horizons, but Oe horizons were not different from either. Rather than including Oe horizons with either group, we decided to consider all three types of O horizons as a unique material type: **Oa, Oe, and Oi** (Figure 1).

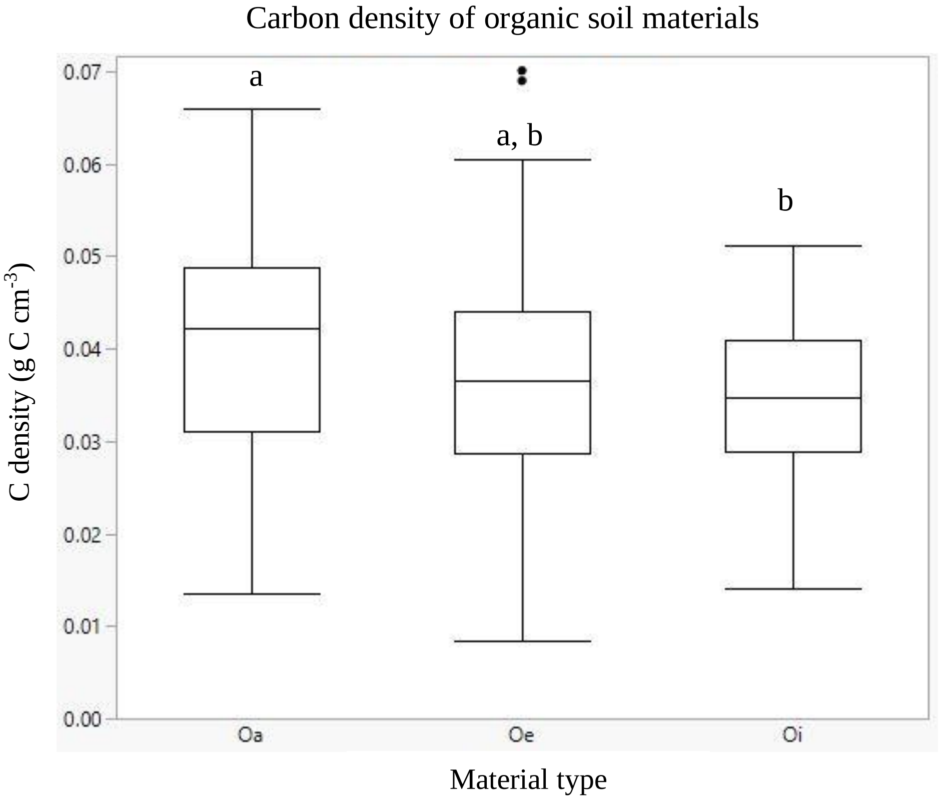


Figure 1. The C densities of materials classified in the Oa, Oe, and Oi classes. Boxes with the same letter are not significantly different at the 0.05 level.

Fluid dark and fluid light

Fluid mineral horizons consisted of A, C, AC, and CA horizons that had a fluidity class of moderate or very fluid. That is, when squeezed, most or all of the soil material is extruded between one's fingers. There was no clear differentiation between the C densities of the four master horizons used to describe these materials. However, a more obvious trend appeared when analyzing fluid mineral horizons on the basis of Munsell value (Figure 2). In these particular soil materials, Munsell value was a much better indicator of the amount of organic matter contained within a soil than was master horizon designation. We found that samples that were darker in color (value ≤ 4) had C densities that were similar in magnitude, so we grouped these into the **fluid dark** class. Those materials that were lighter (value > 4) had extremely low C densities and were also grouped to create the **fluid light** class.

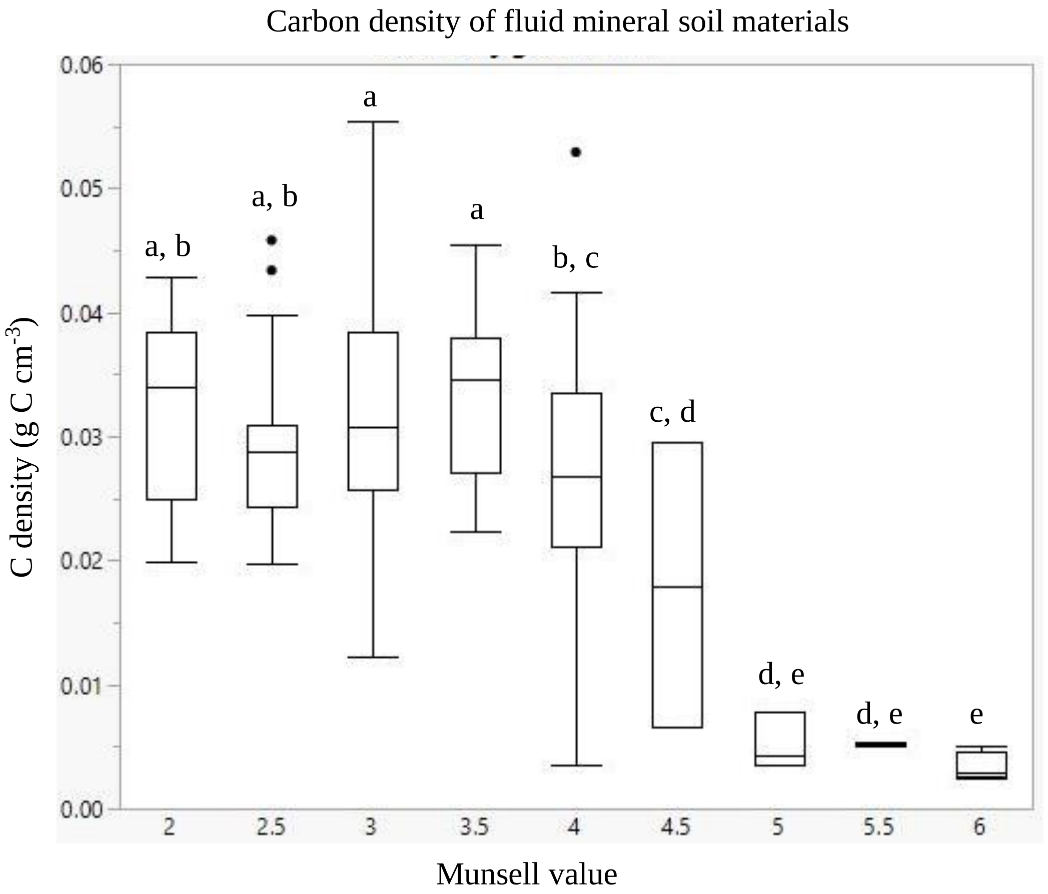


Figure 2. Carbon densities of fluid mineral horizons based on their Munsell value, a measure of lightness or darkness. Darker materials had a higher C density compared to that of lighter materials.

Sandy dark and sandy light

Sandy soils consisted of A, C, AC, CA, and BC horizons that had textures of sand, loamy sand, or sometimes sandy loams. These materials were also differentiated based on Munsell value (Figure 3). Horizons with values ≥ 4 were not significantly different and were grouped to create the **sandy light** material class. Horizons with a value < 4 did have significant differences among them. However, the sample size for this group was small (n = 12). We did not think that splitting these darker materials was warranted since they contained few samples. Thus, they were categorized together into the **sandy dark** group.

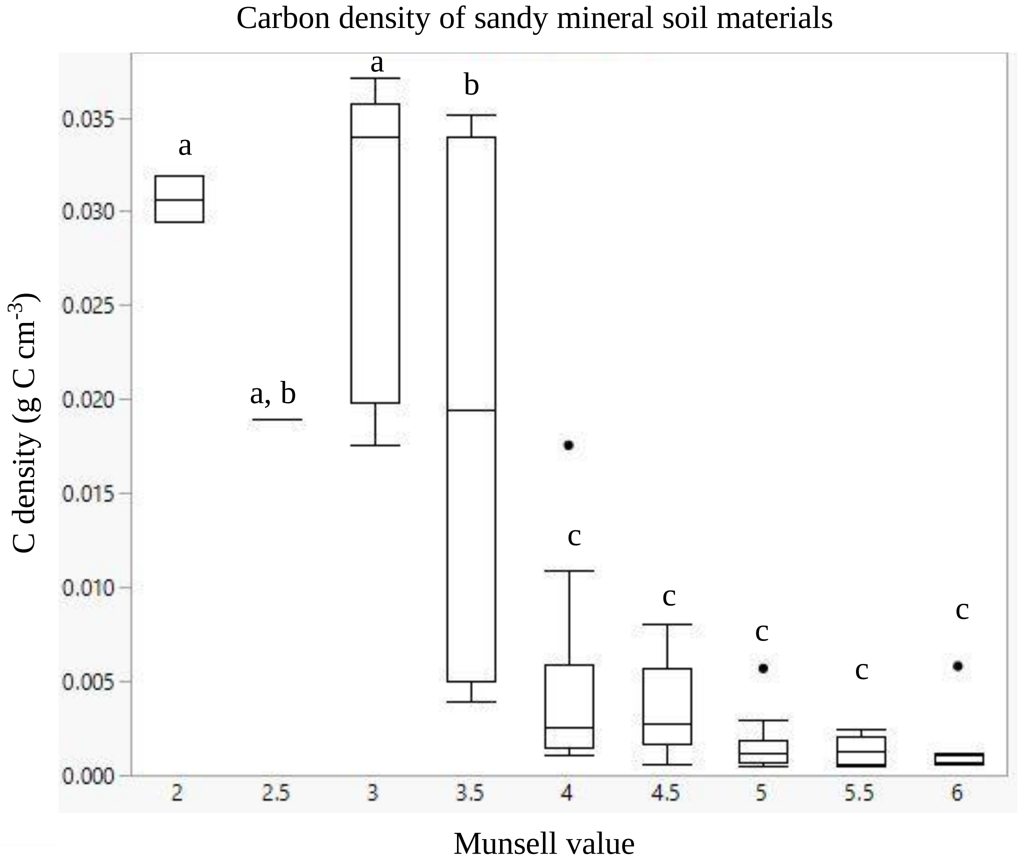
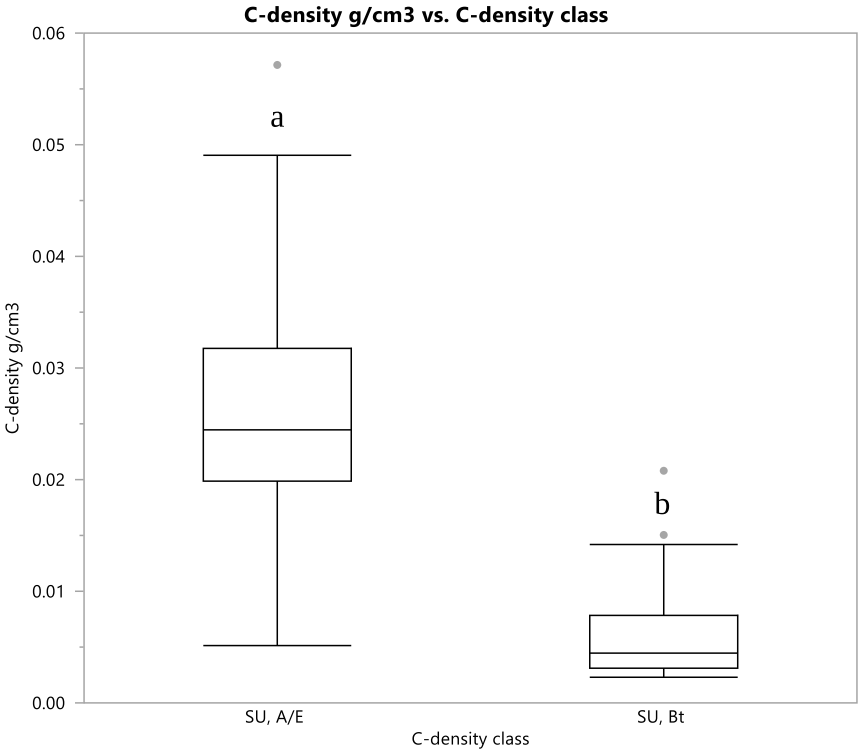


Figure 3. Carbon densities of sandy mineral horizons based on their Munsell value. Light colored materials were more common than darker materials, which typically existed as A horizons in the coastal barrier PGU.

Submerged upland A/E; Bt/Btg

Soil materials unique to the submerged upland PGU were categorized separate from materials common in other PGUs. These materials were **submerged upland A and E** horizons; and **submerged upland Bt and Btg** horizons. Although these classes were not statistically different than some other material classes previously defined, they were different from each other, and they are unique in their pedogenic processes and thus were recognized separately.



Appendix C. Morphological descriptions

Abbreviations used in the tables are as follows. For the purposes of taxonomic classification, any reaction with H_2O_2 was considered an indication of sulfidic materials.

Pedogeomorphic unit (PGU)
CB: coastal barrier
CM: coastal mainland
EF: estuarine fresh
ENF: estuarine non-fresh
SU: submerged upland

Texture
m: muck
mp: mucky peat
p: peat
s: sand
ls: loamy sand
sl: sandy loam
l: loam
scl: sandy clay loam
cl: clay loam
sil: silt loam
sicl: silty clay loam
sic: silty clay
The letter “m” preceding a mineral texture indicates a mucky-modified texture.

Redoximorphic features
(Color, contrast, type, abundance %)
Contrast
f: faint
d: distinct
p: prominent
Type
con: concentration
dep: depletion

Fluidity
NF: non-fluid
SF: slightly fluid
MF: moderately fluid
VF: very fluid

3% H_2O_2
Y: yes
N: no

30% H_2O_2
NE: non-effervescent
VS: very slightly effervescent
SL: slightly effervescent
ST: strongly effervescent
VE: violently effervescent
NT: not tested

alpha-aplha-dipyridyl
-: no reaction
+: slight reaction
++: strong reaction
+++: very strong reaction

Excavation method
BS: biscuit
BK: bucket auger
MC: Macaulay sampler
HC: hand corer
NT: not tested

Pedon: DE CB01 01
Describers: JK, ID, ER
Date: 8/18/21 **Time:** 11:12AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.63401° **Longitude:** -75.06889°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	4	m	10YR	3	2	-	H5	15	-	Y	ST	NT	BS
A1	13	sl	10YR	3	1	-	-	-	SF	N	NE	NT	BK
A2	30	sl	10YR	2	1	-	-	-	MF	N	VS	NT	BK
CA	42	s	10YR	3.5	2	-	-	-	NF	N	NE	NT	BK
Cg1	81	s	5Y	4	1	N2.5 d con, 2%	-	-	NF	N	NE	NT	BK
Cg2	126+	s	N	5.5	0	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB01 02
Describers: JK, ID, ER
Date: 8/18/21 **Time:** 11:45AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.634120° **Longitude:** -75.069740°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	15	p	2.5Y	3	2.5	-	H5	40	-	N	VS	NT	BS
Oe	23	mp	10YR	2	1	-	H7	35	-	N	NE	NT	BS
C	31	s	5Y	3.5	1	-	-	-	SF	N	NE	NT	BK
Ab	60	ls	2.5Y	3	1	-	-	-	SF	N	VS	NT	BK
Cg1	120	s	10Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg2	143+	s	5Y	5.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB01 03
Describers: JK, ID, ER
Date: 8/18/21 **Time:** 1:30PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.634340° **Longitude:** -75.070830°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	3	p	2.5Y	3.5	2	-	H3	65	-	Y	ST	NT	BS
A	10	s	2.5Y	3	1	-	-	-	NF	N	VS	NT	BS
CA	26	s	2.5Y	3	2	-	-	-	NF	N	VS	NT	BS
Cg	80	ls	2.5Y	4	2	-	-	-	NF	N	NE	NT	BK
C	92	ls	5Y	3	1	-	-	-	NF	N	ST	NT	BK
C'g	135+	s	10Y	4.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB01 04
Describers: JK, ID, ER
Date: 8/18/21 **Time:** 2:05PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: MD **County:** SUSSEX
Latitude: 38.634500° **Longitude:** -75.071780°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	15	p	2.5Y	3	2	-	H3	80	-	Y	NE	NT	BS
Oi	32	p	2.5Y	3	1.5	-	H3	60	-	N	NE	NT	BS
Ag1	44	l	2.5Y	4	2	-	-	-	VF	N	SL	NT	BK
Ag2	60	l	10Y	3	1	-	-	-	VF	N	VS	NT	BK
CAg	85	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg1	151	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg2	160+	s	5Y	5	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB02 01
Describers: JK, ID, ER
Date: 8/19/21 **Time:** 10:08AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.645440° **Longitude:** -75.069350°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	11	p	10YR	3	3	-	H3	90	-	N	VS	NT	BS
A	13	l	10YR	3	1	-	-	-	SF	N	SL	NT	BS
Ag	18	l	N	4	0	-	-	-	SF	N	ST	NT	BS
Cg	49	s	5Y	5	2	-	-	-	NF	N	VS	NT	BK
Ab	60	sl	5Y	3	1	-	-	-	MF	N	VS	NT	BK
CA	80	ls	5Y	4	1	-	-	-	MF	N	NE	NT	BK
C'g	130+	s	5Y	4	2	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB02 02
Describers: JK, ID, ER
Date: 8/19/21 **Time:** 10:41AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.645510° **Longitude:** -75.070370°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	10	p	2.5Y	3.5	1	-	H3	45	-	N	NE	NT	BS
Ag	21	sl	5Y	4	1	-	-	-	SF	N	NE	NT	BS
CAg	38	ls	5Y	5	1	-	-	-	NF	N	NE	NT	BK
Agb	52	sl	5Y	3.5	1	-	-	-	SF	N	NE	NT	BK
Cg1	73	ls	5Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg2	95	s	5Y	4	2	-	-	-	NF	N	NE	NT	BK
Cg3	116	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg4	123+	s	5Y	6	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB02 03
Describers: JK, ID, ER
Date: 8/19/21 **Time:** 11:25AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.645510° **Longitude:** -75.071700°
PGU: CB
Remarks: CROSSED SEVERAL MOSQUITO DITCHES TO ACCESS THIS POINT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi1	15	p	2.5Y	3	2	-	H3	70	-	N	NE	NT	BS
Oi2	20	p	2.5Y	2.5	1	-	H3	65	-	N	NE	NT	BS
A	51	ls	2.5Y	3.5	1	-	-	-	NF	N	NE	NT	BK
CAg	68	ls	2.5Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg1	103	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg2	117	s	5Y	5	1	-	-	-	NF	N	NE	NT	BK
Cg3	140+	s	5Y	6	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB02 04
Describers: JK, ID, ER
Date: 8/19/21 **Time:** 12:23PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.645500° **Longitude:** -75.072720°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	19	p	10YR	3	3	-	H7	65	-	N	VS	NT	BS
Oe	46	mp	7.5YR	2.5	2	-	H7	20	-	N	NE	NT	BS
A	58	sl	10YR	3	2	-	-	-	MF	N	NE	NT	BK
CAg	64	ls	N	4.5	0	-	-	-	NF	N	VS	NT	BK
Cg1	107	s	10Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg2	129	s	10Y	5	1	-	-	-	NF	N	NE	NT	BK
Cg3	143+	s	10Y	5.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: DE CB02 05
Describers: JK, ID, ER
Date: 8/19/21 **Time:** 1:06PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: DELAWARE SEASHORE STATE PARK
State: DE **County:** SUSSEX
Latitude: 38.645630° **Longitude:** -75.073460°
PGU: CB
Remarks: MANY SEAGULLS OBSERVED AT THIS POINT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	20	p	5Y	3	3	-	H3	95	-	N	NE	NT	HC
A1	41	msl	10YR	3	2	-	-	-	MF	N	NE	NT	BK
A2	52	sl	5Y	3	1	-	-	-	VF	N	VS	NT	BK
CA	66	sl	5Y	3	1.5	-	-	-	MF	N	NE	NT	BK
Cg1	81	ls	5Y	3.5	1	-	-	-	SF	N	NE	NT	BK
Cg2	94	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg3	145+	s	5Y	6	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB01 01
Describers: JK, ID, ER
Date: 6/28/21 **Time:** 2:56PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.169790° **Longitude:** -75.169850°
PGU: CB
Remarks: NEARING FOREST EDGE. DIFFICULT TO TELL EXACTLY WHERE THE MARSH ENDS AND THE FOREST BEGINS.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	13	m	7.5YR	2.5	1	-	H8	12	-	Y	SL	NT	BS
Ase	17	ms	2.5Y	4	1	-	-	-	MF	Y	NE	NT	BS
Cg1	58	s	2.5Y	5	2	-	-	-	NF	N	NE	NT	BK
Cg2	100+	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB01 02
Describers: JK, ID, ER
Date: 6/28/21 **Time:** 2:08PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.170090° **Longitude:** -75.170430°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	13	p	10YR	3	2	-	H4	45	-	Y	SL	NT	BS
Aseg	18	sl	5Y	3	1	-	-	-	SF	Y	SL	NT	BS
Cg1	40	s	5Y	4	1.5	-	-	-	NF	N	NE	NT	BK
Cg2	61	s	5Y	5	1	-	-	-	NF	N	NE	NT	BK
Agb	67	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK
C'g	74	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
A'gb	83	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK
C"g	98+	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB01 03
Describers: JK, ID, ER
Date: 6/28/21 **Time:** 1:19PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.170360° **Longitude:** -75.171300°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	18	p	10YR	3	2	-	H4	60	-	Y	ST	NT	BK
Ase	30	mls	2.5Y	3	1	-	-	-	SL	Y	SL	NT	BK
CAg	40	ls	2.5Y	4	1	-	-	-	SL	N	NE	NT	BK
Cg1	55	s	2.5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg2	113+	s	5Y	5.5	1	-	-	-	NF	N	VS	NT	BK

Pedon: MD CB01 04
Describers: JK, ID, ER
Date: 6/28/21 **Time:** 12:30PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.170890° **Longitude:** -75.172410°
PGU: CB
Remarks: FIDDLER CRABS, REDWING BLACKBIRDS, AND EGRETS SEEN HERE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	11	mp	2.5Y	3	1	N2.5 p con, 20%	H4	30	-	Y	ST	NT	MC
Oise	21	p	10YR	3	2	-	H4	40	-	Y	SL	NT	MC
AC	50	s	5Y	3	2	-	-	-	NF	N	NE	NT	BK
Cg1	93	s	10Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg1	105+	fs	10Y	4	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB02 01
Describers: JK, ID, ER
Date: 6/30/21 **Time:** 11:30AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.178040° **Longitude:** -75.167500°
PGU: CB
Remarks: CLOSE TO SCRUB-SHRUB VEGETATION.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase1	10	m	7.5YR	2.5	1	-	H4	15	-	Y	SL	NT	BS
Oase2	16	m	10YR	2	1	-	NT	NT	-	Y	SL	NT	BS
C	21	s	2.5Y	5	3	-	-	-	SF	N	NE	NT	BS
Cg1	38	s	2.5Y	4	1	-	-	-	NF	N	NE	NT	BS
Cg2	86	s	5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
Cg3	120+	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB02 02
Describers: JK, ID, ER
Date: 6/30/21 **Time:** 10:53PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.178240° **Longitude:** -75.168140°
PGU: CB
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	16	p	7.5YR	3	1.5	-	H3	78	-	Y	ST	NT	HC
Ase	26	mls	10YR	3	1.5	-	-	-	NF	Y	SL	NT	BK
Cseg	33	s	5Y	4	2	-	-	-	NF	Y	SL	NT	BK
Cg1	48	s	5Y	4	1.5	-	-	-	NF	N	N	NT	BK
Cg2	105+	s	5Y	5.5	1	-	-	-	NF	N	N	NT	BK

Pedon: MD CB02 03
Describers: JK, ID, ER
Date: 6/30/21 **Time:** 9:50AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.178440° **Longitude:** -75.168740°
PGU: CB
Remarks: THERE ARE STRAIGHT PATHS OF *S. PATENS* THAT APPEAR TO FOLLOW OLD MOSQUITO DITHCES THAT WERE FILLED IN.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	18	p	10YR	3	3	-	H3	80	-	Y	NT	NT	HC
Oese	28	mp	10YR	2	2	-	NT	NT	-	Y	NE	NT	BS
Cg1	43	s	10Y	4	1	-	-	-	NF	N	NT	NT	BK
Cg2	55	s	10Y	4.5	1	-	-	-	NF	N	NT	NT	BK
Cg3	93+	s	10Y	5	1	-	-	-	NF	N	NT	NT	BK

