**Supplementary Materials for Dataset:**

*Soil organic carbon in northeast, USA tidal wetlands for depths:*

*0-5, 0-30, 0-100 and 0-200cm*

As posted on:

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Associated Peer-Reviewed Paper:

*Soil organic carbon distributions in tidal wetlands of the northeast, USA;* DOI: XXXXXXXX

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*Note: “Supplementary Figures” are provided in a separate document with the manuscript.*

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**Study Area/ General Characteristics of Each Zone:**

*Here, we detail the geographic extent of each zone and environmental characteristics. Information was predominately obtained from the United States (U.S.) Department of Agriculture (USDA) Handbook 296: Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. (Issued 2006).*

Additional information for terms used in these descriptions, such as soil orders, classifications, and soil temperature and moisture regimes can be found within USDA - Natural Resources Conservation Service (USDA-NRCS) Soil Taxonomy Materials:

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Available at: <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577>

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC.

Available at: <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580>

Soil Survey Staff. 2015. Illustrated guide to soil taxonomy. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska.

Available at: <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580>

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**Zone 1: Maine-Canada border (Eastport, Maine) to Rockport, Massachusetts**: LRR R (Northeastern Forge and Forest Region), MLRA 144A (New England and Eastern New York Upland, Southern Part) and MLRA 144B (New England and Eastern New York Upland, Northern Part). Soils within these areas are comprised of predominately entisols, inceptisols, spodosols and histosols (soil orders) within glacially deposited and influenced sediments. The landscape is till mantled, glacial lake sediments, marine sediments and glacial outwash from the most recent glacial retreat from 10,000 to 12,000 years ago (US Department of Agriculture, 2006). Soil temperature regimes are mesic to frigid (heading north) (US Department of Agriculture, 2006) with aquic or udic moisture regimes. Tidal marsh soils are very poorly drained, predominately Sulfihemists and Sulfaquents taxonomic classifications (US Department of Agriculture, 2006) with Endoaquepts and Epiaquepts adjacent to tidal marshes (US Department of Agriculture, 2006). Average annual precipitation ranges from 840 to 1,370 mm (US Department of Agriculture, 2006) with large amounts of snow from nor’easters in the winter. Annual temperature is 4 to 12 degrees C with an average of 160-190 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 1: Essex, Castle, Ipswich, Eagle Hill, Bowley, Parker, Plum Island, Merrimac, Blackwater, Hampton, Taylor, Piscataqua, York, Cape Neddick, Ogunquit, Webhanney, Merriland, Little, Mousam, Kennebunk, Batson, Saco, Scarborough, Spurwink, Fore, Presumpscot, Royal, Cousins, Harraseeket, Androscoggin, New Meadows, Kennebec, Sasanoa, Sheepscot, Back, Damariscotta, Johns, Pemaquid, Medomak, Meduncook, St. George, Weskeag, Goose, Ducktrap, Skillings, Pleasant, and St. Croix Rivers. Zone 1 is west of the Atlantic Ocean. Due to the glaciated nature of this portion of the study area, numerous bays, coves, harbors and sounds exist. A few of the more prevalent larger waterbodies: Ipswich Bay, Saco Bay, Portland Harbor, Casco Bay, Sheepscot Bay, Johns Bay, Muscongus Bay, West Penobscot Bay, Isle au Haut Bay, Western Bay and the Gulf of Maine.

**Zone 2: Rockport Massachusetts to Rhode Island – Massachusetts east, coastal border**: LRR S (Northern Atlantic Slope Diversified Farming Region) and LRR R (Northeastern Forge and Forest Region), MLRA 149B (Long Island -Cape Code Coastal Lowland) and MLRA 144A (New England and Eastern New York Upland, Southern Part). Soils within these areas comprise of predominately entisols, inceptisols (histosols in tidal wetlands) soil orders within glacially deposited and influenced sediments (US Department of Agriculture, 2006). The landscape is unconsolidated glacial outwash deposits of sand and gravel with coastal plains/margins filled with glacial lake sediments, marine sediments and glacial outwash from the most recent glacial retreat from 10,000 to 12,000 years ago (US Department of Agriculture, 2006). Soil temperature regimes are mesic (US Department of Agriculture, 2006) with aquic or udic moisture regimes. Tidal marsh soils are very poorly drained, predominately Sulfihemists and Sulfaquents taxonomic classifications (US Department of Agriculture, 2006) with Endoaquepts and Epiaquepts adjacent to tidal marshes (US Department of Agriculture, 2006). Average annual precipitation is 1,040 to 1,370 mm (US Department of Agriculture, 2006) with average snowfall of 15 to 100 cm (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 6 to 12 degrees C with an average of 190-220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 2: Mattapoisett, Weweantic, Wareham, Agawam, Pocasset, Quashnet, Mashpee, Quaker, Santuit, Little, Marstons Mill, Bumps, Centerville, Bass, Swan Pond, Herring, Oyster Pond, Mitchell, Namequoit, Pamet, Eel, Jones, Bluefish, Back, Green Harbor, South, North, Weir, Weymouth Back, Town, Neponset, Charles, Chelsea, Pines, Saugus, Danvers, Waters and Annisquam Rivers. Zone 2 is west of the Atlantic Ocean, north of Rhode Island and Nantucket Sounds with Buzzards Bay, Pleasant Bay, Cape Cod Canal, Cape Cod Bay, Plymouth Bay, Quincy Bay, Boston Harbor, Nahant Bay, Massachusetts Bay and Gloucester Harbor also present in the study area.

**Zone 3: Rhode Island – Massachusetts east, coastal border to East Hampton, Long Island, New York**: LRR S (Northern Atlantic Slope Diversified Farming Region) and LRR R (Northeastern Forge and Forest Region), MLRA 149B (Long Island -Cape Code Coastal Lowland), MLRA 144A (New England and Eastern New York Upland, Southern Part) and MLRA 145 (Connecticut Valley). Soils within these areas comprise of predominately entisols and inceptisols (and histosols in tidal wetlands) soil orders within glacially deposited and influenced sediments (US Department of Agriculture, 2006). The landscape is unconsolidated glacial outwash deposits of sand and gravel for Long Island with coastal plains/margins filled with glacial lake sediments, marine sediments and glacial outwash from the most recent glacial retreat from 10,000 to 12,000 years ago (US Department of Agriculture, 2006). Soil temperature regimes are mesic (US Department of Agriculture, 2006) with aquic or udic moisture regimes. Tidal marsh soils are very poorly drained, predominately Sulfihemists and Sulfaquents taxonomic classifications (US Department of Agriculture, 2006) with Endoaquepts and Epiaquepts adjacent to tidal marshes (US Department of Agriculture, 2006). Average annual precipitation is 840 to 1,370 mm (US Department of Agriculture, 2006) with average snowfall of 15 to 100 cm (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 6 to 15 degrees C with an average of 180-220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 3: Hutchison, Byram, Rippowam, Noroton, Fivemile, Norwalk, Saugatuck, Mill, Pequoonnock, Housatonic, Wepawaug, Indian, Oyster, Cove, Quinnipac, Farm, Branford, West, East, Hammonasset, Hammock, Menunketsuck, Patchgue, Connecticut, Lieutenant, Black Hall, Three mile, Four mile, Pattagansett, Niantic, Thames, Poquonock, Mystic, Pettaquamscutt, Providence, Tauton, Sakonnet, Slocumns, Paskamanset and Acushnet Rivers. Zone 3 is situated on either side of the Long Island Sound, west of the Atlantic Ocean containing Smithtown Bay, New Haven Harbor, Guilford Harbor, Clinton Harbor, Westbrook Harbor, Niantic Bay, New London Harbor, Fishers Island Sound, Little Narragansett Bay, Narragansett Bay and Rhode Island Sound.

**Zone 4: East Hampton, Long Island, New York to Point Pleasant, New Jersey**: USDA-NRCS LRR T (Atlantic and Gulf Coast Lowland Forest and Crop Region) and LRR S (Northern Atlantic Slope Diversified Farming Region), MLRA 153D (Northern tidewater area), MLRA 149A (Northern Coastal Plain) and MLRA 149B (Long Island -Cape Code Coastal Lowland). Soils within these areas comprise of predominately utlisols, histosols, entisols, spodosols and inceptisols (soil orders) within coastal plain deposited sediments (US Department of Agriculture, 2006). The landscape is gently sloping coastal plain made up of unconsolidated sand, silt, and clay deposited by ancient rivers as continental sediments in the southern portion to unconsolidated glacial outwash deposits of sand and gravel in the northern portion of this zone (US Department of Agriculture, 2006). Soil temperature regimes are mesic (US Department of Agriculture, 2006) with aquic or udic moisture regimes. Tidal marsh soils are very poorly drained, predominately Sulfihemists and Sulfaquents taxonomic classifications (US Department of Agriculture, 2006). Average annual precipitation is 965 to 1,220 mm (US Department of Agriculture, 2006) with average snowfall of 15 cm (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 10 to 15 degrees C with an average of 220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 4: Shark, Shrewsbury, Navesink, Raritan, Hudson, East, Conneticut, Carmans, Forge, Terrell, East, Speonnk, Aspatick Rivers (south to north). Zone 4 is situated along the Atlantic Ocean with a small portion within the Raritan, Lower, Lower New York and Sandy Hook Bays.

**Zone 5: Point Pleasant, New Jersey to Heislerville, New Jersey**: USDA-NRCS LRR T (Atlantic and Gulf Coast Lowland Forest and Crop Region): MLRA 153D (Northern tidewater area). Soils within MLRA 153D comprise of predominately utlisols, histosols, entisols, spodosols and inceptisols (soil orders) within coastal plain deposited sediments (US Department of Agriculture, 2006). The landscape is gently sloping coastal plain, made up of unconsolidated sand, silt, and clay deposited by ancient rivers as continental sediments (US Department of Agriculture, 2006). Soil temperature regimes are mesic (US Department of Agriculture, 2006) with aquic or udic moisture regimes throughout MLRA 153D. Tidal marsh soils are predominately very poorly drained Sulfihemists and Sulfaquents (US Department of Agriculture, 2006). Average annual precipitation is 965 to 1,145 mm (US Department of Agriculture, 2006) with average snowfall of 15 cm (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 11 to 15 degrees C with an average of 220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 5: Great Egg Harbor, Mullica, Wading, Bass, Toms, Metedecank and Manasquan Rivers (south to north). Zone 5 is situated along the Atlantic Ocean with a small portion within the Delaware River/Bay. Richardson Sound, Great Sound, Ludlam Bay, Egg Harbor Bay, Scull Bay, Lakes Bay, Absecon Bay, Reeds Bay, Little Bay, Great Bay, Barnegat Bay and Silver Bay waterbodies existing north of Cape May, New Jersey along the Atlantic Ocean coast.