Pedon: MD CB02 04
Describers: JK, ID, ER
Date: 6/30/21 **Time:** 8:56AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.178670° **Longitude:** -75.169810°
PGU: CB
Remarks: MUD-FLAT NEAR WATER'S EDGE WITH *SALICORNIA* GROWING ALONG THE MARGINS. DID NOT DESCRIBE IN THE MUD-FLAT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	5	p	7.5YR	3	1.5	-	H3	60	-	Y	ST	NT	HC
Oese	15	mp	10YR	3	1	-	NT	NT	-	N	N	NT	HC
AC	24	s	10YR	4	2	-	-	-	NF	N	N	NT	BK
Cg1	35	s	10YR	4.5	2	-	-	-	NF	N	N	NT	BK
Cg2	50	s	10YR	4.5	2	-	-	-	NF	N	N	NT	BK
Cg3	97	s	2.5Y	5	1.5	-	-	-	NF	N	N	NT	BK
Cg4	150+	s	5Y	6	1	-	-	-	NF	N	N	NT	BK

Pedon: MD CB03 01	**Location:** ASSATEAGUE ISLAND NATIONAL SEASHORE
Describers: JK, ID, ER	**State:** MD **County:** WORCESTER
Date: 6/29/21 **Time:** 1:00PM	**Latitude:** 38.187810° **Longitude:** -75.162830°
Access: FOOT	**PGU:** CB
Taxonomic classification: HAPLIC SULFAQUENT	**Remarks:**

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	16	mp	7.5YR	2.5	1.5	-	H7	22	-	Y	ST	NT	BS
A	27	mls	10YR	3	1	-	-	-	SL	N	SL	NT	BK
CAg	34	s	2.5Y	4	1	-	-	-	SL	N	NE	NT	BK
Cg1	49	s	2.5Y	5.5	1	N2 p con	-	-	NF	N	NE	NT	BK
Cg2	84	s	5Y	5	1	N2 p con	-	-	NF	N	NE	NT	BK
Cg3	112+	s	5Y	6	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB03 02
Describers: JK, ID, ER
Date: 6/29/21 **Time:** 12:10PM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.187900° **Longitude:** -75.163590°
PGU: CB
Remarks: NEAR EDGE OF MARSH, SIMILAR TO GHOST FOREST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise1	7	p	7.5YR	2.5	1	-	H3	70	-	Y	NT	NT	BS
Oise2	19	p	7.5YR	2.5	1.5	-	H6	45	-	N	NT	NT	BS
A	32	mls	10YR	2	2	-	-	-	SL	N	NT	NT	BS
CA	43	ms	10YR	3	2	-	-	-	MF	N	NT	NT	BK
Cg	87	s	5Y	4	1	N2.5 d con, 20%	-	-	NF	N	NT	NT	BK
C	91	s	2.5Y	3.5	2	-	-	-	NF	N	NT	NT	BK
C'g1	100	s	5Y	4	1	-	-	-	NF	N	NT	NT	BK
C'g2	110+	s	2.5Y	4	1.5	-	-	-	NF	N	NT	NT	BK

Pedon: MD CB03 03
Describers: JK, ID, ER
Date: 6/29/21 **Time:** 11:13AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.188090° **Longitude:** -75.164250°
PGU: CB
Remarks: ADJACENT TO GHOST FOREST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	11	p	10YR	3	2	-	H7	40	-	Y	SL	NT	HC
Ase	22	ms	2.5Y	3	1	-	-	-	NF	Y	VS	NT	BK
CA	37	s	2.5Y	3.5	1	-	-	-	NF	N	VS	NT	BK
C	57	s	5Y	3.5	1	2.5Y 4/3 and N2.5 d con, 40%	-	-	NF	N	NE	NT	BK
Cg1	72	s	2.5Y	4	1	10YR 4/4 d con, 15%	-	-	NF	N	NE	NT	BK
Cg2	81	s	2.5Y	5	1.5	-	-	-	NF	N	NE	NT	BK
Cg3	102+	s	2.5Y	4.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB03 04
Describers: JK, ID, ER
Date: 6/29/21 **Time:** 10:03AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.188280° **Longitude:** -75.165430°
PGU: CB
Remarks: LARGE POOL BETWEEN POINTS 4 AND 5. APPROACHING *P. TAEDA* GHOST FOREST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	13	p	7.5YR	3	2	-	H4	40	-	N	ST	NT	HC
Oe	23	mp	10YR	3	1	-	H3	25	-	N	NE	NT	HC
AC	34	ls	2.5Y	4.5	1	-	-	-	NF	N	NE	NT	BK
CA	47	s	2.5Y	4.5	3	10YR 3/4 d con	-	-	NF	N	NE	NT	BK
Cg1	84	s	2.5Y	4.5	2	N3 p con	-	-	NF	Y	NE	NT	BK
Cg2	91	s	5Y	4	1	N3 p con	-	-	NF	Y	NE	NT	BK
Cg3	97	s	5Y	4	1	-	-	-	NF	Y	NE	NT	BK
Cg4	113+	s	5Y	6	1	-	-	-	NF	Y	NE	NT	BK

Pedon: MD CB03 05
Describers: JK, ID, ER
Date: 6/29/21 **Time:** 9:20AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.188640° **Longitude:** -75.166480°
PGU: CB
Remarks: HORSHOE CRABS, FIDDLER CRABS, AND PELICANS OBSERVED HERE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	21	mp	10YR	3	2	-	H3	30	-	N	ST	NT	BS
Oise	41	p	10YR	3	1	-	H4	40	-	Y	SL	NT	BS
A	51	ls	10YR	3.5	1	-	-	-	SF	N	NE	NT	BK
Cg1	66	s	10YR	4	1	-	-	-	NF	N	NE	NT	BK
Cg2	107	s	10YR	5	1	-	-	-	NF	N	NE	NT	BK
Ab	141+	s	10YR	4	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CB04 01
Describers: JK, ID, ER
Date: 7/1/21 **Time:** 9:00AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.199700° **Longitude:** -75.158940°
PGU: CB
Remarks: SMALL *P. TAEDA* GHOST FOREST BEYOND THE START OF THE TRANSECT (IN THE UPLAND DIRECTION).

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	19	m	7.5YR	2.5	1	-	H4	10	-	Y	SL	NT	BS
A	26	ms	10YR	2	1	-	-	-	SF	N	SL	NT	BS
CAg	35	s	10YR	4	2	-	-	-	NF	N	NT	NT	BK
Cg1	71	s	10YR	5	1	-	-	-	NF	N	NT	NT	BK
Cg2	102+	s	2.5YR	5	1	-	-	-	NF	N	NT	NT	BK

Pedon: MD CB04 02
Describers: JK, ID, ER
Date: 7/1/21 **Time:** 9:32AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.200480° **Longitude:** -75.159100°
PGU: CB
Remarks: 100% *J. ROEMERIANUS*. THE ONLY GOOD DESCRIPTION SPOT IS THE MUDDY AREA BETWEEN *JUNCUS* PLANTS.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe1	15	mp	10YR	2	2	-	H4	30	-	N	VS	NT	BS
Oe2	25	mp	2.5Y	2.5	1	-	H5	20	-	N	SL	NT	BS
A	28	mls	2.5Y	3	1	-	-	-	MF	N	SL	NT	BS
CAg	43	s	2.5Y	5	2	-	-	-	NF	N	NT	NT	BK
Cg1	58	s	2.5Y	5.5	2	-	-	-	NF	N	NT	NT	BK
Cg2	115+	s	5Y	6	1	-	-	-	NF	N	NT	NT	BK

Pedon: MD CB04 03
Describers: JK, ID, ER
Date: 7/1/21 **Time:** 10:07AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.201150° **Longitude:** -75.159620°
PGU: CB
Remarks: NEAR MUD-FLAT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	7	m	10YR	2	2	-	H7	15	-	Y	SL	NT	BS
Oese	16	mp	7.5YR	2.5	1.5	-	H7	30	-	Y	SL	NT	BS
Ag	21	ls	5Y	5	1.5	-	-	-	NF	N	NE	NT	BS
Ase	35	ms	2.5Y	3.5	1	-	-	-	MF	Y	SL	NT	BS
CAseg	46	s	10YR	4	2	-	-	-	SF	Y	SL	NT	BK
Cg1	60	s	2.5Y	4.5	2	-	-	-	NF	N	NT	NT	BK
Cg2	88	s	2.5Y	4.5	1	-	-	-	NF	N	NT	NT	BK
Cg3	100+	s	5Y	4.5	1	-	-	-	NF	N	NT	NT	BK

Pedon: MD CB04 04
Describers: JK, ID, ER
Date: 7/1/21 **Time:** 10:51AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: ASSATEAGUE ISLAND NATIONAL SEASHORE
State: MD **County:** WORCESTER
Latitude: 38.201660° **Longitude:** -75.159980°
PGU: CB
Remarks: NEAR MUD-FLAT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	4	mp	2.5Y	4	2	-	H6	30	-	N	SL	NT	BS
Oi	12	p	2.5Y	4	3	-	H3	65	-	N	VS	NT	BS
Ag1	14	ms	2.5Y	3	1.5	-	-	-	NF	N	SL	NT	BS
Ag2	30	ms	2.5Y	4	1	-	-	-	NF	N	VS	NT	BS
CA	44	ms	2.5Y	3	2	-	-	-	NF	N	NE	NT	BK
Cg1	64	s	2.5Y	4	2	-	-	-	NF	N	NE	NT	BK
Cg2	85	s	5Y	4	2	-	-	-	NF	N	NE	NT	BK
Cg3	108	s	5Y	4	1	-	-	-	NF	N	NE	NT	BK
Cg4	145+	s	5Y	5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM02 01

Describers: JK, ID, ER
Date: 7/28/21 **Time:** 11:05AM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: E.A. VAUGHN WILDLIFE MANAGEMENT AREA (WMA)
State: MD **County:** WORCESTER
Latitude: 38.075440° **Longitude:** -75.366680°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	19	mp	10YR	3	1	-	H4	30	-	N	SL	NT	BS
Ase1	37	l	10YR	2	1	-	-	-	NF	N	SL	NT	BK
Ase2	46	l	2.5Y	3	1	-	-	-	NF	N	SL	NT	BK
C	88	sl	2.5Y	5	3	2.5Y 5/4 d con, 45%	-	-	NF	N	SL	NT	BK
2Cg1	125	ls	5Y	5	1	2.5Y 5/4 d con, 40%	-	-	NF	N	SL	NT	BK
2Cg2	136	ls	5Y	6	2	2.5Y 5/4.5 d con, 45%	-	-	NF	N	NE	NT	BK
2Cg3	160	ls	5Y	6	1	10YR 5/6 p con, 30%	-	-	NF	N	NE	NT	BK
2Cg4	180+	s	5Y	6.5	1	5Y 6/3 d con, 45%	-	-	NF	N	NE	NT	BK

Pedon: MD CM02 02
Describers: JK, ID, ER
Date: 7/28/21 **Time:** 12:06PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: E.A. VAUGHN WMA
State: MD **County:** WORCESTER
Latitude: 38.075230° **Longitude:** -75.366100°
PGU: CM
Remarks: JK FELL IN MOSQUITO DITCH WHILE MAKING A MEDIOCRE ATTEMPT TO JUMP ACROSS IT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	12	p	2.5Y	3	2	-	H3	95	-	Y	SL	NT	BS
Ase	51	msil	10YR	3	2	-	-	-	VF	Y	SL	NT	MC
A	75	msil	5Y	4	1	-	-	-	VF	N	VS	NT	MC
CAg	99	sil	10Y	4	1	-	-	-	VF	N	SL	NT	MC
CAse	117	msil	10YR	2	1	-	-	-	VF	Y	SL	NT	MC
Oa	149	m	10YR	2	1	-	H9	3	-	N	VS	NT	MC
2Cg1	189	sl	5Y	4.5	1	-	-	-	MF	N	SL	NT	MC
2Cg2	217+	sl	N	6	0	-	-	-	MF	N	SL	NT	MC

Pedon: MD CM02 03
Describers: JK, ID, ER
Date: 7/28/21 **Time:** 1:44PM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: E.A. VAUGHN WMA
State: MD **County:** WORCESTER
Latitude: 38.074980° **Longitude:** -75.365570°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	33	p	5Y	4	1	-	H3	40	-	Y	VE	NT	MC
Oa	58	m	5Y	3	2	-	H7	15	-	N	SL	NT	MC
Ag	93	msil	5Y	4	1	-	-	-	VF	N	NE	NT	MC
Oase1	126	m	5Y	3	1	-	H10	5	-	N	SL	NT	MC
Oase2	141	m	10YR	3	1	-	H9	12	-	N	VS	NT	MC
O'a	161	m	10YR	2	1	-	H9	5	-	N	NE	NT	MC
2Cg	174	sl	N	4.5	0	-	-	-	MF	N	NE	NT	MC
2Cseg1	190	sl	N	5	0	-	-	-	MF	N	ST	NT	MC
2Cseg2	214+	scl	10Y	5	1	2.5Y 5/6 p con, 35%	-	-	MF	N	SL	NT	MC

Pedon: MD CM02 04
Describers: JK, ID, ER
Date: 7/28/21 **Time:** 2:30PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: E.A. VAUGHN WMA
State: MD **County:** WORCESTER
Latitude: 38.074800° **Longitude:** -75.365210°
PGU: CM
Remarks: ON A SLIGHT LEVEE NEAR WATER'S EDGE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ag	20	sil	2.5Y	4	1	7.5YR 4/4 d con, 20%	-	-	SF	N	SL	NT	MC
CAseg	49	sil	N	3.5	0	N2 p con	-	-	MF	Y	VE	NT	MC
Cseg1	88	sicl	N	4	0	-	-	-	MF	N	ST	NT	MC
Cseg2	99	sil	2.5Y	4	1	-	-	-	MF	N	ST	NT	MC
Cg	131	sil	N	4	0	-	-	-	VF	N	SL	NT	MC
Oase1	146	m	10YR	2	2	-	H9	3	-	Y	ST	NT	MC
Oase2	164	m	10YR	2	1	-	H9	3	-	Y	ST	NT	MC
2Cg	186+	sl	2.5Y	4	2	-	-	-	SF	N	SL	NT	MC

Pedon: MD CM03 01
Describers: JK, ID, ER
Date: 7/29/21 **Time:** 9:12AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR GIRDLETREE, MD
State: MD **County:** WORCESTER
Latitude: 38.101250° **Longitude:** -75.338720°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise1	17	p	10YR	2	2	-	H7	50	-	Y	ST	NT	MC
Oise2	45	p	10YR	2	2	-	H8	40	-	Y	SL	NT	MC
Ase	64	ml	10YR	2	1.5	-	-	-	MF	Y	VS	NT	MC
A	80	ml	10YR	2	1	-	-	-	SF	N	SL	NT	MC
Cg1	100	sl	5Y	5	1	-	-	-	SF	N	VS	NT	BK
Cg2	138	sl	10Y	5	1	-	-	-	SF	N	NE	NT	BK
2Cg3	171+	ls	N	5.5	0	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM03 02
Describers: JK, ID, ER
Date: 7/29/21 **Time:** 10:00AM
Access: FOOT
Taxonomic classification:

Location: PRIVATE PROPERTY NEAR GIRDLETREE, MD
State: MD **County:** WORCESTER
Latitude: 38.100900° **Longitude:** -75.338190°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	36	p	10YR	3	2.5	-	H3	70	-	Y	VS	NT	BS
Oe	64	mp	10YR	3	2	-	H6	20	-	N	VS	NT	MC
Oa	88	m	10YR	2	1	-	H9	5	-	N	NE	NT	MC
Ase	105	ml	2.5Y	2.5	1	-	-	-	MF	Y	VS	NT	MC
CA	116	sl	2.5Y	3	1	-	-	-	MF	N	VS	NT	MC
Cseg	135+	sl	5Y	5	1.5	5Y 6/1 f dep, 2%; 2.5Y 5/6 p con 2%	-	-	VF	Y	SL	NT	MC

Pedon: MD CM03 03
Describers: JK, ID, ER
Date: 7/29/21 **Time:** 11:20AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR GIRDLETREE, MD
State: MD **County:** WORCESTER
Latitude: 38.100510° **Longitude:** -75.337600°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	9	m	2.5Y	3	1	-	H10	5	-	Y	SL	NT	BS
Oise	27	p	10YR	3	2	-	H4	80	-	Y	SL	NT	BS
Oese	64	mp	10YR	2	2	-	H6	25	-	Y	VS	NT	MC
Oa	91	m	10YR	2	1	-	H9	9	-	N	ST	NT	MC
Oe	118	mp	2.5Y	3.5	2	-	H7	25	-	N	ST	NT	MC
C	148	msl	5Y	3	1	-	-	-	VF	N	NE	NT	MC
O'a1	164	m	2.5Y	3	2	-	H10	13	-	N	NE	NT	MC
2A	173	sl	10YR	2	1	-	-	-	VF	N	NE	NT	MC
2ACg	187	sl	2.5Y	3	1	-	-	-	VF	N	SL	NT	MC
2Cg	211+	sl	5Y	5	2	2.5Y 6/4 f con, 25%	-	-	VF	N	SL	NT	MC

Pedon: MD CM03 04	**Location:** PRIVATE PROPERTY NEAR GIRDLETREE, MD
Describers: JK, ID, ER	**State:** MD **County:** WORCESTEER
Date: 7/29/21 **Time:** 12:09PM	**Latitude:** 38.100020° **Longitude:** -75.337010°
Access: FOOT	**PGU:** CM
Taxonomic classification: TYPIC SULFAQUENT	**Remarks:** *PHRAGMITES* STAND ON EITHER SIDE OF PEDON.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	17	msil	2.5Y	3	2	-	-	-	VF	Y	SL	NT	MC
Ag	50	msil	2.5Y	3.5	1	-	-	-	VF	N	SL	NT	MC
A	69	msil	10YR	2	2	-	-	-	VF	N	VS	NT	MC
Oa	102	m	10YR	2	1	-	H9	14	-	N	SL	NT	MC
Cg1	150	msil	5Y	4	1	-	-	-	VF	N	SL	NT	MC
Cg2	210	sil	N	4	0	-	-	-	VF	N	SL	NT	MC
2Cg3	222+	sl	2.5Y	4	1	-	-	-	VF	N	SL	NT	MC

Pedon: MD CM04 01
Describers: JK, ID, ER
Date: 7/14/21 **Time:** 8:18AM
Access: FOOT
Taxonomic classification: HISTIC SULFAQUENT

Location: ASSATEAGUE STATE PARK
State: MD **County:** WORCESTER
Latitude: 38.250970° **Longitude:** -75.154240°
PGU: CM
Remarks: *PHRAGMITES* AND RUSH PRESENT TOWARDS FOREST EDGE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	22	p	10YR	3	4	-	H3	40	-	Y	SL	NT	BS
Oa	35	m	10YR	3	1	-	H8	10	-	N	VS	NT	BS
Ag	49	ls	10YR	3.5	1	-	-	-	SF	N	NE	NT	BK
ACg	60	ls	10YR	4	1	-	-	-	MF	N	NE	NT	BK
CAg	73	ls	2.5YR	4.5	1	-	-	-	NF	N	NE	NT	BK
2Cg1	110	s	5Y	6	1	-	-	-	NF	N	NE	NT	BK
2Cg2	157	s	5Y	5	1.5	-	-	-	NF	N	NE	NT	BK
2C	180+	s	2.5Y	6	4	10YR 5/5 d con, 5%	-	-	NF	N	NE	NT	BK

Pedon: MD CM04 02
Describers: JK, ID, ER
Date: 7/14/21 **Time:** 9:08AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ASSATEAGUE STATE PARK
State: MD **County:** WORCESTER
Latitude: 38.251030° **Longitude:** -75.153780°
PGU: CM
Remarks: WOOD POSTS SEEN DOWN THE LENGTH OF THE MARSH. POSSIBLY AN OLD DOCK.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi1	23	p	10YR	3	2	-	H3	85	-	N	NE	NT	MC
Oi2	33	p	2.5Y	3	1	-	H5	80	-	N	SL	NT	MC
Oe	52	mp	10YR	3	1	-	H9	20	-	N	SL	NT	MC
Ag	75	sil	2.5Y	4	1	-	-	-	MF	N	ST	NT	MC
ACg	80	sil	N	4	0	-	-	-	MF	Y	ST	NT	MC
Oase	104	m	10YR	2	1	-	H9	7	-	Y	NE	NT	MC
Oa	115	m	10YR	3	1.5	-	H9	5	-	N	NE	NT	MC
2A1	128	sl	10YR	2.5	1	-	-	-	VF	N	NE	NT	MC
2A2	162	ls	10YR	2	1	-	-	-	NF	N	NE	NT	MC
2Cg	174	s	N	5	0	N3 p con, 20%	-	-	NF	N	NE	NT	MC

Pedon: MD CM04 03
Describers: JK, ID, ER
Date: 7/14/21 **Time:** 10:27AM
Access: FOOT
Taxonomic classification: HISTIC SULFAQUENT

Location: ASSATEAGUE STATE PARK
State: MD **County:** WORCESTER
Latitude: 38.251030° **Longitude:** -75.153000°
PGU: CM
Remarks: A COUPLE CM OF STANDING WATER ABOVE SOIL SURFACE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	6	p	10YR	3	3	-	H3	70	-	N	NE	NT	BS
Oise	20	p	10YR	3	2	-	H6	70	-	Y	VS	NT	BS
Ase	43	msil	2.5Y	3	2	-	-	-	MF	Y	VS	NT	MC
Aseg	58	msil	2.5Y	3.5	1	-	-	-	MF	Y	NE	NT	MC
CAg	79	sicl	5Y	3.5	1	-	-	-	MF	N	VS	NT	MC
Oa1	119	m	10YR	2	1	-	H9	5	-	N	NE	NT	MC
Oa2	145	m	10YR	2	1.5	-	H10	5	-	N	NE	NT	MC
2A	160+	ms	10YR	2	1	-	-	-	MF	N	SL	NT	MC

Pedon: MD CM04 04	**Location:** ASSATEAGUE STATE PARK
Describers: JK, ID, ER	**State:** MD **County:** WORCESTER
Date: 7/12/21 **Time:** 11:22AM	**Latitude:** 38.251050° **Longitude:** -75.152530°
Access: FOOT	**PGU:** CM
Taxonomic classification: HISTIC SULFAQUENT	**Remarks:**

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	20	p	10YR	3.5	1	-	H4	85	-	N	NE	NT	HC
Ag1	37	sil	5Y	4	1	-	-	-	VF	N	ST	NT	MC
Ag2	71	sil	2.5Y	4	1	-	-	-	MF	N	VS	NT	MC
CAseg	92	sil	5Y	4	1	N2 p con, 20%	-	-	MF	Y	ST	NT	MC
Cseg	101	sil	N	3	0	-	-	-	MF	Y	VE	NT	MC
Oa	136	m	10YR	2	1	-	H9	5	-	N	VS	NT	MC
Ase	190	ml	10YR	2	1.5	-	-	-	VF	N	SL	NT	MC
2A	200+	ls	10YR	2	1	-	-	-	MF	N	ST	NT	MC

Pedon: MD CM07 01

Describers: JK, ID, ER
Date: 7/13/21 **Time:** 10:20AM
Access: FOOT
Taxonomic classification: HAPLIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR WEST OCEAN CITY, MD
State: MD **County:** WORCESTER
Latitude: 38.349840° **Longitude:** -75.097260°
PGU: CM
Remarks: WILDLIFE OBSERVED HERE INCLUDING HERONS, FIDDLER CRABS, AND GEESE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	29	ml	5Y	3	1	-	-	-	VF	N	SL	NT	HC
Cg	39	l	2.5Y	4	1	-	-	-	VF	N	VS	NT	MC
C	91	l	10YR	5	4	2.5Y 5/2 d dep, 45%	-	-	SF	N	SL	NT	BK
C'g	103	sl	2.5Y	6	1.5	2.5Y 5/4 d con, 35%	-	-	MF	N	NE	NT	BK
2Cg1	136	ls	2.5Y	5	1	10YR 4/6 p con, 20%	-	-	VF	N	NE	NT	BK
2Cg2	149	s	5Y	5	2	-	-	-	SF	N	NE	NT	BK
2Cg3	176	s	2.5Y	6	1	2.5Y 6/5 d con	-	-	NF	N	NE	NT	BK
2Cg4	233+	s	2.5Y	5.5	4	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM07 02

Location: PRIVATE PROPERTY NEAR WEST OCEAN CITY, MD

Describers: JK, ID, ER

State: MD **County:** WORCESTER

Date: 7/13/21 **Time:** 11:46AM

Latitude: 38.349610° **Longitude:** -75.097080°

Access: FOOT

PGU: CM

Taxonomic classification: HAPLIC SULFAQUENT

Remarks: MANY FIDDLER CRABS OBSERVED AT THIS SITE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	9	ml	10YR	3.5	2	N2 p con, 30%	-	-	MF	Y	ST	NT	HC
Oase	17	m	10YR	3	1	-	H4	10	-	Y	SL	NT	HC
A	30	l	10YR	2	1	-	-	-	MF	N	SL	NT	BK
Ag	37	l	2.5Y	4	1	-	-	-	SF	N	VS	NT	BK
Cg	87	scl	2.5Y	6	1	2.5Y 5/5 d con, 45%	-	-	MF	N	VS	NT	BK
2Cg1	141	ls	2.5Y	5	3	-	-	-	SF	N	VS	NT	BK
2Cg2	167	s	2.5Y	5	3	-	-	-	SF	N	NE	NT	BK
2Cg3	180+	s	5Y	5	2	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM07 03

Describers: JK, ID, ER
Date: 7/13/21 **Time:** 1:36PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR WEST OCEAN CITY, MD
State: MD **County:** WORCESTER
Latitude: 38.349300° **Longitude:** -75.096740°
PGU: CM
Remarks: EGRETS AND FIDDLER CRABS OBSERVED AT THIS SITE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	35	ml	5Y	4	1	-	-	-	MF	Y	VS	NT	HC
Oese	54	mp	2.5Y	3	1	-	H5	25	-	Y	NE	NT	MC
Oa	65	m	10YR	3	1	-	H9	10	-	N	NE	NT	MC
A	80	ml	10YR	2	1	-	-	-	MF	N	NE	NT	MC
Cg	124	sl	5Y	5	1	2.5Y 4/4 d con, 12%	-	-	MF	N	NE	NT	BK
2Cg	140+	ls	5Y	4	2	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM07 04

Describers: JK, ID, ER
Date: 7/12/21 **Time:** 2:35PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR WEST OCEAN CITY, MD
State: MD **County:** WORCESTER
Latitude: 38.349060° **Longitude:** -75.096520°
PGU: CM
Remarks: MUSSELS AND FIDDLER CRABS OBSERVED AT THIS SITE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg	36	msil	5Y	4	1	-	-	-	VF	Y	NT	NT	BK
Oese	72	mp	2.5Y	3.5	1.5	-	H6	20	-	Y	ST	NT	MC
Ase1	86	msil	5Y	3.5	1	-	-	-	VF	N	ST	NT	MC
Ase2	93	msil	10YR	3	1	-	-	-	MF	Y	SL	NT	MC
Ase3	118	msil	2.5Y	3.5	1	-	-	-	VF	Y	SL	NT	MC
O'ese	146	mp	10YR	2	1	-	H3	35	-	Y	ST	NT	MC
Aseg	153	msil	2.5Y	4	1	-	-	-	VF	Y	NE	NT	MC
Oase	180	m	7.5YR	2.5	1	-	H7	10	-	Y	SL	NT	MC
A'seg	193	msil	N	2.5	0	-	-	-	VF	Y	SL	NT	MC
Cse	200+	sil	5Y	3	1	-	-	-	VF	Y	SL	NT	MC

Pedon: MD CM09 01
Describers: JK, ID, JW
Date: 8/3/21 **Time:** 11:06AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR PUBLIC LANDING, MD
State: MD **County:** WORCESTER
Latitude: 38.129120° **Longitude:** -75.295150°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise1	11	p	10YR	3	3	-	H5	65	-	Y	SL	NT	BS
Oise2	25	p	10YR	3	1	-	H6	60	-	Y	VS	NT	BS
Oi	49	p	10YR	3	2.5	-	H5	40	-	N	VS	NT	MC
A	66	msl	10YR	2	1	-	-	-	MF	N	NE	NT	MC
AC	75	sl	2.5Y	3	2	-	-	-	MF	N	NE	NT	BK
Cg1	93	sl	5Y	4	2	-	-	-	NF	N	NE	NT	BK
Cg2	181+	sl	5Y	5	2	-	-	-	NF	N	NE	NT	BK

Pedon: MD CM09 02
Describers: JK, ID, JW
Date: 8/3/21 **Time:** 11:45AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR PUBLIC LANDING, MD
State: MD **County:** WORCESTER
Latitude: 38.129000° **Longitude:** -75.294910°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	10	p	2.5Y	3	3	-	H6	50	-	Y	SL	NT	HC
Oese	51	mp	2.5Y	3.5	3	-	H7	30	-	Y	VS	NT	HC
A	72	ml	2.5Y	4	2	-	-	-	VF	N	NE	NT	MC
Oe	98	mp	10YR	2	1	-	H5	20	-	N	VS	NT	MC
A'	117	ml	2.5Y	3	2	-	-	-	VF	N	SL	NT	MC
O'a2	135	m	10YR	2	1	-	H6	8	-	N	VS	NT	MC
A"1	160	sl	2.5Y	3	2	-	-	-	MF	N	ST	NT	MC
A"2	174	sl	2.5Y	3	1	-	-	-	VF	N	SL	NT	BK
2Cg	180+	ls	5Y	5.5	1	-	-	-	NF	N	VS	NT	BK

Pedon: MD CM09 03
Describers: JK, ID, JW
Date: 8/3/21 **Time:** 12:27PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR PUBLIC LANDING, MD
State: MD **County:** WORCESTER
Latitude: 38.128860° **Longitude:** -75.294710°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg	35	msil	5Y	4	2	-	-	-	VF	Y	SL	NT	HC
Oise	66	p	2.5Y	4	2	-	H9	45	-	Y	VS	NT	MC
Ag	83	sil	5Y	4	1	-	-	-	VF	N	SL	NT	MC
Oe	115	mp	10YR	2	1	-	H4	20	-	N	VS	NT	MC
Cg	130	sil	2.5Y	4	2	-	-	-	VF	N	NE	NT	MC
ACse	161	msil	5Y	3	1	-	-	-	VF	Y	ST	NT	MC
Ase	175	msil	10YR	2	1	-	-	-	VF	Y	SL	NT	MC
2Cseg	213	scl	N	4	0	5Y 5/4 d con, 2%	-	-	VF	Y	ST	NT	MC
2Cg	230+	scl	5Y	4	2	2.5Y 6/6 d con, 5%	-	-	VF	N	SL	NT	MC

Pedon: MD CM09 04
Describers: JK, ID, JW
Date: 8/3/21 **Time:** 2:28PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR PUBLIC LANDING, MD
State: MD **County:** WORCESTER
Latitude: 38.128750° **Longitude:** -75.294590°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ag	14	msil	2.5Y	4	1	-	-	-	MF	N	VS	NT	BS
A	44	msil	2.5Y	3	1	-	-	-	MF	N	VS	NT	MC
Oe	65	mp	2.5Y	3	2	-	H4	25	-	N	VS	NT	MC
A'g	89	sil	5Y	3	2	-	-	-	MF	N	NE	NT	MC
Oa	119	m	10YR	2	1	-	H4	8	-	N	SL	NT	MC
A'	167	sil	5Y	2.5	1	-	-	-	VF	Y	SL	NT	MC
O'a	180	m	10YR	2	1	-	H10	3	-	N	VS	NT	MC
2A	193+	scl	5Y	3	1.5	-	-	-	VF	N	ST	NT	MC

Pedon: MD CM09 05
Describers: JK, ID, JW
Date: 8/3/21 **Time:** 3:21PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR PUBLIC LANDING, MD
State: MD **County:** WORCESTER
Latitude: 38.128580° **Longitude:** -75.294370°
PGU: CM
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg1	32	sil	5Y	4	2	10YR 3/4 d con, 45%	-	-	SF	N	ST	NT	BS
Aseg2	73	sil	5Y	4	1	-	-	-	MF	N	ST	NT	MC
Oe	100	mp	10YR	3	2	-	H8	20	-	N	VS	NT	MC
Cg	136	sil	5Y	4	1	-	-	-	MF	N	VS	NT	MC
O'e	157	mp	10YR	3	2	-	H3	30	-	N	NE	NT	MC
A	187	sil	2.5Y	3	2	-	-	-	MF	N	VS	NT	MC
Oa	223	m	10YR	2	1	-	H9	5	-	N	VS	NT	MC
A'	234+	ml	2.5Y	2.5	1	-	-	-	MF	N	VS	NT	MC

Pedon: MD EF01 01
Describers: JK, ID, ER, CEP, JW
Date: 6/15/21 **Time:** 12:06PM
Access: BOAT
Taxonomic classification: HISTIC SULFAQUENT

Location: JUG BAY WETLANDS SANCTUARY
State: MD **County:** ANNE ARRUNDEL
Latitude: 38.794920° **Longitude:** -76.704890°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	35	m	2.5Y	3	3	-	H5	12	-	N	VE	+	MC
Aseg	66	msil	2.5Y	4	2	-	-	-	VF	N	ST	++	MC
ACseg	92	msil	5Y	4.5	1	-	-	-	VF	N	SL	+++	MC
Cseg1	152	sicl	5Y	2.5	1	-	-	-	MF	N	SL	+++	MC
Cseg2	226+	sicl	5Y	4	1	-	-	-	MF	N	SL	+++	BK

Pedon: MD EF01 02
Describers: JK, ID, ER, CEP, JW
Date: 6/15/21 **Time:** 1:40PM
Access: BOAT
Taxonomic classification:

Location: JUG BAY WETLANDS SANCTUARY
State: MD **County:** ANNE ARRUNDEL
Latitude: 38.794980° **Longitude:** -76.705650°
PGU: EF
Remarks: 5-20 CM OF STANDING WATER—TIDE COMING IN.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	16	m	5Y	2.5	1	-	H7	10	-	Y	ST	++	MC
Ase	54	msil	5Y	3	2	-	-	-	MF	N	SL	+++	MC
Cseg1	125	sil	5Y	4	1	N2 p con, 2%	-	-	VF	N	SL	+++	MC
Cseg2	162	sicl	5Y	3	2	5Y 4/2 f dep, 35%	-	-	MF	N	SL	++	MC
CAse	185+	sicl	5Y	2.5	2	5Y 4/2 d dep, 35%	-	-	MF	Y	SL	+++	MC

Pedon: MD EF01 03
Describers: JK, ID, ER, CEP, JW
Date: 6/15/21 **Time:** 2:34PM
Access: BOAT
Taxonomic classification: HISTIC SULFAQUENT

Location: JUG BAY WETLANDS SANCTUARY
State: MD **County:** ANNE ARRUNDEL
Latitude: 38.795040° **Longitude:** -76.706210°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	25	mp	2.5Y	4	2	-	H6	30	-	N	SL	++	HC
ACseg1	78	sil	5Y	4	2	-	-	-	VF	N	SL	+++	MC
ACseg2	110	sil	5Y	4	2	10YR 5/4 d con, 2%	-	-	VF	N	SL	+++	MC
CAse	214+	sil	2.5Y	2.5	1	-	-	-	VF	N	SL	+++	BK

Pedon: MD EF01 04

Describers: JK, ID, ER, CEP, JW

Date: 6/15/21 **Time:** 3:36PM

Access: FOOT

Taxonomic classification: TYPIC SULFAQUENT

Location: JUG BAY WETLANDS SANCTUARY

State: MD **County:** ANNE ARRUNDEL

Latitude: 38.795010° **Longitude:** -76.707410°

PGU: EF

Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	16	msil	5Y	2.5	1	-	-	-	VF	Y	ST	++	HC
ACseg1	51	sil	5Y	4	1	N2 p con, 7%	-	-	VF	Y	ST	++	MC
ACseg2	96	sil	5Y	3.5	2	N2 p con, 5%	-	-	VF	Y	SL	+++	MC
ACseg3	206+	sil	5Y	3	1	-	-	-	VF	N	SL	+++	MC

Pedon: MD EF04 01
Describers: JK, ID, ER, JW
Date: 8/17/21 **Time:** 12:47PM
Access: BOAT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR DENTON, MD
State: MD **County:** CAROLINE
Latitude: 38.886090° **Longitude:** -75.838190°
PGU: EF
Remarks: SCRUB-SHRUB OR TIDAL FOREST WETLAND ADJACENT TO MARSH.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	51	p	2.5Y	3	1	-	H2	50	-	N	SL	++	MC
Oe	68	mp	2.5Y	3	2	-	H3	20	-	N	VS	++	MC
CA1	116	msil	2.5Y	3	2	-	-	-	VF	N	SL	++	MC
CA2	179	sil	5Y	3	1	N2 p con, 10%	-	-	VF	N	SL	+++	MC
CA3	210	msil	2.5Y	3	2	-	-	-	VF	N	SL	+++	MC
Oa1	269	m	7.5YR	2.5	1	-	H10	5	-	N	NE	+++	MC
Oa2	288+	m	10YR	2.5	2	-	H10	5	-	N	VS	+++	MC

Pedon: MD EF04 02
Describers: JK, ID, ER, JW
Date: 8/17/21 **Time:** 1:43PM
Access: BOAT
Taxonomic classification: HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR DENTON, MD
State: MD **County:** CAROLINE
Latitude: 38.885850° **Longitude:** -75.838490°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	14	p	5Y	3	1.5	-	H3	40	-	Y	ST	-	MC
Oese	33	mp	2.5Y	3	2	-	H5	20	-	Y	SL	-	MC
A	58	msil	2.5Y	3	1	-	-	-	VF	N	VS	++	MC
Oa	80	m	10YR	3	2	-	H8	8	-	N	VL	++	MC
A	119	msil	2.5Y	3	1.5	-	-	-	VF	N	VS	++	MC
CAg	223	sicl	5Y	3	1	-	-	-	VF	N	SL	++	MC
Cg	270+	sicl	5Y	3.5	1	-	-	-	VF	N	SL	+++	MC

Pedon: MD EF04 03
Describers: JK, ID, ER, JW
Date: 8/17/21 **Time:** 2:19PM
Access: BOAT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR DENTON, MD
State: MD **County:** CAROLINE
Latitude: 38.885700° **Longitude:** -75.838710°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe1	23	mp	10YR	2.5	2	-	H4	30	-	N	VS	+++	MC
Oe2	59	mp	10YR	3	2.5	-	H5	25	-	N	VS	++	MC
Oa	96	m	10YR	3	1	-	H8	15	-	N	VS	+++	MC
CA1	143	sil	2.5Y	3	1	-	-	-	VF	N	VS	+++	MC
CA2	231	sil	5Y	3	1	-	-	-	VF	N	SL	+++	MC
Cg	286+	sil	5Y	3.5	1	-	-	-	VF	N	SL	+++	MC

Pedon: MD EF04 04
Describers: JK, ID, ER, JW
Date: 8/17/21 **Time:** 10:50AM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR DENTON, MD
State: MD **County:** CAROLINE
Latitude: 38.885740° **Longitude:** -75.839320°
PGU: EF
Remarks: ~40 CM STANDING WATER.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
A	20	ml	5Y	3.5	1	-	-	-	VF	N	SL	NT	MC
CAg1	46	ml	5Y	4	1	-	-	-	VF	N	SL	NT	MC
CAg2	89	sicl	5Y	4	2	-	-	-	VF	N	SL	NT	MC
CA1	124	sicl	5Y	3.5	1	-	-	-	VF	N	VS	NT	MC
CA2	179	cl	5Y	3	1	-	-	-	VF	N	VS	NT	MC
CA3	210+	cl	5Y	3	1	-	-	-	VF	N	VS	NT	MC

Pedon: MD EF04 SAS
Describers: JK, ID, ER, JW
Date: 8/17/21 **Time:** 10:06AM
Access: BOAT
Taxonomic classification: FLUVENTIC SULFIWASSENT

Location: OFFSHORE AT MARTINAK STATE PARK
State: MD **County:** CAROLINE
Latitude: 38.86149° **Longitude:** -75.84430°
PGU: EF
Remarks: THIS WAS ORIGNIALLY INTENDED TO BE THE SITE FOR MD EF04. HOWEVER, UPON ARRIVING TO THE MARSH, WE DISCOVERED THAT IT WAS ALMOST ENTIRELY SUBMERGED. THE VEGETATION WAS PRIMARILY SPATTERDOCK. WE DESCRIBED THE “SUBAQUEOUS” SOIL OUTSIDE OF THE MARSH FROM THE BOAT.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ag	20	msil	10Y	2.5	1	-	-	-	VF	N	ST	+++	MC
Cg1	69	sil	5Y	3	1	-	-	-	VF	N	SL	+++	MC
Cg2	100	sil	5Y	3	1.5	-	-	-	VF	N	ST	+++	MC
Cg3	160+	sil	5Y	3	2	-	-	-	VF	N	ST	+++	MC

Pedon: MD EF09 01
Describers: JK, ID, ER, JW
Date: 8/11/21 **Time:** 1:28PM
Access: BOAT
Taxonomic classification: HISTIC SULFAQUENT

Location: ELK NECK STATE PARK
State: MD **County:** CECIL
Latitude: 39.452690° **Longitude:** -76.001240°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	31	mp	10YR	3	2.5	-	H4	35	-	N	SL	++	MC
A	55	msil	2.5Y	4	1	-	-	-	VF	Y	SL	+	MC
Oese	103	mp	10YR	3	1	-	H8	20	-	N	ST	-	MC
O'e	133	mp	10YR	2	2	-	H4	25	-	N	VS	-	MC
AC1	163	msil	10YR	3	1	-	-	-	VF	N	VS	-	MC
AC2	199	msil	5Y	3	1	-	-	-	VF	N	VS	-	MC
Cg	235+	msil	5Y	3.5	1	-	-	-	VF	N	VS	-	MC

Pedon: MD EF09 02
Describers: JK, ID, ER, JW
Date: 8/11/21 **Time:** 12:04PM
Access: BOAT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ELK NECK STATE PARK
State: MD **County:** CECIL
Latitude: 39.452160° **Longitude:** -76.000850°
PGU: EF
Remarks: MARSH IS NEARLY ALL *PHRAGMITES*. SOIL HAD AN INTERESTING ODOR AT THIS POINT—NOT SULFIDES…

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese1	30	mp	10YR	2	2	-	H4	23	-	Y	SL	-	MC
Oese2	50	mp	10YR	3	1	-	NT	NT	-	N	SL	-	MC
Ase	94	msil	10YR	3	2	-	-	-	MF	Y	SL	+	MC
Oa	136	m	10YR	3	1	-	NT	NT	MF	N	VS	-	MC
Oe	183+	mp	10YR	2	2	-	H3	35	-	N	VS	-	MC

Pedon: MD EF09 03
Describers: JK, ID, ER, JW
Date: 8/11/21 **Time:** 11:17AM
Access: BOAT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ELK NECK STATE PARK
State: MD **County:** CAROLINE
Latitude: 39.451760° **Longitude:** -76.000540°
PGU: EF
Remarks: MARSH TERMINATES AT OPEN WATER WITH A SMALL BEACH.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	24	p	10YR	3	2.5	-	H6	40	-	NT	SL	+	BK
Oise	39	p	2.5Y	3.5	2	-	H5	45	-	NT	ST	+	BK
Oese2	66	mp	2.5Y	3.5	1	-	H7	18	-	NT	ST	-	BK
ACg	99	cl	5Y	3	1	-	-	-	MF	NT	SL	+++	BK
2Cg	175+	ls	2.5Y	4	2	-	-	-	MF	NT	NE	+++	BK

Pedon: MD EF11 01
Describers: JK, ID, ER, JW
Date: 6/24/21 **Time:** 2:57PM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.382160° **Longitude:** -75.799100°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	38	msil	2.5Y	3	1.5	-	-	-	VF	NT	ST	-	MC
Oase	58	m	10YR	2	2	-	H5	5	-	NT	ST	-	MC
A'se1	101	msil	2.5Y	3	1	-	-	-	MF	NT	ST	-	MC
A'se2	205	msil	5Y	3	2	-	-	-	VF	NT	ST	-	MC
CAseg1	245	sil	2.5Y	4	1	N2.5 p con, 1%	-	-	VF	NT	ST	-	MC
CAseg2	256	sicl	5Y	4	1	N2.5 p con, 2%	-	-	VF	NT	ST	-	MC
CAseg3	290+	sicl	5Y	4	1	N2.5 p con, 2%	-	-	VF	NT	ST	+	MC

Pedon: MD EF11 02
Describers: JK, ID, ER, JW
Date: 6/24/21 **Time:** 12:30PM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.382560° **Longitude:** -75.798900°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	16	msil	2.5Y	3	2	-	-	-	VF	NT	ST	NT	HC
Oa1	50	m	7.5YR	2.5	1	-	H5	12	-	NT	SL	NT	MC
Oa2	81	m	2.5Y	3	1	-	NT	NT	MF	NT	SL	NT	MC
Oase	124	m	5Y	3	1	-	NT	NT	VF	NT	ST	NT	MC
ACse1	166	sil	5Y	3	1	-	-	-	VF	NT	ST	NT	MC
ACse2	199	sil	5Y	2.5	1	N2.5 p con, 5%	-	-	VF	NT	ST	NT	MC
ACse3	268	sil	5Y	2.5	2	-	-	-	VF	NT	ST	NT	MC
ACse4	286+	sil	5Y	2.5	2	N2.5 p con, 5%	-	-	VF	NT	ST	NT	MC

Pedon: MD EF11 03
Describers: JK, ID, ER, JW
Date: 6/24/21 **Time:** 11:31AM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.382920° **Longitude:** -75.798680°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase1	15	msil	5Y	2.5	2	-	-	-	VF	NT	SL	-	HC
Ase2	38	msil	5Y	3	2	-	-	-	MF	NT	SL	-	MC
CA1	66	sil	5Y	3	1	-	-	-	SF	NT	SL	-	MC
CA2	93	sicl	2.5Y	3	1	-	-	-	MF	NT	SL	-	BK
CA3	120+	sil	2.5Y	2.5	1	N2.5 p con, 5%	-	-	VF	NT	SL	+	BK

Pedon: MD EF12 01
Describers: JK, ID, ER
Date: 8/9/21 **Time:** 2:10PM
Access: BOAT
Taxonomic classification: TYPIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR SALISBURY, MD
State: MD **County:** WICOMICO
Latitude: 38.339690° **Longitude:** -75.718830°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	39	sicl	5Y	3	1	-	-	-	SF	Y	ST	+++	MC
CAse	54	sil	2.5Y	3.5	1	-	-	-	SF	Y	ST	-	MC
Cse1	79	sicl	5Y	3.5	1	-	-	-	SF	N	ST	-	MC
Cse2	121	sicl	5Y	3.5	1	-	-	-	MF	N	ST	++	MC
Oa	140	m	2.5Y	3	2	-	H9	10	-	Y	SL	-	BK
2Ase	148	mls	2.5Y	2.5	1	-	-	-	MF	Y	VS	+++	BK
2Cse	165+	s	5Y	5	2.5	-	-	-	NF	Y	NE	+++	BK