**Zone 6: Heislerville, New Jersey to Bowers Beach, Delaware**: USDA-NRCS LRR T (Atlantic and Gulf Coast Lowland Forest and Crop Region) and LRR S (Northern Atlantic Slope Diversified Farming Region), MLRA 153C (Mid-Atlantic Coastal Plain) and MLRA 149A (Northern Coastal Plain). Soils within MLRA 153C and MLRA 149A comprise of predominately utlisols, entisols and inceptisols (soil orders) with some spodosols and histosols within coastal plain deposited sediments (and some piedmont materials intermixed at times) (US Department of Agriculture, 2006). The landscape is gently sloping coastal plain (embayed section) made up of unconsolidated sand, silt, and clay deposited by ancient rivers as continental sediments (US Department of Agriculture, 2006). In the northern portion of this zone, particularly in and around Wilmington, Delaware exists the fall line, a boundary separating the coastal plain and piedmont regions. In this zone the boundaries are not definitive and there can be mixing of materials. Soil temperature regimes are mesic (US Department of Agriculture, 2006) with predominately aquic or udic soil moisture regimes throughout MLRA 153C and 149A. Tidal marsh soils are predominately very poorly drained, Sulfihemists and Sulfaquents (US Department of Agriculture, 2006). Average annual precipitation is 1,015 to 1,195 mm (US Department of Agriculture, 2006) with average snowfall of 15 to 75 cm (increasing in northern Delaware in most years). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 11 to 14 degrees C with an average of 220 freeze free days (US Department of Agriculture, 2006). Major rivers draining to and within zone 6: Murderkill, St. Jones, Leipsic, Smyrna, Appoquinimink, Christina, Brandywine, Delaware, Salem, Cohansey and Maurice Rivers (clockwise west to east). Note the Chesapeake and Delaware canal also exists in this zone in addition to several coves along the New Jersey shoreline.

**Zone 7: Bowers Beach, Delaware to Onancock, Virginia**: USDA-NRCS LRR T (Atlantic and Gulf Coast Lowland Forest and Crop Region), MLRA 153B (Tidewater Area) and 153D (Northern tidewater area). Soils within MLRA 153B and 153D comprise of predominately utlisols, alfisols, histosols, entisols, spodosols and inceptisols (soil orders) within coastal plain deposited sediments. In agricultural areas, cultivated alfisols do exist, in addition to once freshwater, non-tidal wetlands receiving haline waters (becoming forested seasonally tidal or tidal wetlands; i.e., changing the base saturation of the once wetland ultisols to wetland alfisols). The landscape is gently sloping coastal plain made up of unconsolidated sand, silt, and clay deposited by ancient rivers as continental sediments (US Department of Agriculture, 2006). Soil temperature regimes are thermic (south of Maryland-Virginia line) and mesic (US Department of Agriculture, 2006) with predominately aquic (and to a lesser extent udic) moisture regimes throughout the MLRA 153B and 153D. Tidal marsh soils are predominately very poorly drained, Sulfihemists and Sulfaquents (US Department of Agriculture, 2006). Average annual precipitation is 965 to 1,145 mm (US Department of Agriculture, 2006) with average snowfall of 15 cm, however within the northern portion of this zone (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 11 to 15 degrees C (north to south) with an average of 220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 7: Machipongo, Saint Martin, Indian, Broadkill, Delaware and Mispillion Rivers (south to north). Note: due to the narrow width of the Delmarva Peninsula within the southern portion, there are many creeks and branches of drainage ways entering in and around tidal wetlands and forming small bays in a string of interconnected coastal bays from Delaware south to Virginia, however major rivers are mostly absent due to the large, westward drainage of the Pocomoke River and the narrow geography of the peninsula. Zone 7 is within the Chesapeake Bay (eastern shore), Atlantic Ocean and Delaware River/Bay watersheds. The small bays within the study area from Cape Charles north to Chincoteague, Virginia comprise of: Magothy, Cobb, Outlet, Hog Island, Small Island, Upshur, Swash, Bradford, Burtons, Metompkin, Gargathy, Kegotank, Womans, Bogues, Powells, Watts, Shelly and Toms Cove. North of Chincoteague, the bays take on larger form with small bays within the rather large inland bays existing behind well-defined barrier islands or mainland. Chincoteague, Sinepuxent, Isle of Wight, Assawoman, Little Assawoman, Indian River and Rehoboth Bays are all larger bays existing within the northern portion of the study area. Note, the small bays in Virginia are subject to higher rates of erosion as they are poorly protected from the Atlantic Ocean (Hapke et al., 2013).

**Zone 8: Onancock, Virginia to Taylors Island, Maryland:** USDA-NRCS LRR T (Atlantic and Gulf Coast Lowland Forest and Crop Region), MLRA 153D (Northern tidewater area). Soils within MLRA 153D comprise of predominately utlisols, histosols, entisols, spodosols and inceptisols soil orders within coastal plain deposited sediments (US Department of Agriculture, 2006). In agricultural areas, cultivated alfisols do exist, in addition to once freshwater non-tidal wetlands receiving haline waters (becoming forested seasonally tidal or tidal wetlands) and changing the base saturation of the once wetland ultisols to wetland alfisols. The landscape is gently sloping coastal plain made up of unconsolidated sand, silt and clay deposited by ancient rivers as continental sediments (US Department of Agriculture, 2006). Soil temperature regimes are mesic (US Department of Agriculture, 2006) with aquic or udic moisture regimes throughout the MLRA 153D. Tidal marsh soils are predominately very poorly drained, Sulfihemists and Sulfaquents (US Department of Agriculture, 2006). Average annual precipitation is 965 to 1,145 mm (US Department of Agriculture, 2006) with average snowfall of 15 cm to none in some years of the very southern portion of Delmarva (US Department of Agriculture, 2006). Precipitation is noted to be evenly distributed throughout the year. Average annual temperature is 11 to 15 degrees C with an average of 220 freeze free days (US Department of Agriculture, 2006). Rivers draining to and within zone 8: Blackwater, Honga, Nanticoke, Manokin, Big Annemessex and Pocomoke Rivers (north to south). Zone 8 is entirely within the Chesapeake Bay watershed and is situated on the eastern shore of Maryland and Virginia. Adjacent to zone 8 and within the Chesapeake Bay are: Tar Bay, Fishing Bay, Tangier Sound and the Pocomoke Sound.

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**Creation of the Region of Interest Zones:**

The ROI and zones are the same as those used in Correll et al. (2019). The zones were originally defined by the Saltmarsh Habitat & Avian Research Program (SHARP) and developed based upon major watersheds or geomorphological features (Conway , Courtney J. and Droege, 2006; Wiest et al., 2016). Furthermore, we found zones are additionally differentiated by ecological, climatic (average temperatures, degree days (Northeast Regional Climate Center), plant hardiness zones (USDA)), parent materials (Gridded National Soil Survey Geographic Database (gNATSGO)) and in some cases, halinity (also referred to as salinity in many works) gradients within embayed areas (Reed et al., 2008).

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**Creation of the Region of Interest and Cover Types Map:**

The ROI was previously mapped and classified for marsh vegetation classification/cover types for the purposes of tidal marsh avian habitats by Correll et al. (2019). The final result of the Correll et al. (2019) study was a map of the ROI defining marsh areas by 3 m pixels of high marsh, low marsh, pools/pannes, mudflat, phragmites, open water/streams, terrestrial border and upland/other. Training polygons of marsh cover types were collected by field crews or manually digitized from aerial imagery. Training data was combined with raster covariables that were then run through a series of models consisting of classification and regression trees (CART), random forest (RF) and support vector machines (SVM). The layers were aligned with National Oceanic and Atmospheric Administration’s (NOAA) tidal station data to create the resulting map of marsh vegetation cover types along the northeastern seaboard.

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**Information on Correll et al. (2019) Covariables:**

Here we provide some brief information on each of the Correll et al. (2019) raster covariable layers received. The DEM utilized was from 2015 at 3 m resolution as provided by the U.S. Geological Survey (USGS) National Elevation Dataset (NED)’s 3D Elevation Program (3DEP) (USGS, 2015). Please note: there were some small portions of the ROI where no DEM was available. National Agriculture Imagery Program (NAIP) imagery (USDA, 2016) was flown and taken during the growing season of 2014 and 2015. The original resolution was 1 m raster pixels, rescaled to 3 m resolution by the Correll et al. (2019) authors to match the DEM resolutions. The NAIP imagery is comprised of blue, green, red and near infrared (NIR) spectral bands. The Correll et al. (2019) authors utilized these rescaled bands, to generate Difference Vegetation Index (DVI) (Richardson, 1977), Normalized Difference Vegetation Index (NDVI) (Rouse, Haas, Schell, & Deering, 1973) and Normalized Difference Water Index (NDWI) (**McFeeters, 1996-05)** raster layers. NDVI is calculated using the red and NIR bands resulting in a scale of -1 to +1 (SHARP, 2017; Rouse, Haas, Schell, & Deering, 1973). NDVI is utilized to assess the greenness of surficial vegetation (SHARP, 2017; Rouse, Haas, Schell, & Deering, 1973). NDWI is calculated using the green and NIR bands resulting also in the -1 to +1 scale (**McFeeters, 1996-05;** SHARP, 2017). NDWI indicates the water content in the vegetation or soil (Gao, 1996). DVI is calculated using the red and NIR bands and does not result in values between -1 and +1 like NDVI and NDWI (Richardson, 1977; SHARP, 2017). The advantage of utilizing both DVI and NDVI is coverage of various and differing vegetation types through spectral bands, some of which may not be captured within one of these two indices.

Additional information for the Correll et al. (2019) study, including access to the final cover types map, can be found within the publication, within the following websites and/or three available supplemental documents provided by the Correll et al. (2019) authors (through the following website addresses):

Websites/Resources:

Journal of Applied Wetland Science, “Fine-Scale Mapping of Coastal Plant Communities in the Northeastern USA”, Digital Object Identifier (DOI): <https://doi.org/10.1007/s13157-018-1028-3>

Saltmarsh Habitat & Avian Research Program (SHARP):

<https://www.tidalmarshbirds.org/?page_id=2168>

Northeast Conservation Planning Atlas (NCPA):

<https://nalcc.databasin.org/galleries/46d6e771dd6f4fdb8aa5eb46efffffa7>

Documents:

3157\_2018\_1028\_MOESM1\_ESM.docx (available on the webpage of the journal article)

MarshLayer\_Metadata\_24Aug17-2.pdf (available on NCPA and SHARP websites)

MarshLayer\_Whitepaper\_24Aug17-2.pdf (available on NCPA and SHARP websites)

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**Terrain Derivatives - Additional Information:**

Slope and aspect account for the angle and changes in slope on a given land surface (Hijmans et al., 2020; Fleming & Hoffer, 1979; Horn, 1981; Ritter, 1987). Hillshade is calculated using slope, aspect, angle and direction of the sun (Hijmans et al., 2020; Horn, 1981). Topographic Ruggedness Index (TRI), Topographic Position Index (TPI) and roughness (rough) are calculated based upon the difference calculations with a given pixel and eight (8) surrounding pixels (SHARP, 2017; Wilson, O’Connell, Brown, Guinan, & Grehan, 2007) . TRI is the mean of the absolute differences, TPI is the difference between the cell value and the mean of the surrounding cells. Roughness involves the minimum and maximum values as compared to the surrounding cells (SHARP, 2017; Wilson, O’Connell, Brown, Guinan, & Grehan, 2007).

Six additional raster layers of slope, aspect, hillshade, TRI, TPI and rough were calculated using the DEM provided by the Correll et al. (2019) authors. Terrain derivatives were calculated using the Raster package in open source R software, using R Studio (Hijmans et al., 2020). Terrain derivatives were created using the 2 km by 2 km tiling system.