Pedon: MD EF12 02
Describers: JK, ID, ER
Date: 8/9/21 **Time:** 12:38PM
Access: BOAT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR SALISBURY, MD
State: MD **County:** WICOMICO
Latitude: 38.340370° **Longitude:** -75.718830°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase	45	msicl	5Y	3	1.5	-	-	-	VF	Y	ST	-	MC
A	64	msil	5Y	2.5	1	-	-	-	VF	N	ST	++	MC
Oe	143	mp	10YR	2	1.5	-	H8	35	-	N	SL	-	MC
2A	158	sl	10YR	2	1	-	-	-	MF	N	VS	-	BK
2C	180+	s	2.5Y	4	3	-	-	-	NF	N	NE	+	BK

Pedon: MD EF12 03
Describers: JK, ID, ER
Date: 8/9/21 **Time:** 11:25AM
Access: BOAT
Taxonomic classification: HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR SALISBURY, MD
State: MD **County:** WICOMICO
Latitude: 38.341090° **Longitude:** -75.718870°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	32	mp	2.5Y	3	2	-	H8	35	-	Y	ST	-	MC
Aseg	52	msil	2.5Y	3	1	-	-	-	VF	Y	ST	-	MC
CAseg	80	sicl	5Y	3	1	-	-	-	VF	Y	ST	-	MC
CA1	149	sil	5Y	3	2	-	-	-	VF	N	SL	-	MC
CA2	196	sicl	5Y	3	1	-	-	-	VF	N	ST	-	MC
AC	228	msil	2.5Y	2	1	-	-	-	VF	N	VS	-	MC
Oe	300+	mp	10YR	2	1	-	H9	20	-	N	VS	-	MC

Pedon: MD EF12 04
Describers: JK, ID, ER
Date: 8/9/21 **Time:** 10:37AM
Access: BOAT
Taxonomic classification: TYPIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR SALISBURY, MD
State: MD **County:** WICOMICO
Latitude: 38.341580° **Longitude:** -75.718950°
PGU: EF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg1	36	sil	5Y	3	1	-	-	-	VF	N	ST	-	MC
Aseg2	51	sicl	2.5Y	3	2	-	-	-	VF	Y	ST	-	MC
CAseg1	64	sicl	2.5Y	3	1	-	-	-	MF	N	ST	-	MC
CAseg2	80	sicl	5Y	3	1	-	-	-	MF	N	ST	-	MC
CAseg3	100+	sicl	5Y	3	1	-	-	-	SF	N	ST	-	MC

Pedon: MD ENF02 01	**Location:** NANTICOKE RIVER WMA
Describers: JK, ID, ER, JW	**State:** MD **County:** WICOMICO
Date: 8/5/21 **Time:** 3:00PM	**Latitude:** 38.384800° **Longitude:** -75.826000°
Access: BOAT	**PGU:** ENF
Taxonomic classification: HISTIC SULFAQUENT	**Remarks:** THERE WAS MUCH DIFFICULTY AUGERING AT THIS PLOT. MULTIPLE ATTEMPTS WERE MADE TO AUGER DEEPER AT SEVERAL NEARBY POINTS, BUT THE MAXIMUM DEPTH DESCRIBED WAS 74 CM. COARSE SANDY LENSES OBSERVED IN THE Ase2 HORIZON.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese1	26	mp	2.5Y	2	2	-	H7	30	-	Y	ST	NT	MC
Ase1	48	ml	2.5Y	3	1	-	-	-	VF	Y	SL	NT	MC
Ase2	74+	ml/lcos	2.5Y	3	1	-	-	-	MF	Y	SL	NT	MC

Pedon: MD ENF02 02
Describers: JK, ID, ER, JW
Date: 8/5/21 **Time:** 2:15PM
Access: BOAT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.385780° **Longitude:** -75.826350°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg	42	msil	5Y	3	2	-	-	-	VF	N	SL	-	MC
Oase1	124	m	10YR	2	2	-	H9	2	-	N	SL	-	MC
Oase2	170	m	10YR	2	1	-	H8	13	-	Y	VS	-	MC
Oase3	181+	m	10YR	2	1	-	H10	5	-	N	SL	-	MC

Pedon: MD ENF02 03
Describers: JK, ID, ER, JW
Date: 8/5/21 **Time:** 11:19AM
Access: BOAT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.386578° **Longitude:** -75.826668°
PGU: ENF
Remarks: GPS COORDINATES ARE APPROXIMATE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg	80	msicl	5Y	3.5	1	-	-	-	VF	N	ST	-	MC
Oase	188	m	10YR	2	1	-	H10	5	-	N	SL	-	MC
Ag	254	sicl	5Y	3	1	-	-	-	VF	N	NE	-	MC
A'seg	305	msil	5Y	3	1	-	-	-	VF	Y	ST	-	MC
O'ase	352+	m	10YR	2	1	-	H10	3	-	N	VS	-	MC

Pedon: MD ENF02 04
Describers: JK, ID, ER, JW
Date: 8/5/21 **Time:** 10:21AM
Access: FOOT
Taxonomic classification: THAPTO-HISTIC SULFAQUENT

Location: NANTICOKE RIVER WMA
State: MD **County:** WICOMICO
Latitude: 38.387570° **Longitude:** -75.826950°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Aseg	47	sicl	5Y	3	1	-	-	-	VF	N	SL	NT	MC
Oase	203	m	10YR	2	1	-	H10	7	-	N	VS	NT	MC
A'seg	263	sicl	5Y	3	1	-	-	-	VF	N	SL	NT	MC
CAseg1	295	sicl	5Y	3	1	-	-	-	VF	N	SL	NT	MC
CAseg2	347+	sicl	5Y	3	1	-	-	-	VF	N	VS	NT	MC

Pedon: MD ENF04 01	**Location:** PRIVATE PROPERTY NEAR TRAPPE, MD
Describers: JK, ID, ER, JW, CEP	**State:** MD **County:** TALBOT
Date: 6/8/21 **Time:** 2:30PM	**Latitude:** 38.715350° **Longitude:** -76.010640°
Access: FOOT	**PGU:** ENF
Taxonomic classification: TYPIC SULFAQUENT	**Remarks:**

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase1	21	ml	10YR	2	2	-	-	-	VF	N	SL	NT	MC
Ase2	41	ml	10YR	3	1	-	-	-	VF	N	SL	NT	MC
ACse	81	sl	2.5Y	3	1	-	-	-	SF	N	SL	NT	MC
Cseg1	112	ls	5Y	5.5	1	-	-	-	NF	N	NE	NT	BK
Cseg2	160+	ls	5Y	6	1	2.5Y 5/4.5 d con, 2%	-	-	NF	N	NE	NT	BK

Pedon: MD ENF04 02
Describers: JK, ID, ER, JW, CEP
Date: 6/8/21 **Time:** 1:09PM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: PRIVATE PROPERTY NEAR TRAPPE, MD
State: MD **County:** TALBOT
Latitude: 38.715500° **Longitude:** -76.009820°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase1	31	m	10YR	3	2	-	H9	10	-	N	SL	NT	HC
Oase2	51	m	10YR	2	2	-	H9	13	-	N	SL	NT	MC
Ase	106	msil	2.5Y	3	1	-	-	-	VF	N	SL	NT	MC
Oase	147	m	5Y	3	1	-	H9	16	-	N	SL	NT	MC
Oe	165	mp	10YR	2	1.5	-	H8	22	-	N	NE	NT	MC
A'se	194+	msil	5Y	3	1	-	-	-	VF	N	VS	NT	MC

Pedon: MD ENF02 03
Describers: JK, ID, ER, JW, CEP
Date: 6/8/21 **Time:** 10:33PM
Access: FOOT
Taxonomic classification: HISTIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR TRAPPE, MD
State: MD **County:** TALBOT
Latitude: 38.715810° **Longitude:** -76.008900°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	30	m	5Y	3	2	-	-	-	VF	N	SL	NT	HC
Ase	100	ml	2.5Y	3	2	-	-	-	VF	N	SL	NT	MC
O'ase1	154	m	5Y	2.5	2	-	NT	NT	VF	N	VS	NT	MC
O'ase2	204	m	5Y	2.5	2	-	NT	NT	VF	N	VS	NT	MC
Oe	261	mp	10YR	2	1	-	H9	20	-	N	NE	NT	MC
CAseg	296+	sil	5Y	3.5	1	-	-	-	VF	Y	SL	NT	MC

Pedon: MD ENF04 04
Describers: JK, ID, ER. JW, CEP
Date: 6/8/21 **Time:** 11:46AM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: PRIVATE PROPERTY NEAR TRAPPE, MD
State: MD **County:** TALBOT
Latitude: 38.716440° **Longitude:** -76.007970°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase1	31	ml	2.5Y	3	1	-	-	-	VF	N	ST	NT	HC
Ase2	64	ml	5Y	2.5	1	-	-	-	VF	N	SL	NT	MC
Ase3	110	ml	2.5	3	1	-	-	-	MF	Y	ST	NT	MC
Oase1	161	m	10YR	2	1.5	-	H9	12	-	N	VS	NT	MC
Oase2	203	m	5Y	2.5	1	-	H9	10	-	N	VS	NT	MC
2Cseg1	220	scl	2.5Y	3.5	1	-	-	-	MF	N	SL	NT	MC
2Cseg2	250+	scl	5Y	6	1	5YR 5/8 p con, 5%	-	-	MF	N	SL	NT	MC

Pedon: MD ENF06 01
Describers: JK, ID, ER, JW
Date: 6/17/21 **Time:** 2:24PM
Access: FOOT
Taxonomic classification: HISTIC SULFAQUENT

Location: PARKERS CREEK WMA
State: MD **County:** CALVERT
Latitude: 38.532540° **Longitude:** -76.523610°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	33	m	N	2	0	-	H4	12	-	Y	VE	+	MC
Aseg	73	scl	2.5Y	4	2	10YR 4/6 d con, 15%	-	-	SF	Y	ST	+	BK
Cse	85	sicl	2.5Y	3.5	2	N2 p con, 5%	-	-	MF	Y	SL	++	BK
Cg1	93	sl	2.5Y	4	2	-	-	-	SF	N	ST	++	BK
Cg2	134	sicl	2.5Y	4	2	N2 p con, 2%	-	-	MF	N	SL	-	BK
Ase	156	msil	10YR	2	1	-	-	-	MF	Y	SL	-	BK
O'ase	170+	m	2.5Y	2.5	1	-	H9	9	-	Y	SL	-	BK

Pedon: MD ENF06 02
Describers: JK, ID, ER, JW
Date: 6/17/21 **Time:** 1:04PM
Access: FOOT
Taxonomic classification: TYPIC SULFIHEMIST

Location: PARKERS CREEK WMA
State: MD **County:** CALVERT
Latitude: 38.533140° **Longitude:** -76.523440°
PGU: ENF
Remarks: AN UPLAND “ISLAND” ~50 YDS TO THE WEST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	48	p	10YR	2.5	2	-	H4	65	-	Y	SL	-	MC
Oe	86	mp	10YR	3	2	-	H5	25	-	N	NE	-	MC
O'ese	110	mp	10YR	2.5	1	-	H6	25	-	Y	NE	-	MC
O'e	147	mp	10YR	2	1	-	H6	20	-	N	NE	-	MC
Oase1	177	m	2.5Y	2.5	1	-	H9	3	-	Y	SL	-	MC
Oase2	204	m	10YR	2	2	-	H8	8	-	N	SL	-	MC
Oase3	259	m	10YR	3	1	-	H9	4	-	N	NE	-	MC
Cg	362+	sil	10Y	4	1	-	-	-	VF	N	NE	-	MC

Pedon: MD ENF06 03
Describers: JK, ID, ER, JW
Date: 6/17/21 **Time:** 11:41AM
Access: FOOT
Taxonomic classification: TYPIC SULFIHEMIST

Location: PARKERS CREEK WMA
State: MD **County:** CALVERT
Latitude: 38.533930° **Longitude:** -76.523260°
PGU: ENF
Remarks: THIS AREA IS QUITE SOFT AND CAN FEEL OTHERS WALK AROUND.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	52	mp	10YR	3	2	-	H5	25	-	N	NE	-	MC
Oese1	88	mp	10YR	2	1	-	H5	18	-	Y	SL	-	MC
Oese2	155	mp	5Y	2.5	1	-	H6	17	-	N	VS	-	MC
Oa1	200	m	7.5YR	2.5	1	-	H8	10	-	N	NE	-	MC
Oa2	234	m	2.5Y	3	1	-	H9	6	-	N	NE	-	MC
A	256	msil	5Y	3	2	-	-	-	VF	N	NE	-	MC
Cg	317	sil	N	4	0	-	-	-	VF	N	NE	-	MC
2Cg	327+	l	N	4.5	0	-	-	-	VF	N	NE	-	MC

Pedon: MD ENF06 04
Describers: JK, ID, ER, JW
Date: 6/17/21 **Time:** 10:00AM
Access: FOOT
Taxonomic classification: HISTIC SULFAQUENT

Location: PARKERS CREEK WMA
State: MD **County:** CALVERT
Latitude: 38.534760° **Longitude:** -76.523200°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	24	p	2.5Y	4	2	N2.5 p con, 30%	H8	40	-	N	SL	-	MC
Aseg	73	msil	2.5Y	4	2	-	-	-	VF	N	ST	+	MC
O'ese1	123	mp	10YR	2	1	-	H4	17	-	Y	SL	-	MC
O'ese2	165	mp	2.5Y	2.5	1	-	H4	30	-	Y	SL	-	MC
Oase	223	m	10YR	2	2	-	H5	5	-	N	SL	-	MC
Oa	254	m	10YR	3	2	-	H9	2	-	N	NE	-	MC
Cg	284+	sil	10Y	5	1	-	-	-	VF	N	NE	+	MC

Pedon: MD ENF09 01	**Location:** BOWEN WMA
Describers: JK, ID, ER, JW	**State:** MD **County:** PRINCE GEORGE’S
Date: 7/23/21 **Time:** 1:40PM	**Latitude:** 38.612670° **Longitude:** -76.678760°
Access: BOAT	**PGU:** ENF
Taxonomic classification: TYPIC SULFIHEMIST	**Remarks:**

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase1	14	m	2.5Y	2.5	1	-	H8	5	-	NT	ST	-	MC
Oase2	44	m	10YR	2	2	-	H5	10	-	NT	SL	-	MC
Oa1	57	m	10YR	2	1	-	H5	10	-	NT	NE	-	MC
Oa2	79	m	10YR	2	1.5	-	H5	5	-	NT	NE	-	MC
Oa3	146	m	10YR	2	1	-	H6	3	-	NT	NE	-	MC
O'ase	230	m	7.5YR	2.5	1	-	H7	10	-	NT	VS	-	MC
ACseg1	242	sil	5Y	3	1	-	-	-	VF	NT	SL	-	MC
ACseg2	292+	sicl	N	3.5	0	-	-	-	VF	NT	ST	-	MC

Pedon: MD ENF09 02
Describers: JK, ID, ER, JW
Date: 7/23/21 **Time:** 12:55PM
Access: BOAT
Taxonomic classification: TYPIC SULFIHEMIST

Location: BOWEN WMA
State: MD **County:** PRINCE GEORGE'S
Latitude: 38.612740° **Longitude:** -76.678250°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	71	mp	10YR	3	1.5	-	H6	30	-	NT	NE	-	MC
Oi	94	p	10YR	3	1	-	H8	45	-	NT	NE	-	MC
Oase1	135	m	10YR	2	1	-	H8	15	-	NT	SL	-	MC
Oase2	205	m	10YR	2	2	-	H8	12	-	NT	VS	-	MC
ACseg1	221	msil	5Y	3	1	-	-	-	VF	NT	ST	-	MC
ACseg2	263	sil	N	4	0	-	-	-	VF	NT	ST	-	MC
O'ase	287	m	5Y	3	2	-	H10	2	-	NT	VS	-	MC
AC'seg	302+	msil	5Y	3	1	-	-	-	VF	NT	VS	-	MC

Pedon: MD ENF09 03
Describers: JK, ID, ER, JW
Date: 7/23/21 **Time:** 11:40PM
Access: BOAT
Taxonomic classification: TYPIC SULFIHEMIST

Location: BOWEN WMA
State: MD **County:** PRINCE GEORGE’S
Latitude: 38.612750° **Longitude:** -76.677380°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise1	19	p	2.5Y	2.5	1	N2 d con, 15%	H4	65	-	Y	ST	-	MC
Oise2	67	p	10YR	2	2	-	H4	45	-	N	SL	-	MC
Oese1	112	mp	10YR	2	1	-	H3	28	-	N	SL	-	MC
Oese2	220	mp	10YR	2	1.5	-	H3	30	-	N	SL	-	MC
Aseg	243	sicl	N	4	0	-	-	-	VF	N	ST	-	MC
ACseg1	276	sicl	N	4	0	-	-	-	VF	N	ST	-	MC
ACseg2	305+	sicl	5Y	3	1	-	-	-	VF	N	SL	-	MC

Pedon: MD ENF09 04
Describers: JK, ID, ER, JW
Date: 7/23/21 **Time:** 10:54AM
Access: BOAT
Taxonomic classification:

Location: BOWEN WMA
State: MD **County:** PRINCE GEORGE’S
Latitude: 38.612540° **Longitude:** -76.676730°
PGU: ENF
Remarks: THIS PEDON WAS IN A “MEADOW” OF SORTS—OUT OF THE *PHRAGMITES.*

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	14	mp	2.5Y	3	2	-	H7	25	-	N	SL	NT	MC
Oi	39	p	10YR	2	2	-	H3	45	-	N	NE	NT	MC
O'e	53	mp	10YR	2	1.5	-	H8	20	-	N	NE	NT	MC
Oa1	127	m	10YR	2	1	-	H7	8	-	N	NE	NT	MC
Oa2	159	m	7.5YR	2.5	1.5	-	H8	10	-	N	NE	NT	MC
Oa3	184	m	10YR	2	2	-	H9	8	-	N	NE	NT	MC
Oa4	250	m	10YR	2	1	-	H9	5	-	N	NE	NT	MC
Oa5	274	m	2.5Y	3	2	-	H10	5	-	N	NE	NT	MC
Oa6	300+	m	7.5YR	2.5	2	-	H10	3	-	N	NE	NT	MC

Pedon: MD ENF09 05
Describers: JK, ID, ER, JW
Date: 7/23/21 **Time:** 10:08AM
Access: BOAT
Taxonomic classification:

Location: BOWEN WMA
State: MD **County:** PRINCE GEORGE'S
Latitude: 38.612630° **Longitude:** -76.676050°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase1	13	msil	5Y	3	2	N2 p con	-	-	VF	Y	ST	++	MC
Ase2	69	msicl	5Y	3	1	N2 p con	-	-	VF	Y	ST	+++	MC
Oase	84	m	2.5Y	3	1	-	H4	15	-	Y	ST	-	MC
Oa1	196	m	10YR	3	2	-	H7	10	-	N	SL	-	MC
Oa2	228	m	10YR	2	1	-	H9	8	-	N	SL	-	MC
O'ase1	266	m	10YR	2	1.5	-	H10	10	-	Y	SL	-	MC
O'ase2	315+	m	10YR	2	1	-	H10	5	-	Y	SL	-	MC

Pedon: MD ENF10 01
Describers: JK, ID, ER, JW, CEP
Date: 6/2/21 **Time:** 9:40AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: KING'S CREEK MARSH
State: MD **County:** TALBOT
Latitude: 38.772690° **Longitude:** -75.978970°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe1	13	mp	10YR	3	1	-	H4	20	-	N	NE	NT	MC
Oe2	57	mp	7.5YR	2.5	2	-	H4	25	-	N	SL	NT	MC
Oe3	107	mp	10YR	2	2	-	H4	30	-	N	NE	NT	MC
Oa	125	m	7.5YR	2.5	1	-	NT	NT	SF	N	NE	NT	MC
Cg	150	scl	5Y	5.5	1	-	-	-	VF	N	NE	NT	BK
2Cg	192+	grls	5Y	6	1	-	-	-	VF	N	NE	NT	BK

Pedon: MD ENF10 02 **Location:** KING’S CREEK MARSH
Describers: JK, ID, ER, JW, CEP **State:** MD **County:** TALBOT
Date: 6/2/21 **Time:** 11:00AM **Latitude:** 38.771890° **Longitude:** -75.977960°
Access: FOOT **PGU:** ENF
Taxonomic classification: TYPIC SULFIHEMIST **Remarks:**

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese1	6	mp	10YR	2	1	-	H5	20	-	Y	VE	NT	BS
Oese2	73	mp	2.5Y	3	1	-	H7	30	-	N	SL	NT	MC
Oise	120	p	2.5Y	2.5	1	-	H5	45	-	N	VS	NT	MC
Oase	160	m	10YR	2	1	-	H8	15	-	Y	NE	NT	MC
A	165	sl	5Y	3	1	-	-	-	VF	N	VS	NT	MC
Cg	200+	sl	5Y	5.5	1	5Y 6/6 d con, 15%	-	-	MF	N	NE	NT	MC

Pedon: MD ENF10 03
Describers: JK, ID, ER, JW, CEP
Date: 6/2/21 **Time:** 1:10PM
Access: FOOT
Taxonomic classification: TYPIC SULFIHEMIST

Location: KING'S CREEK MARSH
State: MD **County:** TALBOT
Latitude: 38.771100° **Longitude:** -75.978140°
PGU:
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase	47	m	5Y	2.5	2	-	H9	5	-	N	SL	NT	MC
Oese	65	mp	10YR	2	2	-	H3	25	-	Y	VS	NT	MC
Oe	101	mp	10YR	2	1	-	H4	30	-	N	NE	NT	MC
O'ese	155	mp	2.5Y	3	1	-	H4	35	-	N	VS	NT	MC
Ase1	186	ml	10YR	3	1	-	-	-	MF	Y	SL	NT	MC
Ase2	207+	ml	2.5Y	3	1	-	-	-	MF	N	SL	NT	MC

Pedon: MD ENF10 04
Describers: JK, ID, ER, JW, CEP
Date: 6/2/21 **Time:** 2:10PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: KING'S CREEK MARSH
State: MD **County:** TALBOT
Latitude: 38.770160° **Longitude:** -75.978260°
PGU: ENF
Remarks: DESCRIBING THIS PEDON IN A STAND OF *PHRAGMITES*.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	12	p	10YR	2	1.5	-	H6	20	-	N	ST	NT	MC
Ase	21	sicl	5Y	2.5	2	N2 d con, 35%	-	-	SF	Y	ST	NT	MC
CAseg	64	sicl	5Y	4	1	-	-	-	MF	N	SL	NT	BK
CAse1	109	sicl	5Y	3	1	-	-	-	NF	Y	SL	NT	BK
CAse2	148+	sicl	5Y	2.5	1	-	-	-	SF	N	SL	NT	BK

Pedon: MD ENF10 05
Describers: JK, ID, ER, JW, CEP
Date: 6/2/21 **Time:** 3:15PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: KING'S CREEK MARSH
State: MD **County:** TALBOT
Latitude: 38.769610° **Longitude:** -75.978010°
PGU: ENF
Remarks: SITE DOMINATED BY *PHRAGMITES*. THERE APPEARS TO BE A NATURAL LEVEE NEAR THE OPEN WATER (LARGE TIDAL CREEK).