Terrain Derivatives were also generated through System for Automated Geoscientific Analyses (SAGA) Geographic Information Systems (GIS), however since not all of the terrain derivatives processed through SAGA (particularly for Zone 1, the largest zone), the SAGA generated terrain derivatives were not utilized for our study. This information is simply provided here to let the readers know there is another open source application to gain more layers of terrain derivatives than the six processed through the Raster R package. However, since we had difficulties processing the large Zone 1, the six from the raster package were used.

Example R Code used to generate Terrain Derivatives (per zone):

Note: This code was adapted from code provided within the Raster package documentation (pages 109 and 208, document dated November 14, 2020), (Hijmans et al., 2020).

#Load in the 2 km Study Area Tiles created previously in the code: #Correlletal\_Zones1to8\_2kmTilingCode.R
TwokmStudyAreaTiles\_Zone1 <- list.files('~/Vargas\_Lab/Research/R/Soil Carbon R Work/Covariates/Study Area Tiles/2 km Tiles - CorrellZones/Zone\_1\_TryTwo',
 full.names = TRUE)

#Set the working directory for where the new files will be stored.
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Covariates/Study Area Tiles/Terrain Derivatives - 2km Tiles - All Correll Input Data/Zone\_1\_TryTwo")

#Start the loop!
#i will be the tiles in the file path recognized above.

#Note: First layer to read in is the DEM, which is used to calculate the terrain derivatives.

for (i in 1:length(TwokmStudyAreaTiles\_Zone1)){

#Have the Tile be read in as a raster
 Tile\_X\_Step1<-raster(TwokmStudyAreaTiles\_Zone1 [i])

#Calculate the Slope, Aspect and Hillshade of the tile brought in
 Tile\_X\_Terrain\_Slope <- terrain(Tile\_X\_Step1, opt='slope')
 Tile\_X\_Terrain\_Aspect <- terrain(Tile\_X\_Step1, opt='aspect')
 Tile\_X\_Terrain\_Hillshade <- hillShade(Tile\_X\_Step1, Tile\_X\_Terrain\_Aspect, 40, 270)

#Calculate additional parameters such as TRI, TPI and Rough.
 #TRI = Topographic Ruggedness Index
 #TPI = Topographic Position Index
 #Rough = Roughness
 f <- matrix(1, nrow=3, ncol=3)
 Tile\_X\_Terrain\_TRI <- focal(Tile\_X\_Step1, w=f, fun=function(x, ...) sum(abs(x[-5]-x[5]))/8, pad=TRUE, padValue=NA)
 Tile\_X\_Terrain\_TPI <- focal(Tile\_X\_Step1, w=f, fun=function(x, ...) x[5] - mean(x[-5]), pad=TRUE, padValue=NA)
 Tile\_X\_Terrain\_Rough <- focal(Tile\_X\_Step1, w=f, fun=function(x, ...) max(x) - min(x), pad=TRUE, padValue=NA, na.rm=TRUE) #Stack these all to be one layer
 Terrain\_Derivatives\_TileX<-stack(Tile\_X\_Terrain\_Slope, Tile\_X\_Terrain\_Aspect, Tile\_X\_Terrain\_Hillshade, Tile\_X\_Terrain\_TRI, Tile\_X\_Terrain\_TPI, Tile\_X\_Terrain\_Rough)

 #Change the names of the layers so we know what they are later on...
 names(Terrain\_Derivatives\_TileX)<-c("Slope", "Aspect", "Hillshade", "TRI", "TPI", "Rough")

 #Tell us you (R) did this properly
 print('I utilized a 2km study area tile in Zone 1 and created Terrain Derivatives! Yay!')

#Stack the file
 Tile\_X\_Data <- stack(Terrain\_Derivatives\_TileX)

 #Use the tile # in the tile name
 Tile\_name <- unlist(strsplit(TwokmStudyAreaTiles\_Zone1 [i], '/'))[13]
 Name2 <- unlist(strsplit(Tile\_name, '-'))

#Save the tile... a tif file and name it with the input file name within it.
 writeRaster(Tile\_X\_Data, file=paste0('Tile\_TerrainDeriv\_', Name2[1], 'Zone1\_4-14-2020\_.tif'), overwrite=TRUE)

#Upon this being done, print the file path in the console.
 print(paste0(TwokmStudyAreaTiles\_Zone1[i], 'done'))}

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**Details on**

**Extraction of Cover Types, Mosaics of 2 km Tiles and Calculation of Stocks**

**from Model Results:**

To determine the soil organic carbon (SOC) stocks of just tidal wetlands, we utilized the Correll et al. (2019) marsh cover types map, removed the two marsh vegetation cover types: upland-other and open water/streams from the modeled 2 km tiles (since the original study area comprised of E2EM areas and 500 m buffers). This was accomplished by orchestrating the Correll et al. (2019) marsh cover types map to be in the same 2 km tile format. The cover types of non-tidal wetland areas were changed to NA values in the R program. The modeled tiles were then masked with the marsh cover types map and the resulting tile saved of the SOC predicted values in all areas with the exception of upland-other and open water/streams areas. The result was a 2 km tile with the SOC predictions of E2EM tidal wetlands. This was completed for all depths and all zones utilizing the sequential process of each tile with loops in R. This same process was utilized to generate results of SOC predictions from the RF ranger method model for each of the eight separate marsh cover types (i.e., results of only the high marsh regions, results of only the low marsh regions, etc.).

Example R Code:

#Correll et al DEM
DEM<- raster('~/Vargas\_Lab/Research/R/Soil Carbon R Work/Covariates/Study Area DEM/Regional\_DEM.tif')

#Model Output Results:
TwokmStudyAreaTiles\_Zone1\_RangerResults<-list.files('~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeling/Results/RandomForest\_RangerMethod/30cm/Zone\_1',
 full.names = TRUE)

#Set the working directory for where the new files will be stored.
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeling/Results/Extracted\_Correlletal\_Classes/Class2\_LowMarsh/30cm/Zone\_1")

#Start the loop!

#i will be the tiles in the file path recognized above.
for (i in 1:length(TwokmStudyAreaTiles\_Zone1\_RangerResults))

{ #Have the Tile be read in as a raster
 Tile\_X\_Step1A<-stack(TwokmStudyAreaTiles\_Zone1\_RangerResults[i])

#Set the Coordinate System...
 Tile\_X\_Step1B<- projectRaster(Tile\_X\_Step1A, crs=CRS("+proj=utm +zone=18 +datum=NAD83 +units=m +no\_defs +ellps=GRS80 +towgs84=0,0,0"))

#Crop the DEM to the Tiles with the DEM projection....

#Step 1: Obtain the Extent of the Tile:
 Task1\_Extent<-extent(Tile\_X\_Step1B)

 #Set the extent to be a spatial polygon...
 Task2\_ExtentPolygon<-as(Task1\_Extent, 'SpatialPolygons')

#Set the Coordinate System...
 proj4string(Task2\_ExtentPolygon)<- CRS("+proj=utm +zone=18 +datum=NAD83 +units=m +no\_defs +ellps=GRS80 +towgs84=0,0,0")

#Now Crop the tile....
 Task3\_CroppedTile <- crop(DEM, Task2\_ExtentPolygon)

extent(Task3\_CroppedTile) <- Tile\_X\_Step1B

#Tell R to ignore everything except the low marsh
 Task3\_CroppedTile[Task3\_CroppedTile==1]<- NA
 Task3\_CroppedTile[Task3\_CroppedTile==2]
 Task3\_CroppedTile[Task3\_CroppedTile==4] <- NA
 Task3\_CroppedTile[Task3\_CroppedTile==5] <- NA
 Task3\_CroppedTile[Task3\_CroppedTile==6] <- NA
 Task3\_CroppedTile[Task3\_CroppedTile==7] <- NA
 Task3\_CroppedTile[Task3\_CroppedTile==8] <- NA
 Task3\_CroppedTile[Task3\_CroppedTile==9] <- NA

#Mask the Tile...
 Task5\_MaskTile<-mask(Tile\_X\_Step1B, Task3\_CroppedTile)

print('The low marsh was extracted from this tile')

Tile\_name <- unlist(strsplit(TwokmStudyAreaTiles\_Zone1\_RangerResults[i], '/'))[16]

Name2 <- unlist(strsplit(Tile\_name, '\_'))

writeRaster(Task5\_MaskTile, file=paste0('RF\_RangerMethod\_Tile\_LOWMARSH\_30cm\_', Name2[5], '\_6-25-2020.tif'), overwrite=TRUE)
}

When all of the 2 km tiles for all of the zones and four focus depths were prepared for all of the marsh cover types and desired combinations, a mosaic code was utilized to bring together the results for all the tiles in each zone per depth to be one raster file.

Example R Code:

#Code is thoroughly commented for this first example. For questions further on in different depths and zones, refer back to this first, 5cm, zone 1 code commenting.

#Have R read in the 2km tile grid for Zone 1...
Tileskm2RDS\_Zone1<- readRDS(file = "~/Vargas\_Lab/Research/R/Soil Carbon R Work/Covariates/Study Area Tiles/2 km Tiles RDS Files/Tiles2kmStudyArea3METER-1-13-2020\_Zone1.rds")

#Tell R where to find the 2km Tiles of the random forest ranger method model result, which were then masked with water:
TwokmStudyAreaTiles\_Zone1\_TidalWetlandsOnly<-list.files("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeling/Results/TidalWetlands\_Only/5cm/Zone\_1",
 full.names = TRUE)

#List the files in that path:
list.files()

#Plot the RDS file of the 2km Grid...
plot(Tileskm2RDS\_Zone1)

#Set the working directory to be where the masked with water tiles are, for the zone and depth of interest:
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeling/Results/TidalWetlands\_Only/5cm/Zone\_1")

#Create a mosaic of the data....

#Run this example code provided from Mario in January:
#List the rasters in the file path provided:
ListRasters <- function(list\_names) {
 raster\_list <- list()

# initialize the list of rasters
 #Go through and create a list of the raster file names and stack those rasters.
 for (i in 1:(length(list\_names))){
 grd\_name <- list\_names[i]

# list\_names contains all the names of the images in .grd format

raster\_file <- stack(grd\_name) }

raster\_list <- append(raster\_list, raster\_file)

# update raster\_list at each iteration
}

#Can just do a few by putting [] at the end and putting something like [50:56]

#Select the rasters to proceed with for the mosaic:
wgs84.tif.list <- list.files(path=getwd(), pattern=glob2rx("\*.tif"), full.names=T,recursive=F) list\_names <- NULL
for (i in 1:length(wgs84.tif.list)) {
 list\_names <- c(list\_names, wgs84.tif.list[i])
}raster.list <-sapply(list\_names, FUN = ListRasters)
raster.list$fun <- mean
names(raster.list) <- NULL
raster.list$fun <- mean

#Bring together all the rasters!
Zone1\_TidalWetlandsOnly\_5cm <- do.call(mosaic, raster.list)

#plot the final result:
plot(Zone1\_TidalWetlandsOnly\_5cm )

#Set the Working Directory for where to save the file of the one mosaic for that zone:
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Final\_Mosaics/Results/TidalWetlands\_Only/5cm")

#Save the raster created:
writeRaster(Zone1\_TidalWetlandsOnly\_5cm , (file='5cm\_Zone1\_TidalWetlandsMosaic\_7-4-2020.tif'), overwrite=TRUE)

In all, there were 11 results of SOC stocks generated from the RF ranger method model and predictions for each depth per zone. To be clear, the 11 different results were as follows: one of the entire study area consisting of all eight marsh cover types, one of all terrestrial cover types with only the water cover types/areas removed, a result of only tidal wetland areas (water and upland-other areas removed) and a result for each of the eight marsh vegetation cover types: 11 total results of SOC stocks prepared for interpretation per zone and per depth.

To generate the resulting stocks of the random forest ranger method model and each of the extracted marsh cover types and combinations, an R code was generated that went through every pixel of the mosaics for each zone and calculated the values. The resulting values were then multiplied by 9, since the model applied a square m value to 3 m by 3 m pixels (containing 9 total square meters). By utilizing a conversion factor of 9, we obtained the square meter values of SOC within the study area. Furthermore, areas were computed, which enabled carbon density calculations.

Example R Code:

#Load in the 2 km Study Area Tiles created previously

#Modeled Result et al Tiles:
TwokmStudyAreaTiles\_RFRanger\_Zone1 <- list.files("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeling/Results/TidalWetlands\_Only/5cm/Zone\_1",
 full.names = TRUE)

#Create an empty data frame...
EmptyDataFrame<- data.frame( TileNo\_Zone=character(), Tile\_Min=numeric(), Tile\_Max=numeric(), Tile\_Mean=numeric(), Tile\_Median=numeric(), Tile\_STDDEV=numeric(), Tile\_IQR=numeric(), TotalC\_Tile=numeric(),Tile\_Min\_WholePixel=numeric(), Tile\_Max\_WholePixel=numeric(), Tile\_Mean\_WholePixel=numeric(), Tile\_Median\_WholePixel=numeric(), Tile\_STDDEV\_WholePixel=numeric(), Tile\_IQR\_WholePixel=numeric(), TotalC\_Tile\_WholePixel=numeric(), Total\_Cell\_Pixels=numeric(), Cells\_With\_NoNAs\_Sum=numeric(), Area\_meters\_squared\_of\_SOC\_in\_Zone=numeric())

#Set the location of where to store the resulting file:
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeled\_Stock\_Calcs/TidalWetlands\_Only/Results/5cm/Zone\_1")

#Start the loop!
for (i in 1:length(TwokmStudyAreaTiles\_RFRanger\_Zone1)){

#Have the Tile be read in as a raster
 Tile\_X\_RFResult<-stack(TwokmStudyAreaTiles\_RFRanger\_Zone1[i])

#Generate the Min, Max, Mean, Median, Std. Dev. IQR, and the Sum of each tile
 Tile\_Min<-cellStats(Tile\_X\_RFResult, min)
 Tile\_Max<-cellStats(Tile\_X\_RFResult, max)
 Tile\_Mean<-cellStats(Tile\_X\_RFResult, mean)
 Tile\_Median<-cellStats(Tile\_X\_RFResult, median)
 Tile\_STDDEV<-cellStats(Tile\_X\_RFResult, sd)
 Tile\_IQR<-cellStats(Tile\_X\_RFResult, IQR)
 TotalC\_Tile<-cellStats(Tile\_X\_RFResult, sum)

#Now because the original data was in m2 and this data is in 3m pixels, need to multiply by 9 all
 #original values...
 Tile\_Min\_WholePixel<-Tile\_Min\*9
 Tile\_Max\_WholePixel<-Tile\_Max\*9
 Tile\_Mean\_WholePixel<-Tile\_Mean\*9
 Tile\_Median\_WholePixel<-Tile\_Median\*9
 Tile\_STDDEV\_WholePixel<-Tile\_STDDEV\*9
 Tile\_IQR\_WholePixel<-Tile\_IQR\*9
 TotalC\_Tile\_WholePixel<-TotalC\_Tile\*9

#Now need to obtain the pixel counts for entire tiles and for all cells without NA values
 Total\_Cell\_Pixels<-ncell(Tile\_X\_RFResult)
 Cells\_With\_NoNAs<-freq(Tile\_X\_RFResult, useNA="no")
 Cells\_With\_NoNAs<-as.data.frame(Cells\_With\_NoNAs)
 Cells\_With\_NoNAs\_Sum<-sum(Cells\_With\_NoNAs$layer.count)

Area\_meters\_squared\_of\_SOC\_in\_Zone<-Cells\_With\_NoNAs\_Sum\*9

#Obtain the tile number and zone.... from the original file name
 Tile\_name <- unlist(strsplit(TwokmStudyAreaTiles\_RFRanger\_Zone1 [i], '/'))[16]
 Name2 <- unlist(strsplit(Tile\_name, '\_'))
 TileNo\_Zone <- Name2[6]

#Create a data frame with the resulting calcs obtained above:
 Tile\_Table<- data.frame( TileNo\_Zone, Tile\_Min, Tile\_Max, Tile\_Mean, Tile\_Median, Tile\_STDDEV, Tile\_IQR, TotalC\_Tile, Tile\_Min\_WholePixel, Tile\_Max\_WholePixel, Tile\_Mean\_WholePixel, Tile\_Median\_WholePixel, Tile\_STDDEV\_WholePixel, Tile\_IQR\_WholePixel, TotalC\_Tile\_WholePixel, Total\_Cell\_Pixels, Cells\_With\_NoNAs\_Sum, Area\_meters\_squared\_of\_SOC\_in\_Zone)

#Bring together the table of the resulting calcs and put it into the prepared empty data frame
 DataForTiles<- rbind(EmptyDataFrame, unique(Tile\_Table))

#Save the table created as a .csv file to then review.
 write.table(x=DataForTiles, file="SOC\_Stocks\_Zone1\_5cm\_RFRangerMethod\_TidalWet2kmTiles-7-5-2020.txt", sep="\t", append=TRUE, row.names=FALSE, col.names= FALSE)}

#Add Column names and save the table generated as a .csv

#Read back in the text table
DataTable<-read.table("SOC\_Stocks\_Zone1\_5cm\_RFRangerMethod\_TidalWet2kmTiles-7-5-2020.txt", sep="\t")

#Confirm it did the number of tiles (rows) it was asked to do
dim(DataTable)

#Make sure it is a data frame
str(DataTable)

#specify the names of the columns
colnames(DataTable)<- c("TileNo\_Zone", "Tile\_Min", "Tile\_Max", "Tile\_Mean", "Tile\_Median", "Tile\_STDDEV", "Tile\_IQR", "TotalC\_Tile", "Tile\_Min\_WholePixel", "Tile\_Max\_WholePixel", "Tile\_Mean\_WholePixel", "Tile\_Median\_WholePixel", "Tile\_STDDEV\_WholePixel", "Tile\_IQR\_WholePixel", "TotalC\_Tile\_WholePixel","Total\_Cell\_Pixels", "Cells\_With\_NoNAs\_Sum", "Area\_meters\_squared\_of\_SOC\_in\_Zone")

#Write a .csv file of the results for easier review and access
write.csv(DataTable, file = "SOC\_Stocks\_Zone1\_5cm\_RFRangerMethod\_TidalWet2kmTiles-7-5-2020.csv")

#Done! Yahoooooooo!!!!

#--------------------------

#Set the location of where to store the resulting file:
setwd("~/Vargas\_Lab/Research/R/Soil Carbon R Work/Results/Datasets\_Finalized\_June6/Modeled\_Stock\_Calcs/TidalWetlands\_Only/Results/5cm/Zone\_1")

#Review of Stock Totals: Zone1\_5cmStocks<-read.csv("SOC\_Stocks\_Zone1\_5cm\_RFRangerMethod\_TidalWet2kmTiles-7-5-2020.csv")

#Names:
names(Zone1\_5cmStocks)dim(Zone1\_5cmStocks) #1120 16

#Stock Totals:

Avg\_Tile\_Min<-mean(Zone1\_5cmStocks$Tile\_Min)
Avg\_Tile\_MinAvg\_Tile\_Max<-mean(Zone1\_5cmStocks$Tile\_Max)
Avg\_Tile\_MaxAvg\_Tile\_Mean<-mean(Zone1\_5cmStocks$Tile\_Mean)
Avg\_Tile\_MeanAvg\_Tile\_Median<-mean(Zone1\_5cmStocks$Tile\_Median)
Avg\_Tile\_MedianAvg\_Tile\_STDDEV<-mean(Zone1\_5cmStocks$Tile\_STDEV)
Avg\_Tile\_STDDEVAvg\_Tile\_IQR<-mean(Zone1\_5cmStocks$Tile\_IQR)
Avg\_Tile\_IQRAvg\_TotalC\_Tile<-mean(Zone1\_5cmStocks$TotalC\_Tile)
Avg\_TotalC\_TileSum\_TotalC\_perTitle\_AllTiles<-sum(Zone1\_5cmStocks$TotalC\_Tile)

Sum\_TotalC\_perTitle\_AllTilesAvg\_Tile\_Min\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_Min\_WholePixel)

Avg\_Tile\_Min\_WholePixelAvg\_Tile\_Max\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_Max\_WholePixel)
Avg\_Tile\_Max\_WholePixelAvg\_Tile\_Mean\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_Mean\_WholePixel)
Avg\_Tile\_Mean\_WholePixelAvg\_Tile\_Median\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_Median\_WholePixel)
Avg\_Tile\_Median\_WholePixelAvg\_Tile\_STDDEV\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_STDDEV\_WholePixel)
Avg\_Tile\_STDDEV\_WholePixelAvg\_Tile\_IQR\_WholePixel<-mean(Zone1\_5cmStocks$Tile\_IQR\_WholePixel)
Avg\_Tile\_IQR\_WholePixelAvg\_TotalC\_Tile\_WholePixel<-mean(Zone1\_5cmStocks$TotalC\_Tile\_WholePixel)
Avg\_TotalC\_Tile\_WholePixelSum\_TotalC\_WholePixel\_perTitle\_AllTiles<-

sum(Zone1\_5cmStocks$TotalC\_Tile\_WholePixel)

Sum\_TotalC\_WholePixel\_perTitle\_AllTilesPetagramsofC\_Zone1<-Sum\_TotalC\_perTitle\_AllTiles/1e+12

PetagramsofC\_Zone1Total\_Cell\_Pixels\_Zone1<-sum(Zone1\_5cmStocks$Total\_Cell\_Pixels)

Total\_Cell\_Pixels\_Zone1Cells\_With\_NoNAs\_Sum\_Zone1<-sum(Zone1\_5cmStocks$Cells\_With\_NoNAs\_Sum)

Cells\_With\_NoNAs\_Sum\_Zone1Area\_Zone1\_meters<-Cells\_With\_NoNAs\_Sum\_Zone1\*9

Area\_Zone1\_metersSquareKm\_mapped\_Zone1<-Area\_Zone1\_meters/1000000

SquareKm\_mapped\_Zone1

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**Additional Details on the Processing and Evaluation of Results to Previous Studies**

**of Soil Carbon Mapping:**

The Hinson et al. (2017) study was in a shapefile, non-raster format. The shapefile was trimmed to each of the zone extents. Files were then changed from shapefiles to dataframes, brought together, and a conversion factor applied to harmonize stock units. Areas were then obtained by converting and lastly, stocks calculated for the two depths produced by the study: 15 cm and 100 cm.