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Ase1	11	msil	5Y	2.5	1	-	-	-	VF	Y	SL	NT	MC
Ase2	31	msil	N	2.5	0	-	-	-	MF	Y	ST	NT	MC
Ase3	137	msil	5Y	3	1	-	-	-	MF	Y	SL	NT	MC
Oa	166	m	5Y	2.5	1	-	NT	NT	MF	Y	ST	NT	MC
A'se	204+	msil	5Y	3.5	1	-	-	-	MF	Y	ST	NT	MC

Pedon: NJ ENF01 01
Describers: JK, ID, ER, DS
Date: 8/24/21 **Time:** 11:02AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: JAKES LANDING BAOT RAMP
State: NJ **County:** CAPE MAY
Latitude: 39.182780° **Longitude:** -74.852620°
PGU: ENF
Remarks: LOBLOLLY PINE FOREST IN THE UPLAND. THERE IS AN EXPANSIVE GHOST FOREST TO THE WEST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	21	p	5Y	3	1	-	H3	65	-	N	SL	NT	MC
Oe	38	mp	5Y	2.5	1	-	H5	30	-	N	ST	NT	MC
Oa1	50	m	10YR	2.5	2	-	H7	13	-	N	SL	NT	MC
Oa2	89	m	7.5YR	2.5	2	-	H8	8	-	N	SL	NT	MC
Oa3	113	m	10YR	2	2	-	H9	8	-	N	VS	NT	MC
A1	131	sl	10YR	2	1.5	-	-	-	VF	Y	NE	NT	MC
A2	141+	ls	2.5Y	2.5	1	-	-	-	VF	N	NE	NT	MC

Pedon: NJ ENF01 02
Describers: JK, ID, ER, DS
Date: 8/24/21 **Time:** 1:05PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: JAKES LANDING BAOT RAMP
State: NJ **County:** CAPE MAY
Latitude: 39.181540° **Longitude:** -74.852350°
PGU: ENF
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	9	p	5Y	3	2	-	H4	80	-	N	VS	NT	MC
AC	40	msil	5Y	3	2	-	-	-	VF	N	NE	NT	MC
ACse1	84	msil	5Y	2.5	2	-	-	-	VF	Y	VS	NT	MC
ACse2	102	msil	5Y	3	1	-	-	-	VF	Y	SL	NT	MC
Oe	120	mp	7.5YR	2.5	2	-	H6	20	-	N	VS	NT	MC

Pedon: NJ ENF01 03
Describers: JK, ID, ER, DS
Date: 8/24/21 **Time:** 1:35PM
Access: FOOT
Taxonomic classification: TYPIC SULFAQUENT

Location: JAKES LANDING BAOT RAMP
State: NJ **County:** CAPE MAY
Latitude: 39.180380° **Longitude:** -74.852230°
PGU: ENF
Remarks: LOW-LYING AREAS (POOLS OR PANNES) APPEAR GREY DUE TO SEDIMENT STUCK TO *SPARTINA* STEMS.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	19	p	5Y	3	1	-	H2	90	-	N	VS	NT	MC
ACseg	57	msil	5Y	2.5	2	-	-	-	VF	Y	SL	NT	MC
ACg1	107	msicl	5Y	2.5	2	-	-	-	VF	N	SL	NT	MC
ACg2	125	msicl	5Y	3	2	-	-	-	VF	N	VS	NT	MC
Oa	156	m	7.5YR	2.5	1.5	-	H8	12	-	N	VS	NT	MC
Oe	215+	mp	10YR	2	1	-	H4	30	-	N	VS	NT	MC

Pedon: NJ ENF01 04
Describers: JK, ID, ER, DS
Date: 8/24/21 **Time:** 10:00AM
Access: FOOT
Taxonomic classification:

Location: JAKES LANDING BAOT RAMP
State: NJ **County:** CAPE MAY
Latitude: 39.179190° **Longitude:** -74.851940°
PGU: ENF
Remarks: THIS SOIL CONSISTS OF ESTUARINE DEPOSITS OVER A HISTOSOL (COULD BE MANAHAWKIN).

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	19	p	5Y	3	1	-	H6	45	-	N	VS	NT	MC
Oese	91	mp	5Y	3	1.5	-	H7	28	-	N	VS	NT	MC
Oase	164	m	5Y	3	1	-	H8	10	-	N	SL	NT	MC
Cseg1	196	sicl	5Y	3.5	1	-	-	-	SF	N	ST	NT	MC
Cseg2	220	sicl	5Y	3	1	-	-	-	VF	Y	ST	NT	MC
Oa	283	m	7.5YR	2.5	1	-	H9	15	-	N	SL	NT	MC
Oe	315+	mp	10YR	2	1	-	H9	30	-	N	VS	NT	MC

Pedon: MD SU01 01
Describers: JK, ID, ER
Date: 7/20/21 **Time:** 2:53PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: FAIRMOUNT WMA
State: MD **County:** SOMERSET
Latitude: 38.083530° **Longitude:** -75.803190°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	14	p	10YR	3	2	-	H3	90	-	Y	SL	NT	BS
Oise	27	p	10YR	2	2	-	H5	50	-	Y	ST	NT	BS
Oa	37	m	10YR	2	2	-	H10	10	-	N	SL	NT	BS
Btg1	48	cl	N	4	0	N2 p con, 2%	-	-	MF	N	NE	NT	MC
Btg2	81	cl	10YR	5	1	2.5Y 5/6 p con, 20%			MF	N	SL	NT	MC
Btg3	102	cl	2.5Y	4.5	1	-	-	-	VF	N	SL	NT	BK
2BCg	125	ls	2.5Y	4.5	1	-	-	-	VF	N	SL	NT	BK
2CBg	150+	s	2.5Y	5	1	10YR 5/6 p con, 15%	-	-	NF	N	NE	NT	BK

Pedon: MD SU01 02
Describers: JK, ID, ER
Date: 7/20/21 **Time:** 2:20PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: FAIRMOUNT WMA
State: MD **County:** SOMERSET
Latitude: 38.081530° **Longitude:** -75.803090°
PGU: SU
Remarks: EVIDENCE OF MARSH DEGRADATION (AS POOLS) NEAR THIS PEDON

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	14	mp	7.5YR	2.5	2	-	H4	25	-	Y	SL	NT	BS
Oa	35	m	10YR	2	1	-	H5	15	-	N	SL	NT	BS
Ag	43	ml	10YR	3.5	1	-	-	-	VF	N	SL	NT	BK
Btg1	55	cl	2.5Y	4	1	-	-	-	SF	N	SL	NT	BK
Btg2	72	sicl	N	4	0	-	-	-	SF	N	SL	NT	BK
Btg3	100	cl	N	3.5	0	-	-	-	VF	N	SL	NT	BK
2BCg	136	s	2.5Y	4.5	1	-	-	-	SF	N	NE	NT	BK
2Cg	153	s	2.5Y	5	1	-	-	-	NF	N	NE	NT	BK
3C	165	cl	2.5Y	5	4	5Y 6/1 p dep, 35%	-	-	NF	N	ST	NT	BK
3Cg	180+	sicl	N	5.5	0	2.5Y 5/4 p con, 15%	-	-	MF	N	ST	NT	BK

Pedon: MD SU01 03
Describers: JK, ID, ER
Date: 7/20/21 **Time:** 1:00PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: FAIRMOUNT WMA
State: MD **County:** SOMERSET
Latitude: 38.080280° **Longitude:** -75.803170°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	17	p	10YR	3	2	-	H3	76	-	N	SL	NT	BS
Oa	31	m	10YR	2	1	-	H8	10	-	N	SL	NT	BS
Btg	91	cl	2.5Y	4	1	5Y 5/4 d con, 15%; N2 p con, 2%	-	-	SF	N	ST	NT	BK
2BC	127	ls	10YR	5	1	-	-	-	MF	N	NE	NT	BK
2C	145+	s	10YR	5.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD SU01 04
Describers: JK, ID, ER
Date: 7/20/21 **Time:** 12:09PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: FAIRMOUNT WMA
State: MD **County:** SOMERSET
Latitude: 38.078660° **Longitude:** -75.802910°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	11	p	10YR	3	2.5	-	H3	80	-	Y	SL	NT	BS
Oise	25	p	10YR	3	1	-	H3	55	-	Y	SL	NT	BS
Oase	33	m	10YR	2	1	-	H9	5	-	Y	SL	NT	BK
Ag	48	cl	10YR	4	1	-	-	-	MF	N	SL	NT	BK
Btg1	63	cl	5Y	4	1	-	-	-	MF	N	ST	NT	BK
Btg2	107	sicl/cl	5Y	4	1	2.5Y 6/6 p con, 20%	-	-	MF	N	ST	NT	BK
2Cg1	133	s	2.5Y	5	1	-	-	-	MF	N	NE	NT	BK
2Cg2	160+	s	2.5Y	5.5	1	-	-	-	NF	N	NE	NT	BK

Pedon: MD SU01 05
Describers: JK, ID, ER
Date: 7/20/21 **Time:** 11:10AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: FAIRMOUNT WMA
State: MD **County:** SOMERSET
Latitude: 38.076960° **Longitude:** -75.802010°
PGU: SU
Remarks: COULD NOT ACCESS INTENDED END POINT FOR THIS TRANSECT. INSTEAD, WE TERMINATED THE TRANSECT AT A TIDAL CREEK.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	18	mp	2.5Y	3	2	-	H6	25	-	Y	SL	NT	HC
Oe1	44	mp	2.5Y	3	1	-	H4	30	-	N	SL	NT	MC
Oe2	76	mp	10YR	3	2	-	H3	35	-	N	SL	NT	MC
Oa	88	m	10YR	2	1	-	H9	8	-	N	ST	NT	MC
Ag	107	l	N	3.5	0	-	-	-	MF	N	SL	NT	MC
Btg1	119	cl	2.5Y	4.5	1	-	-	-	SF	N	ST	NT	MC
Btg2	143+	cl	N	5	0	10YR 4/4 d con, 30%	-	-	MF	N	ST	NT	BK

Pedon: MD SU04 01
Describers: JK, ID, ER
Date: 7/21/21 **Time:** 9:21AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: ELLIS BAY WMA
State: MD **County:** SOMERSET
Latitude: 38.270140° **Longitude:** -75.839200°
PGU: SU
Remarks: SPARSEE GHOST FOREST HERE. TREEES HERE WERE MIXED *P. STROBUS* AND *P. TAEDA*.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese1	11	mp	10YR	2	1	-	H5	30	-	Y	NE	NT	BS
Oese2	24	mp	10YR	2	2	-	H6	20	-	Y	SL	NT	BS
Ase	33	ml	10YR	3	2	-	-	-	MF	Y	SL	NT	MC
Aseg	47	l	2.5Y	4	2	-	-	-	VF	N	SL	NT	MC
Btg1	84	cl	2.5Y	5	1	2.5Y 5/6 p con, 45%	-	-	VF	N	NT	NT	BK
Btg2	104+	scl	5Y	6	1	2.5Y 6/4 and 10YR 5/8 p con, 45%	-	-	MF	N	NT	NT	BK

Pedon: MD SU04 02
Describers: JK, ID, ER
Date: 7/21/21 **Time:** 10:05AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: ELLIS BAY WMA
State: MD **County:** SOMERSET
Latitude: 38.269320° **Longitude:** -75.838860°
PGU: SU
Remarks: GRADING OUT OF GHOST FOREST

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise	12	p	7.5YR	2.5	1.5	-	H5	60	-	Y	VS	NT	BS
Oase	21	m	10YR	2	1	-	H7	10	-	Y	VS	NT	BS
Aseg	47	l	10YR	3.5	1	-	-	-	MF	Y	NT	NT	BS
Eg	70	l	2.5Y	5	2	-	-	-	VF	N	NT	NT	MC
Bt	86	sicl	5Y	5	3	-	-	-	VF	N	NT	NT	MC
2Btg	103	scl	5Y	6	1	2.5Y 5/6 p con, 15%	-	-	VF	N	NT	NT	BK
2BC1	142	s	2.5Y	5	5	-	-	-	NF	N	NT	NT	BK
2BC2	149+	s	2.5Y	5	2	-	-	-	NF	N	NT	NT	BK

Pedon: MD SU04 03
Describers: JK, ID, ER
Date: 7/21/21 **Time:** 12:30PM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ELLIS BAY WMA
State: MD **County:** SOMERSET
Latitude: 38.268670° **Longitude:** -75.838520°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi1	10	p	10YR	3	2	-	H3	60	-	N	NT	NT	HC
Oi2	29	p	10YR	2	2	-	H3	85	-	N	NT	NT	BS
Oi3	44	p	10YR	3	2	-	H4	50	-	N	NT	NT	MC
Oa	49	m	10YR	2	1	-	H9	13	-	N	NT	NT	MC
A	62	sil	2.5Y	3	1	-	-	-	MF	N	NT	NT	MC
Eg	74	sil	2.5Y	3.5	1	-	-	-	SF	N	NT	NT	BK
Btg	118	sicl	2.5Y	4.5	1	-	-	-	SF	N	NT	NT	BK
2BCg1	146	sl	5Y	5	1	-	-	-	NF	N	NT	NT	BK
2BCg2	154+	ls	5Y	5	1	-	-	-	NF	N	NT	NT	BK

Pedon: MD SU04 04
Describers: JK, ID, ER
Date: 7/21/21 **Time:** 11:45AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: ELLIS BAY WMA
State: MD **County:** SOMERSET
Latitude: 38.268090° **Longitude:** -75.837490°
PGU: SU
Remarks: NEAR TIDAL CREEK, TIDE IS HIGH. PEDON HAS THICK O HORIZON, RESEMBLES THE UPPER PART OF AN ESTUARINE SOIL.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	25	mp	2.5Y	3	1	-	H8	20	-	Y	NT	NT	MC
Oa	57	m	10YR	3	1	-	H8	15	-	N	NT	NT	MC
O'ese	70	mp	10YR	3	1.5	-	H7	25	-	Y	NT	NT	MC
Oase	91	m	10YR	2.5	1	-	H4	15	-	Y	NT	NT	MC
O'a	100	m	10YR	2	1	-	H9	5	-	N	NT	NT	MC
Ag	130+	cl	10YR	4	1	-	-	-	VF	N	NT	NT	MC

Pedon: MD SU11 01
Describers: JK, ID, ER, JW, CEP
Date: 5/27/21 **Time:** 9:40AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: EASTERN NECK NWR
State: MD **County:** KENT
Latitude: 39.038790° **Longitude:** -76.225260°
PGU: SU
Remarks: FIRST SOIL OF THE SUMMER! NO GHOST FOREST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	2	mp	10YR	2	1	-	H5	35	-	NT	NT	NT	BK
A	7	msl	10YR	3	1	-	-	-	NF	NT	NT	NT	BK
Ag	18	msl	10YR	4.5	1	-	-	-	NF	NT	NT	NT	BK
EAg	43	fsl	2.5Y	4	1	-	-	-	NF	NT	NT	NT	BK
E	73	ls	5Y	5	3	2.5Y 6/6 d con, 35%; 5Y 6/1 d dep, 15%	-	-	NF	NT	NT	NT	BK
Btg	95	sl	5Y	6	1	5Y 5/3 d con; 2.5Y 5/6 d con, 5%	-	-	NF	NT	NT	NT	BK
Bt	137	scl	10YR	5	6	5Y 6/1 p dep, 35%	-	-	NF	NT	NT	NT	BK
BC	189+	sl	10YR	5	4	7.5YR 5/6 d con; 2.5Y 6/2 d dep	-	-	NF	NT	NT	NT	BK

Pedon: MD SU11 02
Describers: JK, ID, ER, JW, CEP
Date: 5/27/21 **Time:** 11:55AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: EASTERN NECK NWR
State: MD **County:** KENT
Latitude: 39.039290° **Longitude:** -76.224650°
PGU: SU
Remarks: STRONG H2S ODOR

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	72	p	2.5Y	2.5	1	-	H5	50	-	N	VS	NT	MC
A	92	scl	2.5Y	4	1	-	-	-	MF	N	VS	NT	MC
Btg	139+	scl	2.5Y	5	1	-	-	-	SF	N	ST	NT	BK

Pedon: MD SU11 03
Describers: JK, ID, ER, JW, CEP
Date: 5/27/21 **Time:** 3:20PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: EASTERN NECK NWR
State: MD **County:** KENT
Latitude: 39.039570° **Longitude:** -76.223930°
PGU: SU
Remarks: NEAR *PHRAGMITES* STAND.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	34	mp	10YR	2	2	-	H5	30	-	N	SL	NT	MC
A	48	ml	10YR	2	1	-	-	-	VF	N	SL	NT	MC
Btg	79	scl	5Y	6	1	5Y 5/4 d con, 3%	-	-	SF	N	NE	NT	BK
Bt	120	scl	2.5Y	5	3	5Y 6/1 p dep, 15%; 2.5Y 5/6 d con, 5%	-	-	SF	N	NE	NT	BK
B'tg	130+	scl	N	6	0	2.5Y 5/4 p con, 2%	-	-	SF	N	NE	NT	BK

Pedon: MD SU11 04
Describers: JK, ID, ER, JW, CEP
Date: 5/27/21 **Time:** 4:56PM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: EASTERN NECK NWR
State: MD **County:** KENT
Latitude: 39.039840° **Longitude:** -76.223620°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese	55	mp	2.5Y	2.5	1	-	H8	22	-	Y	SL	NT	MC
Oase	104	m	5Y	2.5	1	-	H9	15	-	Y	SL	NT	MC
A	122	scl	2.5Y	5	2	2.5Y 6/1 d dep, 5%	-	-	MF	Y	SL	NT	BK
Btg	142+	scl	N	5	0	N6 f dep; 5Y 5/4 p con 20%	-	-	MF	N	SL	NT	BK

Pedon: MD SU13 01
Describers: JK, ID, ER, JW
Date: 6/1/21 **Time:** 9:45AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: BLACKWATER NWR
State: MD **County:** DORCHESTER
Latitude: 38.429300° **Longitude:** -76.225020°
PGU: SU
Remarks: NICE GHOST FOREST COMPRISED OF *P. TAEDA.* DEAD *I. FRUTESCENS.*

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oi	17	p	7.5YR	3	3	-	H5	45	-	N	NE	NT	MC
A	44	sicl	2.5Y	5	1	5YR 5/8 p con, 5%; 10YR 6/8 p con, 10%; N5 d dep 15%	-	-	VF	N	NE	NT	MC
Btg1	76	sicl	2.5Y	6	2	N5 d dep, 25%; 7.5YR 5/8 p con, 12%	-	-	SF	N	NE	NT	BK
Btg2	125	sic	2.5Y	5	1	10YR 5/8 d con, 20%; 2.5Y d dep, 5%	-	-	NF	N	NE	NT	BK
Btg3	150+	sicl	2.5Y	6	2	7.5YR 5/8 p con, 20%; 5Y 4/1 d dep 12%	-	-	NF	N	NE	NT	BK

Pedon: MD SU13 02
Describers: JK, ID, ER, JW
Date: 6/1/21 **Time:** 11:00AM
Access: FOOT
Taxonomic classification: TERRIC SULFIHEMIST

Location: BLACKWATER NWR
State: MD **County:** DORCHESTER
Latitude: 38.428490° **Longitude:** -76.225220°
PGU: SU
Remarks: ~13 CM STANDING WATER. BURN MARKS ON DEAD TREE STUMPS.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	26	mp	10YR	2	2	-	H5	20	-	Y	M	NT	MC
Oi	40	p	2.5Y	2.5	1	-	H4	40	-	Y	ST	NT	MC
A	67	sil	10YR	4	1	-	-	-	MF	Y	SL	NT	MC
Btg1	138	sicl	2.5YR	5	1	2.5Y 5/6 d con, 15%	-	-	SF	N	SL	NT	MC
Btg2	149+	sicl	5Y	6	1	2.5Y 4/4 d con, 30%	-	-	SF	N	SL	NT	MC

Pedon: MD SU13 03	**Location:** BLACKWATER NWR
Describers: JK, ID, ER, JW	**State:** MD **County:** DORCHESTER
Date: 6/1/21 **Time:** 12:50PM	**Latitude:** 38.427760° **Longitude:** -76.225400°
Access: FOOT	**PGU:** SU
Taxonomic classification: TERRIC SULFIHEMIST	**Remarks:** ~10 CM STANDING WATER.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oe	30	mp	2.5Y	2.5	1	-	H5	20	-	N	NE	NT	MC
Oa1	52	m	2.5Y	3	2	-	H4	15	-	N	NE	NT	MC
Oa2	82	m	2.5Y	2.5	1	-	H4	4	-	Y	NE	NT	MC
Oa3	106	m	5Y	3	1	-	NT	NT	SF	Y	VS	NT	MC
ABg	155	sicl	5Y	4	1	-	-	-	MF	Y	NE	NT	MC
Btg	210+	sicl	N	4	0	-	-	-	SF	N	NE	NT	MC

Pedon: MD SU13 04
Describers: JK, ID, ER, JW
Date: 6/1/21 **Time:** 2:40PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: BLACKWATER NWR
State: MD **County:** DORCHESTER
Latitude: 38.427050° **Longitude:** -76.225790°
PGU: SU
Remarks: OOPS.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oa	37	m	5Y	2.5	2	-	H9	15	-	Y	SL	NT	MC
A	78	sil	5Y	2.5	1	-	-	-	NF	N	SL	NT	BK
Btg1	90	sicl	5Y	3.5	1	2.5Y 4/4 d con, 5%;	-	-	NF	N	SL	NT	BK
Btg2	140+	sicl	5Y	5	1	5Y 5/4 d con, 15%	-	-	NF	N	ST	NT	BK

Pedon: MD SU15 01
Describers: JK, ID, ER, JW, CEP
Date: 6/9/21 **Time:** 12:30PM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: CHESAPEAKE BAY ENVIRONMENTAL CENTER
State: MD **County:** QUEEN ANNE'S
Latitude: 38.950560° **Longitude:** -76.228170°
PGU: SU
Remarks: SMALL GHOST FOREST.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase1	15	m	7.5YR	2.5	1	-	H9	10	-	N	VS	NT	BK
Oase2	28	m	10YR	2	1.5	-	H9	10	-	N	VS	NT	BK
Ase	51	cl	10YR	2	2	-	-	-	MF	N	SL	NT	BK
Btg	78	cl	10Y	5	1	2.5Y 6/4 d con, 45%	-	-	MF	N	SL	NT	BK
Bt	160	cl	10YR	4.5	6	5Y 6/1 p dep, 45%	-	-	NF	N	SL	NT	BK
2BCg	170	scl	5Y	6	1	10YR 5/6 p con, 10%	-	-	MF	N	NE	NT	BK
2Cg	180+	lfs	5Y	5	1.5	-	-	-	NF	N	NE	NT	BK

Pedon: MD SU15 02
Describers: JK, ID, ER, JW, CEP
Date: 6/9/21 **Time:** 11:15AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: CHESAPEAKE BAY ENVIRONMENTAL CENTER
State: MD **County:** QUEEN ANNE’S
Latitude: 38.950810° **Longitude:** -76.228070°
PGU: SU
Remarks: THIN SECTION SAMPLE COLLECTED HERE IN SEPTEMBER 2021.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oese1	3	mp	10YR	2	2	-	H5	30	-	N	VS	NT	BS
Oese2	11	mp	10YR	3	3	-	H4	30	-	N	VS	NT	BS
Oase	22	m	10YR	2	1	-	H5	10	-	Y	SL	NT	BS
Ase	33	msl	2.5Y	2.5	1	-	-	-	NF	N	SL	NT	BK
ABg	43	scl	2.5Y	4	2	-	-	-	NF	N	SL	NT	BK
Btg1	71	scl	5Y	4.5	1	10YR 4/6 p con, 24%; N2 p con, 8%	-	-	NF	Y	SL	NT	BK
Btg2	107	scl	10YR	5	6	2.5Y 5/1 p dep, 45%	-	-	NF	N	SL	NT	BK
Btg3	120	scl	N	6	0	2.5Y 5.5/6 p con, 30%	-	-	NF	N	SL	NT	BK
2BC	171+	fsl	5Y	5	4	5Y 4.5/4 f dep, 40%	-	-	NF	N	VS	NT	BK

Pedon: MD SU15 03
Describers: JK, ID, ER, JW, CEP
Date: 6/9/21 **Time:** 10:00AM
Access: FOOT
Taxonomic classification: TYPIC ENDOAQUALF

Location: CHESAPEAKE BAY ENVIRONMENTAL CENTER
State: MD **County:** QUEEN ANNE'S
Latitude: 38.951180° **Longitude:** -76.227940°
PGU: SU
Remarks:

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oise1	11	p	10YR	3	2	-	H3	80	-	N	ST	NT	BS
Oise2	24	p	2.5Y	3	2	-	H4	70	-	N	SL	NT	BS
Ase	38	ml	5Y	2.5	1	-	-	-	SF	N	SL	NT	BK
Btg1	62	scl	N	5	0	5Y 6/6 p con, 15%	-	-	NF	N	ST	NT	BK
Btg2	104+	scl	N	5.5	0	10YR 5/6 p con, 45%	-	-	NF	N	ST	NT	BK

Pedon: MD SU15 04
Describers: JK, ID, ER, JW, CEP
Date: 6/9/21 **Time:** 9:00AM
Access: FOOT
Taxonomic classification: TEERRIC SULFIHEMIST

Location: CHESAPEAKE BAY ENVIRONMENTAL CENTER
State: MD **County:** QUEEN ANNE'S
Latitude: 38.951390° **Longitude:** -76.227570°
PGU: SU
Remarks: FIRM MARSH SURFACE.