However, after review of the shapefile utilized and the website once more, we determined the shapefile of these broad density units was not what we needed. Therefore, each and every density map overlapping the study area was documented and tallied. We arrived at a total range for SOC from the Hinson et al. (2017) study to be 229.59 to 245.25 occupying 3,962.37 square km which is similar to the area of our results.

Webpage where data was obtained: <http://bluecarbon.tamu.edu/>

DOI link to journal article: <https://doi.org/10.1111/gcb.13811>

Citation:

Hinson, A.L., Feagin, R.A., Eriksson, M., Najjar, R.G., Herrmann, M., Bianchi, T.S., Kemp, M., Hutchings, J.A., Crooks, S., Boutton, T. 2017. The spatial distribution of soil organic carbon in tidal wetland soils of the continental United States. Global Change Biology 23: 5468-5480. [Crossref https://doi.org/10.1111/gcb.13811](https://doi.org/10.1111/gcb.13811)

Since the Holmquist et al. (2018) study was a raster based study at 30 m resolution, we upscaled our resulting tidal wetland results per zone to match the 30 m resolution. Then, each raster resulting from the Holmquist et al. (2018) study was cropped to the study area extent, projection systems aligned, and the specified Holmquist et al. (2018) result aligned to our results. Resulting rasters were saved per zone and stocks calculated using a conversion factor of 900 for the 30 m pixels (30 x 30 = 900) to obtain the SOC per meter squared value for an entire pixel.

Webpage where data was obtained: <https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1612>

DOI link to journal article: <https://doi.org/10.3334/ORNLDAAC/1612>

Citation:

Holmquist, J.R., L. Windham-Myers, N. Bliss, S. Crooks, J.T. Morris, P.J. Megonigal, T. Troxler, D. Weller, J. Callaway, J. Drexler, M.C. Ferner, M.E. Gonneea, K. Kroeger, L. Schile-beers, I. Woo, K. Buffington, B.M. Boyd, J. Breithaupt, L.N. Brown, N. Dix, L. Hice, B.P. Horton, G.M. Macdonald, R.P. Moyer, W. Reay, T. Shaw, E. Smith, J.M. Smoak, C. Sommerfield, K. Thorne, D. Velinsky, E. Watson, K. Grimes, and M. Woodrey. 2019. Tidal Wetland Soil Carbon Stocks for the Conterminous United States, 2006-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1612>

Lastly, for the Guevara et al. (2020) study, we upscaled our raster results to 250 m resolution to match the original resolution of the Guevara et al. (2020) study. Similar to our approach with preparing the Holmquist et al. (2018) data, files were cropped, projection systems aligned and the Guevara et al. (2020) study area masked to the tidal wetlands of our study. Resulting raster stocks were calculated using a conversion factor of 62,500 for the 250 m pixels (250 x 250 = 62,500) to obtain the SOC stock per meter squared for one pixel.

Webpage where data was obtained: <https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1737>

DOI link to journal article: <https://doi.org/10.1029/2019GB006219>

Citation:

Guevara, M., C.E. Arroyo-cruz, N. Brunsell, C.O. Cruz-gaistardo, G.M. Domke, J. Equihua, J. Etchevers, D.J. Hayes, T. Hengl, A. Ibelles, K. Johnson, B. de Jong, Z. Libohova, R. Llamas, L. Nave, J.L. Ornelas, F. Paz, R. Ressl, A. Schwartz, S. Wills, and R. Vargas. 2020. Soil Organic Carbon Estimates for 30-cm Depth, Mexico and Conterminous USA, 1991-2011. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1737

Note: Ramcharan et al. (2017) and POLARIS (Chaney et al., 2016, 2019) SOC data were obtained, however, the SOC values were in percentages and not as mass, making comparisons less feasible for a comparable analysis to our study. Due to this, these studies, while relevant and important, were not utilized for comparison. Furthermore, another study by Nahlik and Fennessy (2016), which evaluated SOC in U.S. wetlands based upon the U.S. Environmental Protection Agency – National Wetlands Condition Assessment (EPA-NWCA), was not available for use and evaluation.

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**Information Regarding Processing and Finalization of Soil Organic Carbon Point Data:**

*Notes:*

*All datasets were incorporated into R and processed utilizing R codes*

*For stocks specified in this document, depths of 5, 30, 100, and 200 are noted. Please note, it is implied and intended that these are in fact: 0-5, 0-30, 0-100, and 0-200 centimeters (cm).*

*This document is a guide to the steps taken for each unique dataset. Steps are documented in each R code. This document is intended to simply document and provide the steps taken for each dataset source and to provide some sort of written traceability of how we arrived at our results (for the point data/ training data), particularly for the non-R user, or those who do not wish to review codes to figure out how things were done. Not all steps are documented, however, in general, all steps that were taken to arrive at the final SOC calculations and number of points within the study area should be clear and well documented here and within the R codes themselves. R Codes are available, however for brevity are not provided below. Please contact Dr. Rodrigo Vargas for codes or additional information.*

*For users wishing to acquire additional information, please see:*

Yigini, Y., Federico Olmedo, G., Reiter, S., Baritz, R., Viatkin, K., Vargas, R., … Food and Agriculture Organization of the United Nations (Eds.). (2018). Soil Organic Carbon Mapping Cookbook. Encyclopedia of Global Warming & Climate Change (2nd ed.). Rome. <https://doi.org/10.4135/9781452218564.n636>

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**World Soil Information Service (WoSIS) Dataset:**

Website to view WoSIS information: <https://www.isric.org/explore/wosis/accessing-wosis-derived-datasets>

Data provided by Mario Guevara, October 2018.

Data also downloaded from the WoSIS website.

Documents utilized: wosis\_201607\_attributes.txt, wosis\_201607\_profiles.txt, wosis\_201607\_layers.txt

Code originally adapted from M. Guevara (mpslineWoSIS-SOC.R).

Three data sheets brought in (attributes, profiles, and layers).

Attributes sheet brought into the code, but not needed for processing, however contains information on the units of the data.

Profiles and layers sheets merged by the profile id’s.

Only U.S. data kept (countries column).

WoSIS data trimmed to the study area (the final Correll et al. (2019) study area .tif file)

File saved of the raw data information within the study area.

Data within the study area reviewed.

High bulk density values reviewed and a file saved with values greater than 1.8.

Review of data within the study area and SOC and Organic Carbon values combined, since there were two columns of the information. One column was prioritized and then if there were NA’s in that column, the other column was utilized to fill in missing information.

Where there were NA’s, the data was removed.

Coarse fragments reviewed and where there were no coarse fragments, a “0” was placed in that column.

File saved of the information generated thus far.

Four lines of the bottom depths in the code were problematic with NA’s. In the code the exact lines and profiles where the user should add 1 cm more of depth to ensure proper function of the splines to come is specified, (do in excel, apart from R).

Manually adjusted file is brought back into R.

NA’s in top and bottom columns are removed. (There were a few incomplete profiles).

Since the carbon data was in mass, it changed into percent for the bulk density pedo transfer function…

Pedo transfer function run to estimate bulk densities where unknown based upon the SOC values using the Jeffrey 1979 method.

Carbon values changed back to mass after completion of the pedo transfer function.

Data is prepared for the splines.

Splines are run to estimate values of SOC, Bulk Density and Coarse fragments for each depth.

At each depth the data is saved as a data frame containing: Profile ID, Latitude, Longitude, Organic Content, Bulk Density, and Coarse Fragments.

OCSKGM function utilized to create stocks for 5, 30, 100, and 200 cm.

Only SOC values above “0” are kept.

Source added to the file and the results for each depth are written to a file.

Next the code reviews the max depths of each profile and eliminates points that did not actually go to the depth where the values were estimated to.

Profiles where the min depth does not start at 0 are also noted to be removed later.

Histograms, variograms, a density plots, a box plot, and a preliminary histogram and boxplot of all depths are created.

Now the stocks are reviewed and compared with the dates of the data. Data is reviewed and rows are selected to be removed for the first three depths if they are not within the past 20 years.

Additionally, if any of the points contain the points where the min. depth was not 0, it is removed.

Columns are organized and files are saved.

Final Histograms and box plots generated.

Bubble plots are generated to illustrate the points within the study area.

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**International Soil Carbon Network (ISCN) Dataset:**

Website to view and download data: ISCN Generation 3 Database 12-2015 <https://iscn.fluxdata.org/>

Documents utilized: ISCN\_SOC-DATA\_PROFILE\_1-1.csv and ISCN\_SOC-DATA\_LAYER\_1-1.csv

Code authored by J. Wardrup (ISCN\_Code\_withEdits\_7-10-2019-FINAL.R), adapted from M. Guevara codes and help provided from M. Guevara.

Two data sheets brought into R (Profile and Layer).

A data frame created from the Profile information of date, SOC method, SOC carbon flag, lat, long, profile name, layer top, layer bottom, SOC (g/cm2), country and an ID created per layer.

Where SOC values were “0”, they were changed to be NA.

NA’s omitted and only points within the U.S. are kept.

The points are projected and trimmed to the Continental U.S. (CONUS).

Dataset is then organized and only data greater than the year 1997 is kept (for 5cm, 30cm and 100cm depths).

SOC per profile is averaged based upon the top and bottom depths.

Splines are created for each profile. Datasets for each depth are saved.

Density plots, histograms and variograms are utilized to display the data.

Data combined together (for the three depths of 5cm, 30cm and 100cm) and it is trimmed to the study area.

Only points greater than 0 are kept.

Values are converted from grams to kilograms per meter squared.

Values for the 200cm stock are calculated using the same techniques as the other depths above, however there was no date restriction.

Then, the max depths for each profile are created and then each profile is compared to the max depth of that same profile (all within the study area) and if points did not extend to the depth of the SOC estimation, the point is removed.

Density and histogram plots of the SOC data created.

Bubble plot maps created.

All data merged together and historgrams and boxplots created.

A file of the resulting final data is saved, a .csv file.

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**Holmquist et al. (2018) Dataset:**

Website to view and download data: <https://repository.si.edu/handle/10088/35684>

Documents utilized: V1\_Holmquist\_2018\_core\_data.csv and V1\_Holmquist\_2018\_depth\_series\_data.csv

Two data sheets brought in (core data and depth series data).

Data sheets merged together by the Core IDs.

Columns selected to be kept: Study ID, Core ID, Depth Min, Depth Max, Dry Bulk Density, Fraction Organic Matter, Fraction Organic Carbon, Latitude, Longitude.

Since the data was in “fraction” (or percent as a decimal) the values for organic matter and organic carbon were multiplied by 100. (Note Dr. Holmquist was contacted (via email) and this was confirmed (in writing) to be the correct process to transform from decimal percent to percent).

Percentages of organic matter were divided by 2 (Pribyl, 2010). Carbon converted to percent.

Percentages were then converted to mass. Percentages were multiplied by 10.

Ex: If 1% SOC = 10g per kg, then 10% = 100 g/kg.

High bulk density values reviewed. New file written of those high values. 4 profiles with high bulk density values were noted, in the code high bulk density values are exported to a .csv file and then trimmed to the study area to review where the high values were located.