Horizon	Lower boundary (cm)	Textural class	Hue	Value	Chroma	Redoximorphic features	von Post	Rubbed fiber %	Fluidity	3% H_2O_2	30% H_2O_2	alpha-alpha-dipyridyl	Excavation method
Oase1	24	m	2.5Y	3	2	-	H9	10	-	N	VS	NT	MC
Oase2	37	m	5Y	2.5	1	-	H8	15	-	N	SL	NT	MC
Oase3	52	m	2.5Y	2.5	1	-	H7	15	-	N	VS	NT	BK
Ag	61	sl	2.5Y	4	2	-	-	-	SF	N	SL	NT	BK
Btg1	85	sl	N	4.5	0	-	-	-	SF	N	SL	NT	BK
Btg2	105	scl	N	6	0	2.5Y 5/4 p con, 30%	-	-	SF	N	SL	NT	BK

Appendix D. Sample data

In the following tables, the column “Bulk density function” refers to the pedotransfer function used to estimate the bulk density of that particular horizon. Only the horizons with a value in the “Bulk density function” column had their bulk densities estimated; if no value exists in that field, then the bulk density was directly measured. Detailed information regarding bulk density estimations is located in Appendix A.

Abbreviations used in the table are as follows.

<u>Pedogeomorphic unit (PGU)</u>

CB: coastal barrier
CM: coastal mainland
EF: estuarine fresh
ENF: estuarine non-fresh
SU: submerged upland

<u>Texture</u>

m: muck
mp: mucky peat
p: peat
s: sand
ls: loamy sand
sl: sandy loam
l: loam
scl: sandy clay loam
cl: clay loam
sil: silt loam
sicl: silty clay loam
sic: silty clay

The letter “m” preceding a mineral texture indicates a mucky-modified texture.

Pedons sampled in triplicate are denoted by 1X, 2X, and 3X. Morphological data was only collected in the first replicate pedon (i.e., 1X).

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD SU11 01	SU	Oe	mp	10YR	2	1	0	2	0.21		32.27	0.0690	1.38
MD SU11 01	SU	A	msl	10YR	3	1	2	7	0.21		12.53	0.0257	1.29
MD SU11 01	SU	Ag	msl	10YR	4.5	1	7	18	0.42		5.46	0.0230	2.53
MD SU11 01	SU	EAg	fsl	2.5Y	4	1	18	43	1.33	5	1.24	0.0166	4.15
MD SU11 01	SU	E	ls	5Y	5	3	43	73	1.70	5	0.30	0.0051	1.54
MD SU11 01	SU	Btg	sl	5Y	6	1	73	95	1.65	6a	0.19	0.0032	0.71
MD SU11 01	SU	Bt	scl	10YR	5	6	95	137	1.57	6b	0.14	0.0023	0.95
MD SU11 01	SU	BC	sl	10YR	5	4	137	189	1.74	4b	0.07	0.0012	0.63
MD SU11 02	SU	Oi	p	2.5Y	2.5	1	0	72	0.15		26.73	0.0409	29.48
MD SU11 02	SU	A	scl	2.5Y	4	1	72	92	1.03		2.93	0.0302	6.05
MD SU11 02	SU	Btg	scl	2.5Y	5	1	92	139	1.57	6b	1.32	0.0208	9.77
MD SU11 03	SU	Oe	mp	10YR	2	2	0	34	0.11	1	38.14	0.0416	14.13
MD SU11 03	SU	A	ml	10YR	2	1	34	48	0.29	5	11.17	0.0319	4.47
MD SU11 03	SU	Btg	scl	5Y	6	1	48	79	1.57	6b	0.91	0.0142	4.41
MD SU11 03	SU	Bt	scl	2.5Y	5	3	79	120	1.77		0.18	0.0033	1.34
MD SU11 03	SU	B'tg	scl	N	6	0	120	130	1.57	6b	0.28	0.0044	0.44
MD SU11 04	SU	Oese	mp	2.5Y	2.5	1	0	55	0.18		26.46	0.0480	26.41
MD SU11 04	SU	Oase	m	5Y	2.5	1	55	104	0.14		41.93	0.0598	29.32
MD SU11 04	SU	A	scl	2.5Y	5	2	104	122	0.98	5	2.48	0.0243	4.37
MD SU11 04	SU	Btg	scl	N	5	0	128	142	1.57	6b	0.34	0.0054	0.75

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD SU13 01	SU	Oi	p	7.5YR	3	3	0	17	0.11		32.64	0.0348	5.91
MD SU13 01	SU	A	sicl	2.5Y	5	1	17	44	1.15		1.40	0.0162	4.37
MD SU13 01	SU	Btg1	sicl	2.5Y	6	2	44	76	1.57	6b	0.15	0.0024	0.78
MD SU13 01	SU	Btg2	sic	2.5Y	5	1	76	125	1.57	6b	0.22	0.0035	1.70
MD SU13 01	SU	Btg3	sicl	2.5Y	6	2	125	150	1.57	6b	0.18	0.0029	0.72
MD SU13 03	SU	Oe	mp	2.5Y	2.5	1	0	30	0.14		14.13	0.0197	5.92
MD SU13 03	SU	Oa1	m	2.5Y	3	2	30	52	0.19		17.75	0.0334	7.34
MD SU13 03	SU	Oa2	m	2.5Y	2.5	1	52	82	0.26		24.18	0.0638	19.15
MD SU13 03	SU	Oa3	m	5Y	3	1	82	106	0.33		13.03	0.0437	10.48
MD SU13 03	SU	ABg	sicl	5Y	4	1	106	155	1.19		2.20	0.0263	12.90
MD SU13 03	SU	Btg	sicl	N	4	0	155	210	1.75		0.31	0.0055	3.00
MD SU13 04	SU	Oa	m	5Y	2.5	2	0	37	0.23		12.42	0.0283	10.47
MD SU13 04	SU	A	sil	5Y	2.5	1	37	78	0.99		5.79	0.0571	23.43
MD SU13 04	SU	Btg1	sicl	5Y	3.5	1	78	90	1.42		0.57	0.0081	0.97
MD SU13 04	SU	Btg2	sicl	5Y	5	1	90	140	1.84		0.23	0.0043	2.15
MD ENF10 01	ENF	Oe1	mp	10YR	3	1	0	13	0.09		41.35	0.0365	4.74
MD ENF10 01	ENF	Oe2	mp	7.5YR	2.5	2	13	57	0.11		40.14	0.0425	18.68
MD ENF10 01	ENF	Oe3	mp	10YR	2	2	57	107	0.13	1	33.80	0.0440	21.99
MD ENF10 01	ENF	Oa	m	7.5YR	2.5	1	107	125	0.21	1	17.40	0.0365	6.58
MD ENF10 01	ENF	Cg	scl	5Y	5.5	1	125	150	1.66	2	0.32	0.0053	1.33

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD ENF10 01	ENF	2Cg	grls	5Y	6	1	150	192	1.74	4b	0.33	0.0058	2.44
MD ENF10 02	ENF	Oese1	mp	10YR	2	1	0	6	0.13		21.12	0.0264	1.58
MD ENF10 02	ENF	Oese2	mp	2.5Y	3	1	6	73	0.31		22.69	0.0700	46.91
MD ENF10 02	ENF	Oise	p	2.5Y	2.5	1	73	120	0.09		41.36	0.0354	16.62
MD ENF10 02	ENF	Oase	m	10YR	2	1	120	160	0.23		12.69	0.0297	11.87
MD ENF10 02	ENF	A	sl	5Y	3	1	160	165	0.75	2	3.55	0.0267	1.33
MD ENF10 02	ENF	Cg	sl	5Y	5.5	1	165	200	1.80		0.28	0.0050	1.76
MD ENF10 03	ENF	Oase	m	5Y	2.5	2	0	47	0.11		19.15	0.0214	10.04
MD ENF10 03	ENF	Oese	mp	10YR	2	2	47	65	0.13		34.63	0.0440	7.92
MD ENF10 03	ENF	Oe	mp	10YR	2	1	65	101	0.09		37.80	0.0326	11.75
MD ENF10 03	ENF	O'ese	mp	2.5Y	3	1	101	155	0.14		24.28	0.0339	18.31
MD ENF10 03	ENF	Ase1	ml	10YR	3	1	155	186	0.24		11.37	0.0270	8.37
MD ENF10 03	ENF	Ase2	ml	2.5Y	3	1	186	207	0.29		10.44	0.0300	6.30
MD ENF10 04	ENF	Oise	p	10YR	2	1.5	0	12	0.13		18.25	0.0229	2.75
MD ENF10 04	ENF	Ase	sicl	5Y	2.5	2	12	21	0.39		7.42	0.0288	2.59
MD ENF10 04	ENF	CAseg	sicl	5Y	4	1	21	64	0.57		5.78	0.0330	14.18
MD ENF10 04	ENF	CA'se1	sicl	5Y	3	1	64	109	0.64		6.10	0.0391	17.60
MD ENF10 04	ENF	CA'se2	sicl	5Y	2.5	1	109	148	0.48	2	6.43	0.0310	12.10
MD ENF10 05	ENF	Ase1	msil	5Y	2.5	1	0	11	0.35		7.23	0.0252	2.77
MD ENF10 05	ENF	Ase2	msil	N	2.5	0	11	31	0.33		7.40	0.0243	4.87

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD ENF10 05	ENF	Ase3	msil	5Y	3	1	31	137	0.51		8.35	0.0424	44.97
MD ENF10 05	ENF	Oa	m	5Y	2.5	1	137	166	0.37		14.79	0.0542	15.70
MD ENF10 05	ENF	A'se	msil	5Y	3.5	1	166	204	0.48		9.47	0.0454	17.26
MD ENF04 01	ENF	Ase1	ml	10YR	2	2	0	21	0.17		11.42	0.0199	4.18
MD ENF04 01	ENF	Ase2	ml	10YR	3	1	21	41	0.57	2	5.02	0.0287	5.74
MD ENF04 01	ENF	ACse	sl	2.5Y	3	1	41	81	0.80	2	3.29	0.0262	10.48
MD ENF04 01	ENF	Cseg1	ls	5Y	5.5	1	81	112	1.74	4b	0.10	0.0017	0.52
MD ENF04 01	ENF	Cseg2	ls	5Y	6	1	112	160	1.74	4b	0.04	0.0007	0.35
MD ENF04 02	ENF	Oase1	m	10YR	3	2	0	31	0.09		19.29	0.0178	5.51
MD ENF04 02	ENF	Oase2	m	10YR	2	2	31	51	0.39		14.41	0.0560	11.20
MD ENF04 02	ENF	Ase	msil	2.5Y	3	1	51	106	0.42		8.70	0.0368	20.22
MD ENF04 02	ENF	Oase	m	5Y	3	1	106	147	0.41		15.06	0.0617	25.30
MD ENF04 02	ENF	Oe	mp	10YR	2	1.5	147	165	0.17		34.52	0.0572	10.29
MD ENF04 02	ENF	A'se	msil	5Y	3	1	165	194	0.23		11.68	0.0271	7.85
MD ENF04 03	ENF	Oase	m	5Y	3	2	0	30	0.12		13.52	0.0164	4.93
MD ENF04 03	ENF	Ase	ml	2.5Y	3	2	30	100	0.50		9.57	0.0478	33.49
MD ENF04 03	ENF	O'ase1	m	5Y	2.5	2	100	154	0.33		14.61	0.0484	26.13
MD ENF04 03	ENF	O'ase2	m	5Y	2.5	2	154	204	0.27		16.55	0.0440	22.02
MD ENF04 03	ENF	Oe	mp	10YR	2	1	204	261	0.21		28.44	0.0605	34.48
MD ENF04 03	ENF	CAseg	sil	5Y	3.5	1	261	296	0.55		6.08	0.0334	11.67

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD ENF04 04	ENF	Ase1	ml	2.5Y	3	1	0	31	0.14		8.95	0.0122	3.79
MD ENF04 04	ENF	Ase2	ml	5Y	2.5	1	31	64	0.71		6.15	0.0434	14.32
MD ENF04 04	ENF	Ase3	ml	2.5	3	1	64	110	0.53		7.47	0.0397	18.25
MD ENF04 04	ENF	Oase1	m	10YR	2	1.5	110	161	0.16		41.57	0.0660	33.68
MD ENF04 04	ENF	Oase2	m	5Y	2.5	1	161	203	0.37		12.95	0.0482	20.26
MD ENF04 04	ENF	2Cseg1	scl	2.5Y	3.5	1	203	220	1.20		2.05	0.0247	4.20
MD ENF04 04	ENF	2Cseg2	scl	5Y	6	1	220	250	1.63		0.31	0.0051	1.52
MD SU15 02	SU	Oese1	mp	10YR	2	2	0	3	0.10		40.26	0.0386	1.16
MD SU15 02	SU	Oese2	mp	10YR	3	3	3	11	0.12		41.31	0.0482	3.86
MD SU15 02	SU	Oase	m	10YR	2	1	11	22	0.23		18.18	0.0418	4.59
MD SU15 02	SU	Ase	msl	2.5Y	2.5	1	22	33	0.45	5	8.05	0.0363	3.99
MD SU15 02	SU	ABg	scl	2.5Y	4	2	33	43	1.01	5	2.33	0.0237	2.37
MD SU15 02	SU	Btg1	scl	5Y	4.5	1	43	71	1.57	6b	0.28	0.0043	1.21
MD SU15 02	SU	Btg2	scl	10YR	5	6	71	107	1.57	6b	0.17	0.0026	0.95
MD SU15 02	SU	Btg3	scl	N	6	0	107	120	1.57	6b	0.15	0.0023	0.30
MD SU15 02	SU	2BC	fsl	5Y	5	4	120	171	1.74	4b	0.10	0.0017	0.87
MD SU15 03	SU	Oise1	p	10YR	3	2	0	11	0.10		38.84	0.0371	4.08
MD SU15 03	SU	Oise2	p	2.5Y	3	2	11	24	0.09		40.75	0.0385	5.01
MD SU15 03	SU	Ase	ml	5Y	2.5	1	24	38	0.28	5	11.19	0.0317	4.44
MD SU15 03	SU	Btg1	scl	N	5	0	38	62	1.57	6b	0.34	0.0054	1.29

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD SU15 03	SU	Btg2	scl	N	5.5	0	62	104	1.57	6b	0.21	0.0032	1.36
MD SU15 04	SU	Oase1	m	2.5Y	3	2	0	24	0.10		14.17	0.0147	3.53
MD SU15 04	SU	Oase2	m	5Y	2.5	1	24	37	0.07		43.06	0.0293	3.80
MD SU15 04	SU	Oase3	m	2.5Y	2.5	1	37	52	0.06		40.14	0.0259	3.88
MD SU15 04	SU	Ag	sl	2.5Y	4	2	52	61	1.42	5	1.01	0.0142	1.28
MD SU15 04	SU	Btg1	sl	N	4.5	0	61	85	1.65	6a	0.49	0.0081	1.93
MD SU15 04	SU	Btg2	scl	N	6	0	85	105	1.57	6b	0.20	0.0031	0.62
MD EF01 01	EF	Oase	m	2.5Y	3	3	0	35	0.09		33.54	0.0291	10.18
MD EF01 01	EF	Aseg	msil	2.5Y	4	2	35	66	0.35		10.48	0.0368	11.40
MD EF01 01	EF	ACseg	msil	5Y	4.5	1	66	92	1.22		2.41	0.0295	7.66
MD EF01 01	EF	Cseg1	sicl	5Y	2.5	1	92	152	0.74		3.27	0.0243	14.61
MD EF01 01	EF	Cseg2	sicl	5Y	4	1	152	226	0.84	2	3.03	0.0256	18.94
MD EF01 02	EF	Oase	m	5Y	2.5	1	0	16	0.08		16.06	0.0135	2.16
MD EF01 02	EF	Ase	msil	5Y	3	2	16	54	0.37		9.93	0.0365	13.86
MD EF01 02	EF	Cseg1	sil	5Y	4	1	54	125	0.72		3.02	0.0216	15.34
MD EF01 02	EF	Cseg2	sicl	5Y	3	2	125	162	0.72		3.62	0.0261	9.64
MD EF01 02	EF	CAse	sicl	5Y	2.5	2	162	185	0.51	2	5.90	0.0300	6.90
MD EF01 03	EF	Oese	mp	2.5Y	4	2	0	25	0.10		27.58	0.0265	6.64
MD EF01 03	EF	ACseg1	sil	5Y	4	2	25	78	0.37		7.72	0.0287	15.23
MD EF01 03	EF	ACseg2	sil	5Y	4	2	78	110	0.55		4.59	0.0251	8.05

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD EF01 03	EF	CAse	sil	2.5Y	2.5	1	110	214	0.50	2	6.15	0.0305	31.68
MD EF01 04	EF	Ase	msil	5Y	2.5	1	0	16	0.18		10.99	0.0197	3.15
MD EF01 04	EF	ACseg1	sil	5Y	4	1	16	51	0.20		6.82	0.0133	4.66
MD EF01 04	EF	ACseg2	sil	5Y	3.5	2	51	96	0.81		2.77	0.0223	10.04
MD EF01 04	EF	ACseg3	sil	5Y	3	1	96	206	0.52		4.87	0.0253	27.81
MD ENF06 03	ENF	Oe	mp	10YR	3	2	0	52	0.20		16.27	0.0331	17.21
MD ENF06 03	ENF	Oese1	mp	10YR	2	1	52	88	0.08		39.50	0.0301	10.83
MD ENF06 03	ENF	Oese2	mp	5Y	2.5	1	88	155	0.17		35.50	0.0593	39.74
MD ENF06 03	ENF	Oa1	m	7.5YR	2.5	1	155	200	0.14		32.98	0.0446	20.05
MD ENF06 03	ENF	Oa2	m	2.5Y	3	1	200	234	0.27		14.11	0.0385	13.08
MD ENF06 03	ENF	A	msil	5Y	3	2	234	256	0.34		8.58	0.0295	6.49
MD ENF06 03	ENF	Cg	sil	N	4	0	256	317	0.58		1.22	0.0071	4.32
MD ENF06 03	ENF	2Cg	l	N	4.5	0	317	327	1.25	2	1.43	0.0179	1.79
MD CB02 02	CB	Oise	p	7.5YR	3	1.5	0	16	0.10		42.72	0.0419	6.71
MD CB02 02	CB	Ase	mls	10YR	3	1.5	16	26	0.48	3	7.04	0.0340	3.40
MD CB02 02	CB	Cseg	s	5Y	4	2	26	33	1.55	4a	0.22	0.0035	0.24
MD CB02 02	CB	Cg1	s	5Y	4	1.5	33	48	1.55	4a	0.11	0.0016	0.25
MD CB02 02	CB	Cg2	s	5Y	5.5	1	48	105	1.55	4a	0.04	0.0006	0.33
MD CB02 03	CB	Oise	p	10YR	3	3	0	18	0.09		38.11	0.0340	6.11
MD CB02 03	CB	Oese	mp	10YR	2	2	18	28	0.21	1	17.46	0.0366	3.66

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CB02 03	CB	Cg1	s	10Y	4	1	28	43	1.55	4a	0.18	0.0029	0.43
MD CB02 03	CB	Cg2	s	10Y	4.5	1	43	55	1.55	4a	0.04	0.0006	0.07
MD CB02 03	CB	Cg3	s	10Y	5	1	55	93	1.55	4a	0.04	0.0006	0.22
MD CB02 04	CB	Oise	p	7.5YR	3	1.5	0	5	0.17		26.02	0.0444	2.22
MD CB02 04	CB	Oese	mp	10YR	3	1	5	15	0.28		21.28	0.0586	5.86
MD CB02 04	CB	AC	s	10YR	4	2	15	24	1.29	3	1.36	0.0176	1.58
MD CB02 04	CB	Cg1	s	10YR	4.5	2	24	35	1.55	4a	0.24	0.0038	0.42
MD CB02 04	CB	Cg2	s	10YR	4.5	2	35	50	1.55	4a	0.14	0.0022	0.34
MD CB02 04	CB	Cg3	s	2.5Y	5	1.5	50	97	1.55	4a	0.04	0.0007	0.32
MD CB02 04	CB	Cg4	s	5Y	6	1	97	150	1.55	4a	0.07	0.0011	0.56
MD CB03 03	CB	Oise	p	10YR	3	2	0	11	0.14		37.83	0.0511	5.63
MD CB03 04	CB	Oi	p	7.5YR	3	2	0	13	0.16		25.41	0.0412	5.36
MD CB03 04	CB	Oe	mp	10YR	3	1	13	23	0.17		17.18	0.0286	2.86
MD CB03 04	CB	AC	ls	2.5Y	4.5	1	23	34	1.41	3	0.58	0.0081	0.89
MD CB03 04	CB	CA	s	2.5Y	4.5	3	34	47	1.55	4a	0.41	0.0063	0.82
MD CB03 04	CB	Cg1	s	2.5Y	4.5	2	47	84	1.55	4a	0.12	0.0018	0.67
MD CB03 04	CB	Cg2	s	5Y	4	1	84	91	1.55	4a	0.09	0.0014	0.10
MD CB03 04	CB	Cg3	s	5Y	4	1	91	97	1.55	4a	0.07	0.0010	0.06
MD CB03 04	CB	Cg4	s	5Y	6	1	97	113	1.55	4a	0.07	0.0011	0.18
MD CB03 05	CB	Oese	mp	10YR	3	2	0	21	0.27		14.57	0.0399	8.37

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CB03 05	CB	Oise	p	10YR	3	1	21	41	0.29		15.59	0.0451	9.02
MD CB03 05	CB	A	ls	10YR	3.5	1	41	51	1.09	3	2.80	0.0305	3.05
MD CB03 05	CB	Cg1	s	10YR	4	1	51	66	1.55	4a	0.14	0.0022	0.34
MD CB03 05	CB	Cg2	s	10YR	5	1	66	107	1.55	4a	0.05	0.0008	0.34
MD CB03 05	CB	Ab	s	10YR	4	1	107	141	1.48	3	0.09	0.0013	0.44
MD EF11 01	EF	Ase	msil	2.5Y	3	1.5	0	38	0.40		6.26	0.0249	9.44
MD EF11 01	EF	Oase	m	10YR	2	2	38	58	0.29		20.54	0.0593	11.87
MD EF11 01	EF	A'se1	msil	2.5Y	3	1	58	101	0.36		11.43	0.0414	17.80
MD EF11 01	EF	A'se2	msil	5Y	3	2	101	205	0.41		9.33	0.0386	40.13
MD EF11 01	EF	CAseg1	sil	2.5Y	4	1	205	245	0.81		4.77	0.0385	15.40
MD EF11 01	EF	CAseg2	sicl	5Y	4	1	245	256	0.56		6.55	0.0367	4.04
MD EF11 01	EF	CAseg3	sicl	5Y	4	1	256	290	0.63		4.70	0.0298	10.14
MD EF11 02	EF	Ase	msil	2.5Y	3	2	0	16	0.19		10.38	0.0196	3.13
MD EF11 02	EF	Oa1	m	7.5YR	2.5	1	16	50	0.23		22.43	0.0509	17.31
MD EF11 02	EF	Oa2	m	2.5Y	3	1	50	81	0.27		13.84	0.0370	11.48
MD EF11 02	EF	Oase	m	5Y	3	1	81	124	0.36		12.02	0.0437	18.79
MD EF11 02	EF	ACse1	sil	5Y	3	1	124	166	0.44		8.13	0.0358	15.04
MD EF11 02	EF	ACse2	sil	5Y	2.5	1	166	199	0.44		5.90	0.0261	8.60
MD EF11 02	EF	ACse3	sil	5Y	2.5	2	199	268	0.47		9.69	0.0458	31.61
MD EF11 02	EF	ACse4	sil	5Y	2.5	2	268	286	0.48		5.07	0.0244	4.39