Organic carbon and organic matter values were sorted. Where both values for organic matter and organic carbon existed, organic carbon was kept. Where no organic carbon value existed and an organic matter value existed, the organic matter value was utilized. These values were stored in a separate column of the dataset. (*note organic matter was converted to SOC with the 2.0 conversion factor prior to going into this column*). So everything is now in percent carbon, not organic matter.

Bulk density values were multiplied by 1000 to go from g/cm3 to g/kg3.

Dataset is for coastal wetlands of CONUS, at this point, there existed 2,454 NA’s for organic matter, 11,773 for carbon, and 123 for bulk density. In the column of combined carbon data (which was utilized moving forward, 1,994 NA’s existed).

Remember the high carbon values will be because it is in mass and not percentage anymore…

Before going into the splines, carbon changed back to percentage and changed to organic matter.

Where no bulk density information existed, NA values were estimated utilizing the SOC values (in organic matter) in the dataset, utilizing the Jeffrey 1979 method.

After bulk densities are estimated, organic matter was changed back to carbon and back to mass.

Columns reordered and renamed.

File saved of these raw values generated thus far.

Data verified to project properly…

Splines created for estimates of SOC and bulk density to specified stock depths of 5, 30, 100, and 200.

Coarse fragments column of 0 added.

OCSKGM function utilized to create stocks for 5, 30, 100, and 200.

Only values above 0 were utilized. Any “0” points were dropped. Note: There were no “0” points dropped for this dataset, as there were no “0” values generated.

Stocks were then combined and trimmed to the study area. Note: the splines utilized here, did not take into account the maximum depth of excavation. Therefore, all four depths of data contained 1,472 values for 5, 30, 100, and 200 for each profile.

The original raw sorted data was then brought back into the code to obtain the max depths of the profiles. The raw sorted data was trimmed to the study area, the max depths were identified, a new column created, with the max depth for each ID. A .csv file was saved of the max depths.

The max depths and SOC stock files were merged together by their ID’s. At this point, each depth contained the following information: ID, Bulk Density, SOC (at specified depth), Mean Error, Long, Lat, Max Depth.

A code was run for each depth, where if the Max Depth column was equal to or greater than the stock depth, the profile was kept. If the profile was 25 cm for example, when it needed to be 30cm, that profile was dropped, because the carbon to 30cm is in fact unknown at that location.

Files were written.

For the 5, 30, and 100cm depths, data older than 20 years was removed. For this dataset, the years in the Study ID column were utilized, which are the published dates since this dataset is a compilation of published carbon data/cores. Individual lines were identified from the older years identified, and were removed. Files were double checked and re-created to ensure the correct lines were removed.

Final numbers were: 173 for 5cm, 169 for 30cm, 4 for 100cm, and 1 for 200cm.

Histograms and box plots were created.

Bubble plots created as well.

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**Coastal Carbon Research Coordination Network (CCRCN) Dataset:**

Website to view and download data: <https://serc.si.edu/coastalcarbon/data> and <https://ccrcn.shinyapps.io/CoastalCarbonAtlas/>

Documents utilized: CCRCB\_core\_data.csv, CCRCN\_depthseries\_data.csv

Note: this dataset is very similar to the Holmquist et al. (2018) (Holmquist) dataset. It is essentially an expansion of the Holmquist dataset. Therefore, there will be some redundancy from what was detailed above from Holmquist for this dataset (the above description was copied and pasted and, certain sections were edited, for CCRCN vs. Holmquist et al. (2018)).

Two data sheets brought in (core data and depth series data).

Columns selected to be kept per sheet: Site ID, Study ID, Core ID, Depth Min, Depth Max, Dry Bulk Density, Fraction Organic Matter, Fraction Organic Carbon, Latitude, Longitude.

Data sheets merged together by “Core ID”.

Some lines were removed that were causing issues later on in mapping, points were from Rio de Janerio, therefore, they did not affect the study area’s dataset.

Points verified to be able to project properly.

The CCRCN data was trimmed to the study area. A file is written of those points.

Since the data was in “fraction” (or percent as a decimal) the values for organic matter and organic carbon were multiplied by 100. (Note Dr. Holmquist was contacted via email and this was confirmed (in writing) to be the correct process to transform from decimal percent to percent).

Percentages of organic matter were divided by 2 (based upon article of “A critical review of the conventional SOC to SOM conversion factor”, Douglas W. Pribyl, Geoderma 156 (2010) 75-83). Organic matter was divided to be transformed to carbon.

Percentages were converted to mass. Percentages were multiplied by 10.

If 1% SOC = 10g per kg, then 10% = 100 g/kg.

Organic carbon and organic matter values were sorted. Where both values for organic matter and organic carbon existed, organic carbon was kept. Where no organic carbon value existed and an organic matter value existed, the organic matter value was utilized. These values were stored in a separate column of the dataset (fraction\_carbon2). (note: organic matter was converted to SOC with the 2.0 conversion factor prior to going into this column).

Review of high bulk density values and values above 1.8 were extracted and saved to a new file.

Bulk density values were multiplied by 1000 to go from g/cm3 to g/kg3.

Where no bulk density information existed, NA values were estimated utilizing the SOC values in the dataset, utilizing the Jeffrey 1979 method. Prior to this, SOC values were changed back to SOM values and then after the pedo-function, SOC was changed back to mass.

Data verified to project correctly.

Splines created for estimates of SOC and bulk density to specified stock depths of 5, 30, 100, and 200.

Coarse fragments column of 0 added for each depth.

OCSKGM utilized to create stocks for 5, 30, 100, and 200.

Only values above 0 were utilized. Any “0” points were dropped.

Stocks were then combined to be columns of all 4 spline results. Note: the splines utilized here, did not take into account the maximum depth of excavation. Therefore, all four depths of data contained 170 values for 5, 30, 100, and 200 for each profile.

The original raw sorted data was then merged together by the ID’s.

Max depths for each of the study area points was created.

The max depths and SOC stock files were merged together by their ID’s. At this point, each depth contained the following information: ID, Bulk Density, SOC (at specified depth), Mean Error, Long, Lat, Max Depth.

A code was run for each depth, where if the max depth column was equal to or greater than the stock depth, the profile was kept. If the profile was 25 cm for example, when it needed to be 30cm, that profile was dropped, because the carbon to 30cm is in fact unknown at that location.

Files were written.

For the 5, 30, and 100cm depths, data older than 20 years was removed (200cm depth accepting points from all available dates). For this dataset, the years indicated in the Study ID column were utilized. Which are the published dates since this dataset is a compilation of published carbon data/cores. Only the 5cm and 30cm depths were affected.

Final numbers were: 159 for 5cm, 155 for 30cm, 4 for 100cm, and 1 for 200cm.

Histograms and box plots were created.

Bubble plot maps of the study area created.

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**U.S. Environmental Protection Agency –**

**National Wetlands Condition Assessment (EPA-NWCA) Dataset:**

Website to view and download data: <https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys>

Documents utilized: nwca2011\_siteinfo.csv, nwca2011\_soilchem.csv

Two data files brought in (site info and soil chem).

Columns selected to be kept from both sheets: UID, Analysis Lat, Analysis Long, Layer, Depth, Tot Carbon, and Bulk Density DBF. (Carbon was in percent and bulk density in g/cm3). (Soil textures also selected, however not utilized later on, since not all datasets contained textures).

Data sheets merged together by “UID”.

Dataset trimmed to the study area.

Dataset contained depth, but not a top and bottom. M. Guevara helped by creating a top and bottom column layer code. Some of the points did not create a “0” for the top, therefore they had to be done by hand. Columns changed by hand are indicated in the code. Approximately 21 profiles needed corrections in depths. Instructions are provided within the code and exactly which lines were adjusted are documented. If these profiles are not corrected, the code does not run. However, these profiles also did not start at the surface. They will be removed later on…

Since there were no coarse fragments available, a coarse fragments columns was created and all values set to “0”

Columns selected and readjusted.

Some code where the bulk density values are reviewed and high values are extracted. File written.

Carbon values were changed to mass by multiplying by 10.

Bulk density values changed from g/cm3 to g/kg3 by multiplying by 1000.

SOC values brought back to Organic Matter and percentage….

Where no bulk density information existed, NA values were estimated utilizing the SOC values in the dataset, utilizing the Jeffrey 1979 method.

After bulk density values estimated for missing horizons, SOC values brought back in from OM percentages to SOC in mass.

Splines created for estimates of SOC and bulk density to specified stock depths of 5, 30, and 100. There were no points that went to 200cm.

The organic carbon values are calculated.

Only values above 0 were utilized. Any “0” points were dropped.

Results written to files.

Results of the 3 splines, SOC calculations, were then combined and merged by ID.

Max depths for each of the study area points was created.

The max depths and SOC stock files were merged together by their ID’s. At this point, each depth contained the following information: ID, Bulk Density, SOC (at specified depth), Mean Error, Long, Lat, Max Depth.

A code was run for each depth, where if the Max Depth column was equal to or greater than the stock depth, the profile was kept. If the profile was 25 cm for example, when it needed to be 30cm, that profile was dropped, because the carbon to 30cm is in fact unknown at that location.

Profiles where the min depth did not begin at 0 were also removed.

Histograms and box plots were created.

Maps of the study area using bubble plots are created.

Points did not need to be sorted through for data, this was an effort done in 2011.

Note: Website of data reviewed in Oct. 2019 and no new data was available.

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**Rapid Carbon Assessment (RaCA) Dataset:**

Website to view RaCA information: <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054164>

Documents utilized: RaCA\_data\_summary.xlsx

Note: RaCA data summary was provided M. Guevara to J. Wardrup in fall 2018. This spreadsheet was provided by the USDA-NRCS to M. Guevara. The data with the location information is not available through online resources. However, the dataset is publicly available through the USDA-NRCS, anyone can contact them and request it. Permission for use of the data for this particular study was formally obtained in June 17, 2020 by Dr. Skye Wills of the USDA, NRCS.

Data Citation: Soil Survey Staff and T. Loecke. 2016. Rapid Carbon Assessment: Methodology, Sampling, and Summary. S. Wills (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Two data sheets brought in (sheet 2 and 4 of the data summary excel file). Soil texture also brought in for a brief review, but not utilized in calculating the stocks.

Data selected to be kept: ID, Lat, Long, SOCStock5cm, SOCStock30cm, SOCStock100cm. Note: RaCA had already generated stocks for these depths, therefore no splines were needed.

Files of stocks at each depth saved.

Variograms and Histograms and line density plots created with the CONUS RaCA data for the three depths.

Data Trimmed to study area, file written for study area points.

Values of ranges in SOC reviewed.

Values converted to OCSKGM. Skye Wills was contacted (4.18.2019) to ensure the proper calculations. Mg/ha to kg/m = multiply by 0.1. Value ranges of SOC reviewed again to ensure calculation worked. Email of this correspondence is documented/saved.

Histograms and Boxplots created of the stocks for RaCA.

Final .csv file of information exported.

Variograms, bubble maps, and autokrige plots created for each depth, just to review the data and see what results.

Note: The RaCA study only went to approximately 100cm, therefore there were no 200cm depths.

9 RaCA points for 5cm, 30cm, and 100cm depths.

RaCA was part of a single and complete effort in 2010-2012.

Lastly, for general intrigue, soil texture and bulk density values were reviewed.

Note: This dataset was reviewed and finalized on 10.28.2019 and then again finalized in late November 2019 and triple checked on 5.26.2020. The code provided has the same beneficial results as it did in early July 2019.

Note: Max depths and min depths were reviewed apart from the code. All 9 profiles started at 0 and ended at 100cm or deeper. Therefore, 9 points for each depth is correct.

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**National Cooperative Soil Survey (NCSS) Dataset:**

Website to view and download data: <https://ncsslabdatamart.sc.egov.usda.gov/>

Documents utilized: Microsoft access database: NCSS\_Lab\_Data\_Mart\_01512017.mbd

 Two “tabs” within that database were utilized: Geochemistry\_query and

 Bulk\_Density\_and\_Moisture. These were exported to excel workbooks, which were then

 utilized in the code described below.

Two data sheets brought in (Geochemistry\_query and Bulk\_Density\_and\_Moisture). Certain columns from those datasets identified and selected.

There were several columns of bulk density values (BLD). If one value was NA, the next column was utilized. They were then combined to have the most values possible.

Data selected to be kept from the site data: upedonid, labsampnum, hzn\_desn, hzn\_top, hzn\_bot, latitude\_decimal\_degrees, longitude\_decimal\_degrees, c\_tot, clay\_tot\_psa, silt\_tot\_psa, sand\_tot\_psa.

Data selected and merged with the bulk density values by “labsampnum”

Data then narrowed down to just be: ID, top, bottom, Lat, Long, SOC, and BLD and column titles renamed to be simpler.

Source column added.

Brief review of high (>1.8) bulk density values within the study area.

Brief review of soil textures.

NA data omitted.

Data trimmed to the study area.

Carbon was in percent. It was changed to mass by multiplying by 10.

Writing of .csv file with high bulk density values.

Bulk Density was in g/cm3, multiplied by 1000 to be kg/m3.

NCSS did not have coarse fragments within these data tables… they may have it elsewhere(?), but it was not observed here. A column for coarse fragments was created and values set to “0”.

Three lines in the spreadsheet with the trimmed data above were edited, so splines to be created could run smoothly. These lines are noted in the code. In the end of the preliminary study points lines were duplicated. Duplicated lines were removed so the code could proceed.

Where no bulk density information existed, NA values were estimated utilizing the SOC values in the dataset, utilizing the Jeffrey 1979 method…. But there were no missing bulk density values, so the pedo-function to estimate bulk density was not used.

Splines created for estimates of SOC and bulk density to specified stock depths of 5, 30, and 100. There were no points that went to 200cm.

Only values above 0 were utilized. Any “0” points were dropped.

Files created of points in each focus depth and OCSKGM values.

Obtain the max depth of each profile and utilize the max depths to eliminate points in other depths that do not belong…

Remove the three profiles that did not begin at a depth of “0”

Write files of each stock.

Create variograms to review the spatial autocorrelation of the data.

Review data via a density plot.

Histograms and Boxplots created.

Bubble plot maps created of the study area.

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**Dataset Source Citations and Acknowledgements:**

**ISRIC – WoSIS**

International Soil Reference and Information Centre. World Soil Information Service. Retrieved August 23, 2019, from <https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/4a76ff8c-0f33-4327-a3d7-56b7c47005ba>

**ISCN**

https://iscn.fluxdata.org/data/data-information/data-policy/

Acknowledgement Statement from ISCN website:

“This work was facilitated by the International Soil Carbon Network.”

**CCRCN**

Coastal Carbon Research Coordination Network. Coastal Carbon Clearinghouse. Retrieved August 23, 2019, from <https://ccrcn.shinyapps.io/CoastalCarbonAtlas/>

https://serc.si.edu/coastalcarbon/principles-and-governance

**Holmquist et al.**

Holmquist, James R., Windham-Myers, Lisamarie, Bliss, Norman, Crooks, Stephen, Morris, James T., Megonigal, J. Patrick, Troxler, Tiffany, Weller, Donald E., Callaway, John, Drexler, Judith, Ferner, Matthew C., Gonneea, Meagan E., Kroeger, Kevin D., Schile-Beers, Lisa, Woo, Isa, Buffington, Kevin, Boyd, Brandon M., Breithaupt, Joshua, Brown, Lauren N., Dix, Nicole, Hice, Lyndie, Horton, Benjamin P., MacDonald, Glen M., Moyer, Ryan P., Reay, William et al. 2018. [Dataset] "*Accuracy and Precision of Tidal Wetland Soil Carbon Mapping in the Conterminous United States: Public Soil Carbon Data Release*." Distributed by Smithsonian Research Online. <https://repository.si.edu/handle/10088/35684;jsessionid=69413A3CB7DE93309CE3572F50DA836A>. Date accessed: 2020-12-07.

**EPA-NWCA**

U.S. Environmental Protection Agency. 2011. *National Aquatic Resource Surveys. National Wetlands Condition Assessment 2011 (Site Information and Soil Chemistry data and metadata files)*. Available from U.S. EPA website: [http://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys](https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys). Date accessed: 2020-12-07.

Acknowledgement Statement from EPA-NWCA website:

“The *National Wetland Condition Assessment 2011* data were a result of the collective efforts of dedicated field crews, laboratory staff, data management and quality control staff, analysts and many others from EPA, states, tribes, federal agencies, universities, and other organizations. Please contact nars-hq@epa.gov with any questions.”

**NCSS**

National Cooperative Soil Survey. National Cooperative Soil Survey Soil Characterization Database. Retrieved August 23, 2019, from <http://ncsslabdatamart.sc.egov.usda.gov/>

**RaCA**

Soil Survey Staff and T. Loecke. 2016. Rapid Carbon Assessment: Methodology, Sampling, and Summary. S. Wills (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

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**Notes on Process and Calculation of Removal of Outliers:**

Outliers were calculated for organic, sandy and fine textured soils. Ranges in values were generated from known values in fundamental soil science literature (Brady & Wiel, 2008; Buol, S.W., Southard, R.J., Graham, R.C., McDaniel, 2003) of bulk densities for the varying soils and soil materials. Since bulk density is the mass of the soil within a given volume, understanding the maximum values possible was essential to comprehending realistic limits of SOC that could exist in a given volume of soil.

Known bulk density values, obtained from: Figure 4.34, Page 150, 14th edition, 2008, “Nature and Properties of Soils” by Brady and Weil:

Organics: 0.1 to 0.7 Mg/m3 which equates to 100 to 700 kg/m3

Sandy Textured: 1.3 to 1.8 Mg/m3 which equates to 1,300 to 1,800 kg/m3

Fine (Clayey) Textured: 0.8 to 1.2 Mg/m3 which equates to 800 to 1,200 kg/m3

**Calculation of values:**

Organics: Since organic soils can reach up to 50% organic matter content, by dividing the known bulk density ranges in half, the corresponding values can provide the maximum possible values for the 1 meter stock depth: 50 to 375 kg/m3. (Note: the traditional conversion factor of 1.724 was not used.) Consistent with our SOC stock calculations for datasets, we used the 2.0 conversion factor as detailed and proposed (Pribyl, 2010), which equates to 50% SOC in organic matter. To obtain the values of maximum stocks for 0-5 cm and 0-30 cm depths, we took 5% and 30% of the maximum stock for 1 m which resulted in: 18.75 kg/m3 and 112.5 kg/m3 respectively. To obtain the maximum SOC stock for the 0-200 cm depth, we doubled the 0-100 cm maximum stock, which equates to 700 kg/m3.

Sandy Textured: If a soil has a 0% clay, 12% maximum carbon can exist and that soil can still be classified as mineral materials (mineral and mucky modified ranges were ignored and we only reviewed the difference between organic and non-organic (mineral, which from this perspective is also mucky modified). Ranges for the bulk densities were calculated. 1 meter stock depth: 96 to 144 kg/m3. To obtain the values of maximum stocks for 0-5 cm and 0-30 cm depths, we took 5% and 30% of the 1 m maximum stock which resulted in: 4.8 to 7.2 kg/m3 and 28.8 to 43.2 kg/m3 respectively. To obtain the maximum SOC stock for the 0-200 cm depth, we doubled the 0-100 cm maximum stocks which equates to 192-288 kg/m3.

Fine (Clayey) Textured: If a soil has a 60% clay, 18% maximum carbon can exist and that soil be classified as mineral materials (mineral and mucky modified ranges were ignored and we only reviewed the difference between organic and non-organic (mineral, which from this perspective was also mucky modified). Ranges for the bulk densities were calculated; 1 meter stock depth: 144 to 216 kg/m3. To obtain the values of maximum stocks for 0-5 cm and 0-30 cm depths, we took 5% and 30% of the 1 m maximum stock which resulted in: 7.2 to 10.95 kg/m3 and 43.2 to 64.8 kg/m3 respectively. To obtain the maximum SOC stock for the 0-200 cm depth, we doubled the 0-100c m maximum stocks which equates to 288-432 kg/m3.

While we calculated the ranges for sandy and fine textured soils, since not all datasets contained soil textures to evaluate if soils were mineral or organic (based upon the definition of these materials established through the USDA-NRCS), we solely used the values calculated for organic soils to have a universal and fair means of threshold criteria across datasets.

The methodology and the values for other soil textures are provided here for complete transparency and perhaps, future methodology to be used in future endeavors. Please note: during the time of these calculations and as of March 2021, the definitions of the percentages of organic materials within sandy and clayey soils are proposed to change to one universal percentage of 12%. The variations in percentages and the sliding scale (shown below) were originally conceived because to the variability in the soil materials themselves. However, as it has been shown (Rabenhorst and Stolt, 2012), practice and application of hand texturing to arrive at SOC percentages is greatly variable and as noticed by this author, not well understood, applied or considered by periphery disciplines to pedology.

A graph of the sliding scale for SOC can be found on page 39 of the following document:

United States Department of Agriculture, Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

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**USDA-NRCS Block Diagrams reviewed for Soil Carbon/ Soil Distributions:**

To evaluate previous expert knowledge of SOC distributions within the study area, soil survey block diagrams were reviewed. The following block diagrams were reviewed from the USDA-NRCS:

Soil Survey Staff, 1981. Typical pattern of soils and parent material in the Carlisle-Adrian-Saco map unit (Soil Survey of Fairfield County, Connecticut; 1981). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/CT-2011-05-31-05.tif>.

Soil Survey Staff, 1987. The typical pattern of the soils on the landscape and the underlying material and bedrock in the Peru-Tunbridge-Marlow map unit (Soil Survey of Knox and Lincoln Counties, Maine; January 1987). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/ME-2012-02-03-01.tif>.

Soil Survey Staff, 1993. Relationship of soils, landscapes, and parent material in some map units in Barnstable County (Soil Survey of Barnstable County, Massachusetts; March 1993). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/MA-2012-02-01-01.tif>.

Soil Survey Staff, 2019. Coastal and subaqueous soils of the Mid-Atlantic States. (Soil Survey Areas of NJ029, MD047, DE005). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/NJ-2019-12-16-01.tif>.