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD EF11 03	EF	Ase1	msil	5Y	2.5	2	0	15	0.23		9.49	0.0214	3.21
MD EF11 03	EF	Ase2	msil	5Y	3	2	15	38	0.61		9.13	0.0554	12.75
MD EF11 03	EF	CA1	sil	5Y	3	1	38	66	0.65		5.92	0.0386	10.81
MD EF11 03	EF	CA2	sicl	2.5Y	3	1	66	93	0.53	2	5.61	0.0295	7.97
MD EF11 03	EF	CA3	sil	2.5Y	2.5	1	93	120	0.61	2	4.63	0.0282	7.61
MD CM04 03	CM	Oi	p	10YR	3	3	0	6	0.18		20.69	0.0381	2.29
MD CM04 03	CM	Oise	p	10YR	3	2	6	20	0.22		21.18	0.0460	6.44
MD CM04 03	CM	Ase	msil	2.5Y	3	2	20	43	0.38		9.13	0.0348	7.99
MD CM04 03	CM	Aseg	msil	2.5Y	3.5	1	43	58	0.68		5.25	0.0357	5.35
MD CM04 03	CM	CAg	sicl	5Y	3.5	1	58	79	0.84		4.12	0.0346	7.26
MD CM04 03	CM	Oa1	m	10YR	2	1	79	119	0.34		16.75	0.0567	22.69
MD CM04 03	CM	Oa2	m	10YR	2	1.5	119	145	0.31		12.66	0.0396	10.29
MD CM04 03	CM	2A	ms	10YR	2	1	145	160	0.47		6.31	0.0295	4.43
MD CM04 04	CM	Oi	p	10YR	3.5	1	0	20	0.29		12.29	0.0352	7.05
MD CM04 04	CM	Ag1	sil	5Y	4	1	20	37	0.74		3.14	0.0233	3.97
MD CM04 04	CM	Ag2	sil	2.5Y	4	1	37	71	0.41		9.76	0.0401	13.65
MD CM04 04	CM	CAseg	sil	5Y	4	1	71	92	1.00		3.08	0.0308	6.46
MD CM04 04	CM	Cseg	sil	N	3	0	92	101	0.95		3.32	0.0315	2.83
MD CM04 04	CM	Oa	m	10YR	2	1	101	136	0.32		13.18	0.0428	14.98
MD CM04 04	CM	Ase	ml	10YR	2	1.5	136	190	0.56		6.35	0.0355	19.17

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM04 04	CM	2A	ls	10YR	2	1	190	200	1.38		2.30	0.0319	3.19
MD CM07 01	CM	Ase	ml	5Y	3	1	0	29	0.69		4.49	0.0308	8.93
MD CM07 01	CM	Cg	l	2.5Y	4	1	29	39	1.88		0.50	0.0094	0.94
MD CM07 01	CM	C	l	10YR	5	4	39	91	1.71	2	0.21	0.0036	1.85
MD CM07 01	CM	C'g	sl	2.5Y	6	1.5	91	103	1.73	2	0.15	0.0025	0.30
MD CM07 01	CM	2Cg1	ls	2.5Y	5	1	103	136	1.74	4b	0.17	0.0029	0.96
MD CM07 01	CM	2Cg2	s	5Y	5	2	136	149	1.55	4a	0.08	0.0012	0.16
MD CM07 01	CM	2Cg3	s	2.5Y	6	1	149	176	1.55	4a	0.06	0.0010	0.27
MD CM07 01	CM	2Cg4	s	2.5Y	5.5	4	176	233	1.55	4a	0.06	0.0009	0.51
MD CM07 02	CM	Ase	ml	10YR	3.5	2	0	9	0.36		7.18	0.0262	2.36
MD CM07 02	CM	Oase	m	10YR	3	1	9	17	0.24		17.70	0.0419	3.35
MD CM07 02	CM	A	l	10YR	2	1	17	30	0.78	2	3.41	0.0264	3.44
MD CM07 02	CM	Ag	l	2.5Y	4	1	30	37	1.33	2	1.18	0.0157	1.10
MD CM07 02	CM	Cg	scl	2.5Y	6	1	37	87	1.72	2	0.17	0.0030	1.49
MD CM07 02	CM	2Cg1	ls	2.5Y	5	3	87	141	1.74	4b	0.09	0.0016	0.85
MD CM07 02	CM	2Cg2	s	2.5Y	5	3	141	167	1.55	4a	0.05	0.0007	0.18
MD CM07 02	CM	2Cg3	s	5Y	5	2	167	180	1.55	4a	0.03	0.0005	0.06
MD CM07 03	CM	Ase	ml	5Y	4	1	0	35	0.28		9.68	0.0270	9.46
MD CM07 03	CM	Oese	mp	2.5Y	3	1	35	54	0.27		16.36	0.0436	8.29
MD CM07 03	CM	Oa	m	10YR	3	1	54	65	0.41		11.99	0.0488	5.36

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM07 03	CM	A	ml	10YR	2	1	65	80	0.75		4.34	0.0325	4.87
MD CM07 03	CM	Cg	sl	5Y	5	1	80	124	1.72		0.45	0.0077	3.40
MD CM07 03	CM	2Cg	ls	5Y	4	2	124	140	1.74	4b	0.25	0.0043	0.69
MD CM07 04	CM	Aseg	msil	5Y	4	1	0	36	0.41		7.34	0.0304	10.95
MD CM07 04	CM	Oese	mp	2.5Y	3.5	1.5	36	72	0.19		17.69	0.0333	11.98
MD CM07 04	CM	Ase1	msil	5Y	3.5	1	72	86	0.38		11.26	0.0428	6.00
MD CM07 04	CM	Ase2	msil	10YR	3	1	86	93	0.37		10.19	0.0374	2.62
MD CM07 04	CM	Ase3	msil	2.5Y	3.5	1	93	118	0.33		10.43	0.0348	8.69
MD CM07 04	CM	O'ese	mp	10YR	2	1	118	146	0.16		26.35	0.0426	11.93
MD CM07 04	CM	Oase	m	7.5YR	2.5	1	153	180	0.13		27.18	0.0346	9.34
MD CM07 04	CM	A'seg	msil	N	2.5	0	180	193	0.51		5.98	0.0307	3.99
MD CM07 04	CM	Cse	sil	5Y	3	1	193	200	1.09		1.68	0.0182	1.28
MD SU01 01	SU	Btg2	cl	10YR	5	1	48	81	1.90		0.29	0.0054	1.80
MD SU01 03	SU	Oi	p	10YR	3	2	0	17	0.09		30.60	0.0286	4.85
MD SU01 03	SU	Oa	m	10YR	2	1	17	31	0.22	1	14.64	0.0327	4.58
MD SU01 03	SU	Btg	cl	2.5Y	4	1	31	91	1.57	6b	0.96	0.0150	9.03
MD SU01 03	SU	2BC	ls	10YR	5	1	91	127	1.74	4b	0.33	0.0057	2.04
MD SU01 03	SU	C	s	10YR	5.5	1	127	145	1.55	4a	0.13	0.0020	0.35
MD SU01 05	SU	Oese	mp	2.5Y	3	2	0	18	0.22		14.33	0.0319	5.74
MD SU01 05	SU	Oe1	mp	2.5Y	3	1	18	44	0.12		29.51	0.0350	9.11

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD SU01 05	SU	Oe2	mp	10YR	3	2	44	76	0.14		35.94	0.0493	15.76
MD SU01 05	SU	Oa	m	10YR	2	1	76	88	0.23		26.86	0.0607	7.29
MD SU01 05	SU	Ag	l	N	3.5	0	88	107	1.53		1.37	0.0210	3.98
MD SU01 05	SU	Btg1	cl	2.5Y	4.5	1	107	119	1.54		0.70	0.0108	1.30
MD SU01 05	SU	Btg2	cl	N	5	0	119	143	1.57	6b	0.39	0.0062	1.48
MD SU04 03	SU	Oi1	p	10YR	3	2	0	10	0.09		34.79	0.0310	3.10
MD SU04 03	SU	Oi2	p	10YR	2	2	10	29	0.09	1	42.68	0.0371	7.04
MD SU04 03	SU	Oi3	p	10YR	3	2	29	44	0.10		41.19	0.0400	6.00
MD SU04 03	SU	Oa	m	10YR	2	1	44	49	0.16	1	27.66	0.0443	2.21
MD SU04 03	SU	A	sil	2.5Y	3	1	49	62	0.76		6.42	0.0491	6.38
MD SU04 03	SU	Eg	sil	2.5Y	3.5	1	62	74	1.14	5	1.85	0.0211	2.53
MD SU04 03	SU	Btg	sicl	2.5Y	4.5	1	74	118	1.57	6b	0.49	0.0077	3.39
MD SU04 03	SU	2BCg1	sl	5Y	5	1	118	146	1.74	4b	0.14	0.0024	0.68
MD SU04 03	SU	2BCg2	ls	5Y	5	1	146	154	1.74	4b	0.08	0.0014	0.11
MD SU04 04	SU	Oese	mp	2.5Y	3	1	0	25	0.17		15.72	0.0261	6.53
MD SU04 04	SU	Oa	m	10YR	3	1	25	57	0.11		38.14	0.0408	13.07
MD SU04 04	SU	O'ese	mp	10YR	3	1.5	57	70	0.08		33.82	0.0282	3.67
MD SU04 04	SU	Oase	m	10YR	2.5	1	70	91	0.12		35.28	0.0434	9.12
MD SU04 04	SU	O'a	m	10YR	2	1	91	100	0.21		23.38	0.0488	4.39
MD SU04 04	SU	Ag	cl	10YR	4	1	100	130	1.36		1.82	0.0247	7.40

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM03 03	CM	Oase	m	2.5Y	3	1	0	9	0.09		16.38	0.0147	1.32
MD CM03 03	CM	Oise	p	10YR	3	2	9	27	0.19		15.49	0.0291	5.25
MD CM03 03	CM	Oese	mp	10YR	2	2	27	64	0.14		21.29	0.0293	10.84
MD CM03 03	CM	Oa	m	10YR	2	1	64	91	0.18		23.70	0.0426	11.50
MD CM03 03	CM	Oe	mp	2.5Y	3.5	2	91	118	0.22		12.33	0.0277	7.48
MD CM03 03	CM	C	msl	5Y	3	1	118	148	0.37		7.25	0.0270	8.09
MD CM03 03	CM	O'a1	m	2.5Y	3	2	148	164	0.16		24.87	0.0396	6.33
MD CM03 03	CM	2A	sl	10YR	2	1	164	173	0.53		7.07	0.0374	3.37
MD CM03 03	CM	2ACg	sl	2.5Y	3	1	173	187	1.25		1.72	0.0216	3.02
MD CM03 03	CM	2Cg	sl	5Y	5	2	187	211	1.63		0.27	0.0043	1.04
MD CM03 04	CM	Ase	msil	2.5Y	3	2	0	17	0.42		5.55	0.0233	3.96
MD CM03 04	CM	Ag	msil	2.5Y	3.5	1	17	50	0.42		6.65	0.0281	9.27
MD CM03 04	CM	A	msil	10YR	2	2	50	69	0.37		9.99	0.0367	6.98
MD CM03 04	CM	Oa	m	10YR	2	1	69	102	0.27		14.52	0.0388	12.82
MD CM03 04	CM	Cg1	msil	5Y	4	1	102	150	0.44		4.46	0.0194	9.31
MD CM03 04	CM	Cg2	sil	N	4	0	150	210	0.67		3.93	0.0265	15.90
MD CM03 04	CM	2Cg3	sl	2.5Y	4	1	210	222	0.73		0.97	0.0071	0.85
MD CM02 02 1X	CM	Oise	p	2.5Y	3	2	0	12	0.26		12.35	0.0316	3.79
MD CM02 02 1X	CM	Ase	msil	10YR	3	2	12	51	0.17		10.40	0.0174	6.80
MD CM02 02 1X	CM	A	msil	5Y	4	1	51	75	0.51		5.78	0.0296	7.11

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM02 02 1X	CM	CAg	sil	10Y	4	1	75	99	0.51		4.35	0.0222	5.33
MD CM02 02 1X	CM	CAse	msil	10YR	2	1	99	117	0.38		11.32	0.0429	7.72
MD CM02 02 1X	CM	Oa	m	10YR	2	1	117	149	0.15		25.69	0.0380	12.15
MD CM02 02 1X	CM	2Cg1	sl	5Y	4.5	1	149	189	1.62		0.40	0.0065	2.62
MD CM02 02 1X	CM	2Cg2	sl	N	6	0	189	217	1.87		0.14	0.0027	0.76
MD CM02 02 2X	CM	Oise					0	12	0.23		11.49	0.0268	3.21
MD CM02 02 2X	CM	Ase					12	51	0.20		11.26	0.0229	8.95
MD CM02 02 2X	CM	A					51	75	0.44		6.83	0.0302	7.26
MD CM02 02 2X	CM	CAg					75	99	0.56		4.46	0.0250	6.01
MD CM02 02 2X	CM	CAse					99	117	0.36		11.03	0.0402	7.24
MD CM02 02 2X	CM	Oa					117	149	0.17		25.80	0.0447	14.31
MD CM02 02 2X	CM	2Cg1					149	189	1.54		0.45	0.0070	2.79
MD CM02 02 2X	CM	2Cg2					189	217	1.78		0.15	0.0026	0.73
MD CM02 02 3X	CM	Oise					0	12	0.17		11.48	0.0198	7.73
MD CM02 02 3X	CM	Ase					12	51	0.25		11.79	0.0292	3.51
MD CM02 02 3X	CM	A					51	75	0.45		6.78	0.0307	7.37
MD CM02 02 3X	CM	CAg					75	99	0.48		4.35	0.0207	4.97
MD CM02 02 3X	CM	CAse					99	117	0.32		12.70	0.0407	7.33
MD CM02 02 3X	CM	Oa					117	149	0.17		27.31	0.0465	14.89
MD CM02 02 3X	CM	2Cg1					149	189	1.77		0.37	0.0065	2.62

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM02 02 3X	CM	2Cg2					189	217	1.77		0.14	0.0024	0.67
MD ENF09 03	ENF	Oise1	p	2.5Y	2.5	1	0	19	0.07		20.31	0.0141	2.68
MD ENF09 03	ENF	Oise2	p	10YR	2	2	19	67	0.11		41.23	0.0440	21.12
MD ENF09 03	ENF	Oese1	mp	10YR	2	1	67	112	0.10		47.31	0.0463	20.83
MD ENF09 03	ENF	Oese2	mp	10YR	2	1.5	112	220	0.11		45.63	0.0481	51.92
MD ENF09 03	ENF	Aseg	sicl	N	4	0	220	243	0.52		5.88	0.0306	7.03
MD ENF09 03	ENF	ACseg1	sicl	N	4	0	243	276	0.64	2	4.37	0.0279	9.20
MD ENF09 03	ENF	ACseg2	sicl	5Y	3	1	276	305	0.71		5.38	0.0382	11.07
MD CM09 02	CM	Oise	p	2.5Y	3	3	0	10	0.21		14.03	0.0289	2.89
MD CM09 02	CM	Oese	mp	2.5Y	3.5	3	10	51	0.18		11.24	0.0202	8.29
MD CM09 02	CM	A	ml	2.5Y	4	2	51	72	0.39		8.95	0.0350	7.35
MD CM09 02	CM	Oe	mp	10YR	2	1	72	98	0.08		39.28	0.0306	7.95
MD CM09 02	CM	A'	ml	2.5Y	3	2	98	117	0.23		6.64	0.0155	2.95
MD CM09 02	CM	O'a2	m	10YR	2	1	117	135	0.23	1	13.28	0.0306	5.50
MD CM09 02	CM	A"1	sl	2.5Y	3	2	135	160	1.48		1.08	0.0160	3.99
MD CM09 02	CM	A"2	sl	2.5Y	3	1	160	174	1.42	2	0.92	0.0131	1.84
MD CM09 02	CM	2Cg	ls	5Y	5.5	1	174	180	1.74	4b	0.14	0.0024	0.14
MD CM09 03 1X	CM	Aseg	msil	5Y	4	2	0	35	0.27		8.62	0.0233	8.16
MD CM09 03 1X	CM	Oise	p	2.5Y	4	2	35	66	0.21		14.47	0.0307	9.51
MD CM09 03 1X	CM	Ag	sil	5Y	4	1	66	83	0.32		8.25	0.0265	4.51

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM09 03 1X	CM	Oe	mp	10YR	2	1	83	115	0.12		34.17	0.0410	13.13
MD CM09 03 1X	CM	Cg	sil	2.5Y	4	2	115	130	0.57		4.41	0.0253	3.79
MD CM09 03 1X	CM	ACse	msil	5Y	3	1	130	161	0.39		9.81	0.0380	11.79
MD CM09 03 1X	CM	Ase	msil	10YR	2	1	161	175	0.38		10.81	0.0414	5.80
MD CM09 03 1X	CM	2Cseg	scl	N	4	0	175	213	1.79		0.20	0.0035	1.34
MD CM09 03 1X	CM	2Cg	scl	5Y	4	2	213	230	1.64		0.33	0.0055	0.93
MD CM09 03 2X	CM	Aseg					0	35	0.29		8.38	0.0239	8.37
MD CM09 03 2X	CM	Oise					35	66	0.15		15.76	0.0235	7.29
MD CM09 03 2X	CM	Ag					66	83	0.58		6.11	0.0353	6.00
MD CM09 03 2X	CM	Oe					83	115	0.11		35.68	0.0401	12.83
MD CM09 03 2X	CM	Cg					115	130	0.60		4.04	0.0241	3.62
MD CM09 03 2X	CM	ACse					130	161	0.46		6.12	0.0279	8.65
MD CM09 03 2X	CM	Oase					161	175	0.30		15.49	0.0459	6.42
MD CM09 03 2X	CM	2Cseg					175	213	1.56		0.56	0.0088	3.33
MD CM09 03 2X	CM	2Cg					213	230	1.65		0.27	0.0044	0.75
MD CM09 03 3X	CM	Aseg					0	36	0.30		8.98	0.0273	9.81
MD CM09 03 3X	CM	Oise					36	57	0.18		18.32	0.0329	6.92
MD CM09 03 3X	CM	Ag					57	75	0.52		6.40	0.0331	5.96
MD CM09 03 3X	CM	Oe					75	109	0.18		27.05	0.0488	16.60
MD CM09 03 3X	CM	Cg					109	130	0.49		5.65	0.0274	5.76

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD CM09 03 3X	CM	ACse					130	148	0.49		6.94	0.0339	6.10
MD CM09 03 3X	CM	Oase					148	167	0.19		26.86	0.0523	9.94
MD CM09 03 3X	CM	2Cseg					167	207	1.92		0.42	0.0080	3.22
MD CM09 03 3X	CM	2Cg					207	230	1.84		0.27	0.0049	1.13
MD CM09 04	CM	Ag	msil	2.5Y	4	1	0	14	0.33		10.54	0.0350	4.90
MD CM09 04	CM	A	msil	2.5Y	3	1	14	44	0.34		8.62	0.0292	8.76
MD CM09 04	CM	Oe	mp	2.5Y	3	2	44	65	0.22		15.18	0.0334	7.00
MD CM09 04	CM	A'g	sil	5Y	3	2	65	89	0.60		5.38	0.0323	7.76
MD CM09 04	CM	Oa	m	10YR	2	1	89	119	0.16		28.43	0.0452	13.57
MD CM09 04	CM	A'	sil	5Y	2.5	1	119	167	0.59		5.22	0.0307	14.73
MD CM09 04	CM	O'a	m	10YR	2	1	167	180	0.22		22.06	0.0486	6.31
MD CM09 04	CM	2A	scl	5Y	3	1.5	180	193	1.37		1.53	0.0210	2.72
MD ENF02 01	ENF	Oese1	mp	2.5Y	2	2	0	26	0.30		13.03	0.0393	10.23
MD ENF02 01	ENF	Ase1	ml	2.5Y	3	1	26	48	0.43		7.10	0.0308	6.78
MD ENF02 01	ENF	Ase2	ml	2.5Y	3	1	48	74	0.52		5.02	0.0263	6.83
MD ENF02 03 1X	ENF	Aseg	msicl	5Y	3.5	1	0	80	0.45		8.44	0.0379	30.34
MD ENF02 03 1X	ENF	Oase	m	10YR	2	1	80	188	0.11		45.48	0.0501	54.09
MD ENF02 03 1X	ENF	Ag	sicl	5Y	3	1	188	254	0.42		7.77	0.0329	21.74
MD ENF02 03 1X	ENF	A'seg	msil	5Y	3	1	254	305	0.46		10.51	0.0484	24.69
MD ENF02 03 1X	ENF	O'ase	m	10YR	2	1	305	352	0.17		37.15	0.0636	29.87

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD ENF02 03 2X	ENF	Aseg					0	75	0.41		7.75	0.0317	23.81
MD ENF02 03 2X	ENF	Oase					75	194	0.11		43.67	0.0484	57.56
MD ENF02 03 2X	ENF	Ag					194	255	0.45		10.04	0.0451	27.50
MD ENF02 03 2X	ENF	A'seg					255	322	0.33		11.90	0.0391	26.20
MD ENF02 03 2X	ENF	O'ase					322	350	0.14		38.06	0.0543	15.19
MD ENF02 03 3X	ENF	Aseg					0	86	0.34		11.26	0.0386	33.16
MD ENF02 03 3X	ENF	Oase					86	168	0.12		40.99	0.0497	40.73
MD EF09 02	EF	Oese1	mp	10YR	2	2	0	30	0.11	1	36.95	0.0424	12.72
MD EF09 02	EF	Oese2	mp	10YR	3	1	30	50	0.23	1	13.91	0.0316	6.32
MD EF09 02	EF	Ase	msil	10YR	3	2	50	94	0.29	2	11.47	0.0336	14.80
MD EF09 02	EF	Oa	m	10YR	3	1	94	136	0.23	1	12.51	0.0293	12.29
MD EF09 02	EF	Oe	mp	10YR	2	2	136	183	0.20	1	18.58	0.0380	17.84
MD EF12 02 1X	EF	Ase	msicl	5Y	3	1.5	0	45	0.52		7.47	0.0388	17.47
MD EF12 02 1X	EF	A	msil	5Y	2.5	1	45	64	0.43		9.28	0.0398	7.56
MD EF12 02 1X	EF	Oe	mp	10YR	2	1.5	64	143	0.12		32.00	0.0382	30.18
MD EF12 02 1X	EF	2A	sl	10YR	2	1	143	158	0.81	2	3.19	0.0260	3.89
MD EF12 02 1X	EF	2C	s	2.5Y	4	3	158	180	1.55	4a	0.41	0.0063	1.40
MD EF12 02 2X	EF	Ase					0	39	0.52		8.24	0.0431	16.81
MD EF12 02 2X	EF	A					39	69	0.45		8.30	0.0370	11.09
MD EF12 02 2X	EF	Oe					69	135	0.15		35.85	0.0550	36.33