Soil Survey Staff, 2019. Coastal and subaqueous soils of the Northeast. (Soil Survey Areas of RI600, CT600, NY081, NY047, NH015, NH017). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/RI-2019-12-16-01.tif>.

Soil Survey Staff, Date Unknown. Typical pattern of soils and examples of profiles and underlying material near tidal marsh and upland interface (Soil Survey of Somerset County, Maryland). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/MD-2010-09-10-10.tif>.

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**Bibliography/References/Citations:**

**Brady, N. C., & Wiel, R. R. (2008). The Nature and Properties of Soils (14th ed.). Pearson Prentice Hall.**

Buol, S.W., Southard, R.J., Graham, R.C., McDaniel, P. A. (2003). *Soil Genesis and Classification* (5th ed.). Ames: Blackwell.

**Chaney, N. W., Minasny, B., Herman, J. D., Nauman, T. W., Brungard, C. W., Morgan, C. L. S., … Yimam, Y. (2019). POLARIS Soil Properties: 30-m Probabilistic Maps of Soil Properties Over the Contiguous United States. Water Resources Research, 55(4), 2916–2938.** <https://doi.org/10.1029/2018WR022797>

**Chaney, N. W., Wood, E. F., McBratney, A. B., Hempel, J. W., Nauman, T. W., Brungard, C. W., & Odgers, N. P. (2016). POLARIS: A 30-meter probabilistic soil series map of the contiguous United States. Geoderma, 274, 54–67.** <https://doi.org/10.1016/j.geoderma.2016.03.025>

Coastal Carbon Research Coordination Network. Coastal Carbon Clearinghouse. Retrieved August 23, 2019, from <https://ccrcn.shinyapps.io/CoastalCarbonAtlas/>

Conway, Courtney J. and Droege, S. (2006). A unified strategy for monitoring changes in abundance of birds associated with North American tidal marshes. In *Studies in Avian Biology* (Issue 32, pp. 282–297).

**Correll, M. D., Hantson, W., Hodgman, T. P., Cline, B. B., Elphick, C. S., Gregory Shriver, W., … Olsen, B. J. (2019). Fine-Scale Mapping of Coastal Plant Communities in the Northeastern USA. Wetlands, 39(1), 17–28.** <https://doi.org/10.1007/s13157-018-1028-3>

**Fleming, M. D., & Hoffer, R. M. (1979). Machine Processing of Landsat MSS Data and DMA Topographic Data for Forest Cover Type Mapping LARS Technical Report 062879 Machine Processing of Landsat MSS Data and DMA Topographic Data for Forest Cover Type Mapping Department of Forestry and Natural Res. LARS Technical Report 062879. Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, Indiana.**

**Gao, B.-C. (1996). Naval Research Laboratory, 4555 Overlook Ave. Remote Sens. Environ, 7212(April), 257–266.**

**Guevara, M., Arroyo, C., Brunsell, N., Cruz, C. O., Domke, G., Equihua, J., … Vargas, R. (2020). Soil Organic Carbon Across Mexico and the Conterminous United States (1991–2010). Global Biogeochemical Cycles, 34(3), no.** <https://doi.org/10.1029/2019GB006219>

**Guevara, M., Arroyo, C., Brunsell, N., Cruz, C. O., Domke, G., Equihua, J., … Vargas, R. (2020). Soil Organic Carbon Across Mexico and the Conterminous United States (1991–2010). Global Biogeochemical Cycles, 34(3), no.** <https://doi.org/10.1029/2019GB006219>

Guevara, M., C.E. Arroyo-cruz, N. Brunsell, C.O. Cruz-gaistardo, G.M. Domke, J. Equihua, J. Etchevers, D.J. Hayes, T. Hengl, A. Ibelles, K. Johnson, B. de Jong, Z. Libohova, R. Llamas, L. Nave, J.L. Ornelas, F. Paz, R. Ressl, A. Schwartz, S. Wills, and R. Vargas. 2020. Soil Organic Carbon Estimates for 30-cm Depth, Mexico and Conterminous USA, 1991-2011. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1737>

Hapke, C. J., Kratzmann, M. G., & Himmelstoss, E. A. (2013). Geomorphic and human influence on large-scale coastal change. *Geomorphology*, *199*, 160–170. <https://doi.org/10.1016/j.geomorph.2012.11.025>

**Hijmans, R., Etten, J. Van, Sumner, M., Cheng, J., Bevan, A., Bivand, R., … Wueest, R. (2020). Package “raster” Type Package Title Geographic Data Analysis and Modeling. Retrieved from** [https://cran.r-project.org/package=raster](https://cran.r-project.org/package%3Draster)

**Hinson, A. L., Feagin, R. A., Eriksson, M., Najjar, R. G., Herrmann, M., Bianchi, T. S., … Boutton, T. (2017). The spatial distribution of soil organic carbon in tidal wetland soils of the continental United States. Global Change Biology, 23(12), 5468–5480.** <https://doi.org/10.1111/gcb.13811>

Holmquist, J. R., Windham-Myers, L., Bliss, N., Crooks, S., Morris, J. T., Megonigal, J. P., … Grimes, K. W. (2018). Accuracy and Precision of Tidal Wetland Soil Carbon Mapping in the Conterminous United States. *Scientific Reports*, (October 2017), 1–16. <https://doi.org/10.1038/s41598-018-26948-7>

Holmquist, J. R., Windham-Myers, L., Bliss, N., Crooks, S., Morris, J. T., Megonigal, J. P., … Woodrey, M. (2018). Accuracy and Precision of Tidal Wetland Soil Carbon Mapping in the Conterminous United States: Public Soil Carbon Data Release. Retrieved August 23, 2019, from <https://repository.si.edu/handle/10088/35684;jsessionid=69413A3CB7DE93309CE3572F50DA836A>

**Horn, B. K. P. (1981). Hill Shading and the Reflectance Map. Proceedings of the IEEE, 69(1), 14–47.** <https://doi.org/10.1109/PROC.1981.11918>

International Soil Reference and Information Centre. World Soil Information Service. Retrieved August 23, 2019,

from <https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/4a76ff8c-0f33-4327-a3d7-56b7c47005ba>

**McFeeters, S. K. (1996-05). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. International Journal of Remote Sensing, 17(7), 1425-1432.doi:10.1080/01431169608948714**

**Nahlik, A. M., & Fennessy, M. S. (2016). Carbon storage in US wetlands. Nature Communications, 7, 1–9.** <https://doi.org/10.1038/ncomms13835>

National Cooperative Soil Survey. National Cooperative Soil Survey Soil Characterization Database. Retrieved August 23, 2019, from <http://ncsslabdatamart.sc.egov.usda.gov/>

**﻿Pribyl, D. W. (2010). A critical review of the conventional SOC to SOM conversion factor. Geoderma, 156(3–4), 75–83.** <https://doi.org/10.1016/j.geoderma.2010.02.003>

**Rabenhorst, M. C., & Stolt, M. H. (2012). Field Estimations of Soil Organic Carbon. Soil Science Society of America Journal, 76(4), 1478–1481.** <https://doi.org/10.2136/sssaj2011.0366>

**Ramcharan, A., Hengl, T., Nauman, T., Brungard, C., Waltman, S., Wills, S., & Thompson, J. (2017). Soil Property and Class Maps of the Conterminous US at 100 meter Spatial Resolution based on a Compilation of National Soil Point Observations and Machine Learning.** <https://doi.org/10.2136/sssaj2017.04.0122>

Reed, D. J., Bishara, D. A., Cahoon, D. R., Donnelly, J. P., Kearney, M. S., Kolker, A. S., Leonard, L. L., Orson, R. A., & Stevenson, J. C. (2008). Site-Specific Scenarios for Wetlands Accretion as Sea Level Rises in the Mid-Atlantic Region. In *Background Documents supporting Climate Change Science Program Synthesis and Assessment Product 4.1*.

**Richardson, A. (1977). Distinguishing Vegetation from Soil Background Information. Photogrammetric Engineering and Remote Sensing, 43(12), 1541-1552.**

**Ritter, P. (1987). Vector-Based Slope and Aspect Generation Algorithm. Photogrammetric Engineering and Remote Sensing, 53(8), 1109–1111.**

**Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1973). Monitoring the vernal advancement and retrogradation (green wave effect) of natural vegetation. Progress Report RSC 1978-1, 112.**

**﻿Saltmarsh Habitat and Avian Research Program (SHARP). 2017. General Information: Remote sensing of tidal wetlands using NAIP and NED elevation data.**

Soil Survey Staff, 1981. Typical pattern of soils and parent material in the Carlisle-Adrian-Saco map unit (Soil Survey of Fairfield County, Connecticut; 1981). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/CT-2011-05-31-05.tif>.

Soil Survey Staff, 1987. The typical pattern of the soils on the landscape and the underlying material and bedrock in the Peru-Tunbridge-Marlow map unit (Soil Survey of Knox and Lincoln Counties, Maine; January 1987). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/ME-2012-02-03-01.tif>.

Soil Survey Staff, 1993. Relationship of soils, landscapes, and parent material in some map units in Barnstable County (Soil Survey of Barnstable County, Massachusetts; March 1993). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/MA-2012-02-01-01.tif>.

Soil Survey Staff, 2019. Coastal and subaqueous soils of the Mid-Atlantic States. (Soil Survey Areas of NJ029, MD047, DE005). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/NJ-2019-12-16-01.tif>.

Soil Survey Staff, 2019. Coastal and subaqueous soils of the Northeast. (Soil Survey Areas of RI600, CT600, NY081, NY047, NH015, NH017). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/RI-2019-12-16-01.tif>.

Soil Survey Staff, Date Unknown. Typical pattern of soils and examples of profiles and underlying material near tidal marsh and upland interface (Soil Survey of Somerset County, Maryland). <https://www.nrcs.usda.gov/Internet/NRCS_DIAGRAMS/graphics/MD-2010-09-10-10.tif>.

Soil Survey Staff and T. Loecke. 2016. Rapid Carbon Assessment: Methodology, Sampling, and Summary. S. Wills (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

United States Department of Agriculture, Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

**US Department of Agriculture. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. United States Department of Agriculture Handbook, (296), 1–669.**

**﻿US Department of Agriculture (2016) National Agriculture Imagery Program accessed through the Geospatial Data Gateway. Available at: http:// datagateway.nrcs.usda.gov. Accessed February 2016**

U.S. Environmental Protection Agency. (2011). National Aquatic Resource Surveys. National Wetlands Condition Assessment 2011 (Site Information and Soil Chemistry data and metadata files). Available from U.S. EPA website: [http://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys](https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys). Date accessed: 2020-12-07.

US Geological Survey (2015) National Elevation Dataset (NED). Available at: https://nationalmap.gov/elevation.html.Accessed January 2016

Wiest, W. A., Correll, M. D., Olsen, B. J., Elphick, C. S., Hodgman, T. P., Curson, D. R., & Shriver, W. G. (2016). Population estimates for tidal marsh birds of high conservation concern in the northeastern USA from a design-based survey. *Condor*, *118*(2), 274–288. https://doi.org/10.1650/CONDOR-15-30.1

**Wilson, M. F. J., O’Connell, B., Brown, C., Guinan, J. C., & Grehan, A. J. (2007). Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope. Marine Geodesy (Vol. 30).** <https://doi.org/10.1080/01490410701295962>