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD EF12 02 2X	EF	2A					135	145	1.16	2	1.72	0.0200	2.00
MD EF12 02 2X	EF	2C					145	166	1.55	4a	0.39	0.0060	1.26
MD EF12 02 3X	EF	Ase					0	46	0.58		7.12	0.0411	18.90
MD EF12 02 3X	EF	A					46	87	0.42		11.17	0.0468	19.19
MD EF12 02 3X	EF	Oe					87	160	0.21		28.30	0.0600	43.83
MD EF12 02 3X	EF	2A					160	170	0.67	2	4.13	0.0276	2.76
MD EF12 02 3X	EF	2C					170	180	1.55	4a	0.64	0.0099	0.99
MD EF04 04 1X	EF	A	ml	5Y	3.5	1	0	20	0.40	2	9.40	0.0379	7.59
MD EF04 04 1X	EF	CAg1	ml	5Y	4	1	20	46	0.55		7.52	0.0417	10.83
MD EF04 04 1X	EF	CAg2	sicl	5Y	4	2	46	89	0.67		7.90	0.0529	22.75
MD EF04 04 1X	EF	CA1	sicl	5Y	3.5	1	89	124	0.53		6.26	0.0334	11.71
MD EF04 04 1X	EF	CA2	cl	5Y	3	1	124	179	0.70		6.64	0.0467	25.66
MD EF04 04 1X	EF	CA3	cl	5Y	3	1	179	210	0.57		7.44	0.0421	13.06
MD EF04 04 2X	EF	A					0	25	0.40		8.97	0.0363	9.08
MD EF04 04 2X	EF	CAg1					25	42	0.46		8.56	0.0393	6.68
MD EF04 04 2X	EF	CAg2					42	94	0.33		11.52	0.0377	19.63
MD EF04 04 2X	EF	CAg3					94	200	0.56		6.24	0.0352	37.29
MD EF04 04 3X	EF	A					0	29	0.30		11.28	0.0341	9.88
MD EF04 04 3X	EF	CAg1					29	65	0.60		8.77	0.0523	18.82
MD EF04 04 3X	EF	CAg2					65	112	0.46		8.69	0.0397	18.66

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
MD EF04 04 3X	EF	CA1					112	142	0.67		6.61	0.0441	13.24
MD EF04 04 3X	EF	CA2					142	178	0.63		7.63	0.0484	17.42
MD EF04 04 3X	EF	CA3					178	200	0.55		7.98	0.0440	9.67
DE CB01 02 1X	CB	Oi	p	2.5Y	3	2.5	0	15	0.20		14.69	0.0289	4.34
DE CB01 02 1X	CB	Oe	mp	10YR	2	1	15	23	0.11		20.17	0.0220	1.76
DE CB01 02 1X	CB	C	s	5Y	3.5	1	23	31	1.55	4a	0.54	0.0084	0.68
DE CB01 02 1X	CB	Ab	ls	2.5Y	3	1	31	60	1.23	3	1.80	0.0222	6.43
DE CB01 02 1X	CB	Cg1	s	10Y	4.5	1	60	120	1.55	4a	0.11	0.0016	0.98
DE CB01 02 1X	CB	Cg2	s	5Y	5.5	1	120	143	1.55	4a	0.03	0.0005	0.12
DE CB01 02 2X	CB	Oe1					0	12	0.20		20.77	0.0411	4.93
DE CB01 02 2X	CB	Oe2					12	19	0.11		24.23	0.0255	1.79
DE CB01 02 2X	CB	C					19	29	1.55	4a	0.82	0.0127	1.27
DE CB01 02 2X	CB	Ab					29	44	1.15	3	2.35	0.0271	4.06
DE CB01 02 2X	CB	Cg1					44	69	1.55	4a	0.35	0.0054	1.34
DE CB01 02 2X	CB	Cg2					69	159	1.55	4a	0.12	0.0018	1.65
DE CB01 02 3X	CB	Oe1					0	11	0.17		21.19	0.0362	3.98
DE CB01 02 3X	CB	Oe2					11	18	0.14		18.27	0.0256	1.79
DE CB01 02 3X	CB	C					18	30	1.55	4a	1.01	0.0157	1.88
DE CB01 02 3X	CB	Ab					30	49	1.15	3	2.35	0.0271	5.14
DE CB01 02 3X	CB	Cg1					49	65	1.55	4a	0.20	0.0031	0.50

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
DE CB01 02 3X	CB	Cg2					65	145	1.55	4a	0.10	0.0016	1.26
DE CB02 03	CB	Oi1	p	2.5Y	3	2	0	15	0.15		22.53	0.0348	5.21
DE CB02 03	CB	Oi2	p	2.5Y	2.5	1	15	20	0.19	1	21.84	0.0411	2.06
DE CB02 03	CB	A	ls	2.5Y	3.5	1	20	51	0.97	3	3.61	0.0351	10.89
DE CB02 03	CB	CAg	ls	2.5Y	4	1	51	68	1.74	4b	0.63	0.0109	1.85
DE CB02 03	CB	Cg1	s	5Y	4.5	1	68	103	1.55	4a	0.21	0.0033	1.14
DE CB02 03	CB	Cg2	s	5Y	5	1	103	117	1.55	4a	0.06	0.0009	0.13
DE CB02 03	CB	Cg3	s	5Y	6	1	117	140	1.55	4a	0.04	0.0006	0.15
DE CB02 05	CB	Oi	p	5Y	3	3	0	20	0.19		16.68	0.0324	6.48
DE CB02 05	CB	A1	msl	10YR	3	2	20	41	0.49	3	6.96	0.0344	7.22
DE CB02 05	CB	A2	sl	5Y	3	1	41	52	0.90	3	4.13	0.0371	4.08
DE CB02 05	CB	CA	sl	5Y	3	1.5	52	66	1.74	4b	1.01	0.0175	2.46
DE CB02 05	CB	Cg1	ls	5Y	3.5	1	66	81	1.74	4b	0.22	0.0039	0.58
DE CB02 05	CB	Cg2	s	5Y	4	1	81	94	1.55	4a	0.10	0.0015	0.20
DE CB02 05	CB	Cg3	s	5Y	6	1	94	145	1.55	4a	0.07	0.0011	0.56
NJ SU01 01 1x	ENF	Oi	p	5Y	3	1	0	21	0.13		20.00	0.0267	5.60
NJ SU01 01 1x	ENF	Oe	mp	5Y	2.5	1	21	38	0.19		11.21	0.0213	3.62
NJ SU01 01 1x	ENF	Oa1	m	10YR	2.5	2	38	50	0.10		34.46	0.0332	3.98
NJ SU01 01 1x	ENF	Oa2	m	7.5YR	2.5	2	50	89	0.10		37.55	0.0371	14.48
NJ SU01 01 1x	ENF	Oa3	m	10YR	2	2	89	113	0.11		22.32	0.0254	6.11

Pedon	PGU	Horizon	Texture	Hue	Value	Chroma	Upper (cm)	Lower (cm)	Bulk density (g cm^{-3})	Bulk density function	SOC content (%)	Carbon density (g C cm^{-3})	Carbon stock (kg C m^{-2})
NJ SU01 01 1x	ENF	A1	sl	10YR	2	1.5	113	131	0.23		9.31	0.0217	3.90
NJ SU01 01 1x	ENF	A2	ls	2.5Y	2.5	1	131	141	1.28	3	1.48	0.0189	1.89
NJ SU01 01 2x	ENF	Oe1					0	18	0.14		21.82	0.0298	5.36
NJ SU01 01 2x	ENF	Oe2					18	43	0.05		16.39	0.0084	2.11
NJ SU01 01 2x	ENF	Oa1					43	62	0.16		15.56	0.0254	4.83
NJ SU01 01 2x	ENF	Oa2					62	113	0.12		36.80	0.0451	22.98
NJ SU01 01 2x	ENF	Oa3					113	141	0.10		34.98	0.0351	9.83
NJ SU01 01 2x	ENF	A1					141	147	1.03		2.15	0.0220	1.32
NJ SU01 01 2x	ENF	A2					147	154	0.80		1.32	0.0105	0.74
NJ SU01 01 3x	ENF	Oe1					0	22	0.11		23.87	0.0269	5.93
NJ SU01 01 3x	ENF	Oe2					22	37	0.08		14.77	0.0116	1.74
NJ SU01 01 3x	ENF	Oa1					37	57	0.13		13.17	0.0167	3.33
NJ SU01 01 3x	ENF	Oa2					51	59	0.08		27.44	0.0211	1.69
NJ SU01 01 3x	ENF	Oa3					59	110	0.23		17.55	0.0404	20.62
NJ SU01 01 3x	ENF	A					110	115	0.20		12.74	0.0252	1.26

Appendix E. Dominant vegetation at each pedon

Transect	Pedon	Scientific name	Common name
MD EF01	1	*Typha angustifolia*	Narrowleaf cattail
		Peltandra virginica	Arrow arum
		Pontederia cordata	Pickerelweed
		Ipomoea sp.	Morning glory
		Sium suave	Water hemlock parsnip
	2	*Typha angustifolia*	Narrowleaf cattail
		Peltandra virginica	Arrow arum
	3	*Typha angustifolia*	Narrowleaf cattail
		Peltandra virginica	Arrow arum
		Persicaria perfoliata	Mile-a-minute
	4	*Typha angustifolia*	Narrowleaf cattail
		Peltandra virginica	Arrow arum
		Nuphar advena	Spatterdock
MD EF11	1	*Spartina patens*	Saltmeadow cordgrass
		Bolboschoenus maritimus	Saltmarsh bullrush
	2	*Spartina alterniflora*	Smooth cordgrass
		Hibiscus grandiflorus	Swamp hibiscus
		Amaranthus tuberculatus	Freshwater hemp
		Equisetum sp.	Horsetail
		Leersia oryzoides	Rice cut grass
	3	*Hibiscus grandiflorus*	Swamp hibiscus
		Peltandra virginica	Arrow arum
		Rumex verticillatus	Swamp dock
		Pontederia cordata	Pickerelweed
		Spartina alterniflora	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass
MD EF04	1	*Polygonum arifolium*	Halberd leaved tearthumb
		Spartina cynosuroides	Big cordgrass
		Pontederia cordata	Pickerelweed
		Nuphar advena	Spatterdock
	2	*Pontederia cordata*	Pickerelweed
		Typha angustifolia	Narrowleaf cattail
		Peltandra virginica	Arrow arum

	3	*Peltandra virginica* *Pontederia cordata* *Typha angustifolia* *Polygonum arifolium* *Hibiscus grandiflorus*	Arrow arum Pickerelweed Narrowleaf cattail Halberd leaved tearthumb Swamp hibiscus
	4	*Pontederia cordata* *Nuphar advena*	Pickerelweed Spatterdock
	Subaqueous pedon	*Nuphar advena*	Spatterdock
MD EF12	1	*Typha angustifolia* *Spartina cynosuroides* *Peltandra virginica* *Polygonum arifolium* *Ponteria cordata*	Narrowleaf cattail Big cordgrass Arrow arum Halberd leaved tearthumb Pickerelweed
	2	*Polygonum arifolium* *Peltandra virginica* *Typha angustifolia* *Spartina cynosuroides*	Halberd leaved tearthumb Arrow arum Narrowleaf cattail Big cordgrass
	3	*Typha angustifolia* *Peltandra virginica* *Polygonum arifolium* *Hibiscus grandiflorus* *Persicaria sp.*	Narrowleaf cattail Arrow arum Halberd leaved tearthumb Swamp hibiscus Knotweed
	4	*Typha angustifolia* *Peltandra virginica* *Polygonum arifolium* *Spartina alterniflora* *Spartina cynosuroides*	Narrowleaf cattail Arrow arum Halberd leaved tearthumb Spartina alterniflora Big cordgrass
MD EF09	1	*Phragmites australis* *Hibiscus grandiflorus* *Impatiens capensis*	Common reed Swamp hibiscus Jewelweed
	2	*Phragmites australis*	Common reed
	3	*Phragmites australis*	Common reed

MD ENF10	1	*Phragmites australis* *Impatiens capensis* *Berberis sp.*	Common reed Jewelweed Barberry
	2	*Typha angustifolia* *Peltandra virginica* *Althaea officinalis* *Pontederia cordata*	Narrowleaf cattail Arrow arum Marshmallow Pickerelweed
	3	*Typha angustifolia* *Peltandra virginica* *Althaea officinalis* *Phragmites australis*	Narrowleaf cattail Arrow arum Marshmallow Common reed
	4	*Phragmites australis*	Common reed
	5	*Typha angustifolia* *Phragmites australis* *Spartina patens* *Peltandra virginica* *Bolboschoenus maritimus*	Narrowleaf cattail Common reed Saltmeadow cordgrass Arrow arrum Saltmarsh bullrush
MD ENF04	1	*Phragmites australis* *Typha angustifolia* *Schoenoplectus americanus* *Nyssa sylvatica* (dead)	Common reed Narrowleaf cattail Olney's three square Black gum
	2	*Phragmites australis* *Schoenoplectus americanus* *Hibiscus grandiflorus*	Common reed Olney's three square Swamp hibiscus
	3	*Bolboschoenus maritimus* *Juncus romarianus* *Spartina cynosuroides*	Saltmarsh bulrush Black needlerush Big cordgrass
	4	*Phragmites australis*	Common reed
MD ENF06	1	*Phragmites australis* *Toxicodendron radicans*	Common reed Poison ivy
	2	*Phragmites australis* *Schoenoplectus americanus* *Eleocharis parvula*	Common reed Olney's three square Dwarf spikerush

	3	*Spartina patens* *Distichlis spicata* *Schoenoplectus americanus*	Saltmeadow cordgrass Seashore saltgrass Olney's three square
	4	*Spartina patens* *Distichlis spicata* *Spartina cynosuroides*	Saltmeadow cordgrass Seashore saltgrass Big cordgrass
MD ENF09	1	*Typha latifolia* *Typha angustifolia* *Hibiscus grandiflorus*	Broadleaf cattail Narrowleaf cattail Swamp hibiscus
	2	*Asclepias incarnata* *Hibiscus grandiflorus*	Saltmarsh bulrush Swamp Milkweed Swmap hibiscus
	3	*Typha latifolia* *Bolboschoenus maritimus* *Hibiscus grandiflorus*	Broadleaf cattail Salmarsh bulrush Swamp hibiscus
	4	*Typha latifolia* *Typha angustifolia* *Hibiscus grandiflorus* *Phragmites australis* *Symphyotrichum subulatum* *Schoenoplectus americanus*	Braodleaf cattail Narrowleaf cattail Swamp hibiscus Common reed Saltmarsh aster Olney's three sqaure
	5	*Saprtina alternifora* *Bolboschoenus maritimus* *Hibiscus grandiflorus* *Spartina cynosuroides*	Smooth cordgrass Salmarsh bulrush Swamp hibiscus Big cordgrass
MD ENF09	1	*Persicaria sp.* *Phragmites australis* *Spartina alterniflora* *Schoenoplectus americanus* *Pinus taeda (standing dead)* *Typha angustifolia* *Spartina patens*	Knotweed Common reed Smooth cordgrass Olney's three sqaure Loblolly pine Narrowleaf cattail Saltmeadow cordgrass

	2	*Spartina alterniflora*	Smooth cordgrass
		Spartina cynosuroides	Big cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
		Spartina cynosuroides	Big cordgrass
		Althaea officinalis	Marsh mallow
		Amaranthus cannabinus	Saltmarsh hemp
	4	*Phragmites australis*	Common reed
		Spartina alterniflora	Smooth cordgrass
		Spartina cynosuroides	Big cordgrass
		Bolboschoenus maritimus	Salmarsh bulrush
NJ ENF01	1	*Spartina alterniflora*	Smooth cordgrass
	2	*Spartina alterniflora*	Smooth cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass
MD SU11	1	*Typha angustifolia*	Narrowleaf cattail
		Lonicera japonica	Japanese honeysuckle
		Nyssa sylvatica	Blackgum
		Baccharis halimifolia	Groundseltree
	2	*Spartina alterniflora*	Smooth cordgrass
		Iva frutescens	High tide bush
		Spartina patens	Saltmeadow cordgrass
	3	*Phragmites australis*	Common Reed
		Iva frutescens	High tide bush
		Spartina alterniflora	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass
		Phragmites australis	Common Reed
		Iva frutescens	High tide bush
MD SU13	1	*Spartina patens*	Saltmeadow cordgrass
		Distichlis spicata	Seashore saltgrass
		Iva frutescens	High tide bush
		Pinus taeda	Loblolly pine
	2	*Iva frutescens*	High tide bush
		Spartina patens	Saltmeadow cordgrass
		Scirpus sp.	Sedge
	3	*Spartina alterniflora*	Smooth cordgrass
		Distichilis spicata	Seashore saltgrass
		Scirpoides holoschoenus	Bullrush

	4	*Scirpoides holoschoenus*	Bullrush
		Spartina alterniflora	Smooth cordgrass
MD SU15	1	*Phragmites australis*	Common Reed
		Iva frutescens	High tide bush
		Pinus taeda	Loblolly pine
		Diospyros virginiana	Persimmon
		Quercus phellos	Willow oak
	2	*Phragmites australis*	Common Reed
		Iva frutescens	High tide bush
		Spartina patens	Saltmeadow cordgrass
		Distichilis spicata	Seashore saltgrass
	3	*Phragmites australis*	Common Reed
		Iva frutescens	High tide bush
		Spartina patens	Saltmeadow cordgrass
		Distichilis spicata	Seashore saltgrass
		Schoenoplectus americanus	Olney's three square
		Juncus roemerianus	Black needlerush
		Bolboschoenus maritimus	Saltmarsh bulrush
	4	*Phragmites australis*	Common Reed
		Iva frutescens	High tide bush
		Bolboschoenus maritimus	Saltmarsh bulrush
		Spartina alterniflora	Smooth cordgrass
		Spartina cynosuroides	Big cordgrass
MD SU01	1	*Phragmites australis*	Common reed
		Distichlis spicata	Seashore saltgrass
		Iva frutescens	High tide bush
		Spartina patens	Saltmeadow cordgrass
	2	*Spartina patens*	Saltmeadow cordgrass
		Spartina alterniflora	Smooth cordgrass
		Distichlis spicata	Seashore saltgrass
	3	*Spartina patens*	Saltmeadow cordgrass
		Spartina alterniflora	Smooth cordgrass
		Distichlis spicata	Seashore saltgrass
		Junas roemerianus	Needlerush
	4	*Distichlis spicata*	Seashore saltgrass
		Juncus roemerianus	Needlerush

	5	*Juncus roemerianus*	Needlersuh
		Spartina alterniflora	Smooth cordgrass
MD SU04	1	*Phragmites australis*	Common reed
		Pinus taeda	Loblolly pine
		Toxicodendron radicans	Poison Ivy
		Juniperus virginiana	Red cedar
	2	*Phragmites australis*	Common reed
	3	*Phragmites australis*	Common reed
		Distichlis spicata	Seashore saltgrass
		Iva frutescens	High tide bush
		Spartina patens	Saltmeadow cordgrass
		Fimbristylis	Fringe rush
	4	*Juncus roemerianus*	Needlersuh
		Spartina alterniflora	Smooth cordgrass
		Juncus roemerianus	Needlerush
MD CB02	1	*Phragmites australis*	Common reed
		Distichlis spicata	Seashore saltgrass
		Iva frutescens	High tide bush
		Myrica sp.	Bayberry
	2	*Spartina patens*	Saltmeadow cordgrass
		Iva frutescens	High tide bush
		Myrica sp.	Bayberry
	3	*Spartina patens*	Saltmeadow cordgrass
		Spartina alterniflora	Smooth cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass
		Iva frutescens	High tide bush
		Distichlis spicata	Seashore saltgrass
		Salicornia sp.	Glasswort
MD CB01	1	*Iva frutescens*	High tide bush
		Myrica sp.	Bayberry
		?	Rush sp.?
	2	*Iva frutescens*	High tide bush
		Phragmites australis	Common reed
		Morella cerifera	Wax myrtle
		Myrica sp.	Bayberry
		Schoenoplectus americanus	Olney's 3 square
		Eleocharis parvula	Dwarf spikerush

	3	*Spartina patens*	Saltmeadow cordgrass
		Iva frutescens	High tide bush
		Distichlis spicata	Seashore saltgrass
	4	*Spartina alterniflora*	Smooth cordgrass
		Spartina patens	High tide bush
		Salicornia sp.	Glasswort
MD CB03	1	*Iva frutescens*	High tide bush
		Myrica sp.	Bayberry
		Pinus taeda	Loblolly pine (dead)
		Eleocharis parvula	Dwarf spikerush
	2	*Spartina patens*	Saltmeadow cordgrass
		Iva frutescens	High tide bush
		Distichlis spicata	Seashore saltgrass
		Myrica sp.	Bayberry
	3	*Spartina alterniflora*	Smooth cordgrass
		Juncus roemerianus	Black needlerush
	4	*Spartina alterniflora*	Smooth cordgrass
		Juncus roemerianus	Black needlerush
		Salicornia sp.	Glasswort
	5	*Spartina patens*	Saltmeadow cordgrass
		Distichlis spicata	Seashore saltgrass
MD CB04	1	*Spartina patens*	Saltmeadow cordgrass
		Iva frutescens	High tide bush
		Distichlis spicata	Seashore saltgrass
		Pinus taeda	Loblolly pine
	2	*Spartina alterniflora*	Smooth cordgrass
		Juncus roemerianus	Black needlerush
	3	*Spartina alterniflora*	Smooth cordgrass
		Juncus roemerianus	Black needlerush
		Salicornia sp.	Glasswort
	4	*Juncus roemerianus*	Black needlerush
		Salicornia sp.	Glasswort
DE CB01	1	*Spartina alterniflora*	Smooth cordgrass
		Iva frutescens	High tide bush
		Myrica sp.	Baryberry
		Phragmites australis	Common reed
	2	*Spartina alterniflora*	Smooth cordgrass

	3	*Spartina alterniflora* *Salicornia sp.*	Smooth cordgrass Glasswort
	4	*Spartina alterniflora*	Smooth cordgrass
DE CB01	1	*Spartina patens* *Iva frutescens* *Salicornia sp.* *Cedrus sp.*	Saltmeadow cordgrass High tide bush Glasswort Cedar
	2	*Spartina alterniflora* *Salicornia sp.*	Smooth cordgrass Glasswort
	3	*Spartina alterniflora* *Salicornia sp.*	Smooth cordgrass Glasswort
	4	*Spartina alterniflora*	Smooth cordgrass
	5	*Spartina alterniflora*	Smooth cordgrass
MD CM02	1	*Spartina alterniflora* *Phragmites australis* *Iva frutescens*	Smooth cordgrass Common Reed High tide bush
	2	*Spartina alterniflora*	Smooth cordgrass
	3	*Spartina alterniflora* *Salicornia sp. (dead)*	Smooth cordgrass Glasswort (dead)
	4	*Spartina alterniflora* *Salicornia sp.* *Iva frutescens*	Smooth cordgrass Glassworts sp. High tide bush
MD CM03	1	*Spartina alterniflora* *Bolboschoenus maritimus*	Smooth cordgrass Saltmarsh bullrush
	2	*Spartina alterniflora* *Bolboschoenus maritimus* *Spartina patens*	Smooth cordgrass Saltmarsh bullrush Saltmeadow cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass
MD CM07	1	*Phragmites australis* *Distichlis spicata* *Spartina alterniflora*	Common reed Seashore saltgrass Smooth cordgrass
	2	*Spartina alterniflora*	Smooth cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass

MD CM04	1	*Spartina patens*	Saltmeadow cordgrass
		Spartina alterniflora	Smooth cordgrass
		Distichlis spicata	Seashore saltgrass
	2	*Spartina alterniflora*	Smooth cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
	4	*Spartina patens*	Saltmeadow cordgrass
		Spartina alterniflora	Smooth cordgrass
MD CM09	1	*Spartina alteriniflora*	Smooth cordgrass
		Phragmites australis	Common reed
	2	*Spartina alterniflora*	Smooth cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
	4	*Spartina alterniflora*	Smooth cordgrass
	5	*Spartina alterniflora*	Smooth cordgrass
NJ CM01	1	*Spartina alterniflora*	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass
		Phragmites australis	Common reed
	2	*Spartina alterniflora*	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass
	3	*Spartina alterniflora*	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass
		Salicornia sp.	Glasswort
	4	*Spartina alterniflora*	Smooth cordgrass
	5	*Spartina alterniflora*	Smooth cordgrass
		Spartina patens	Saltmeadow cordgrass

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