State of the Data:

United States Blue Carbon Data Report

Coastal Carbon Network
Database Version 1.2.0
June 12, 2024

This writeup will cover the report and highlights of the state-level work that the CCN delivered for the second round of Pew funding.

Table of Contents

Executive Summary **2**
Introduction **2**
Data Summary **3**
Highlights **3**
Blue Carbon Data Inventory **3**
Blue Carbon Report Card (V1.2.0) 4
Progress Report: Data Quantity 5
Progress Report: Data Quality 6
Spotlight Efforts **6**
US State Data Stewardship Initiative 6
Inventorying Applications: Carbon Stocks and Accumulation Rates 7
Acknowledgements **9**
References **9**
CCN Published Datasets Added **9**
Externally Published Data Added **11**
Tables **11**
Table: New Cores in US States 11

Executive Summary

- Since the official publication of Version 1.0.0 in October of 2023, the Coastal Carbon Network has added 1,393 soil cores located within the United States to the Data Library, which is served through the Coastal Carbon Atlas
- The CCN has updated the original 2021 Blue Carbon Inventory report card, with data included in Version 1.2.0 of the Data Library.
- Improvements and initiatives in stewardship and accessibility of previously unpublished data increased both quality and quantity metrics of state-level blue carbon data.
- The CCN sought to derive estimates of carbon accumulation rates from soil core data in the Coastal Carbon Atlas. This analysis contributed to U.S National Greenhouse Gas Inventory to update emissions factors.

CCN Data Library US Representation

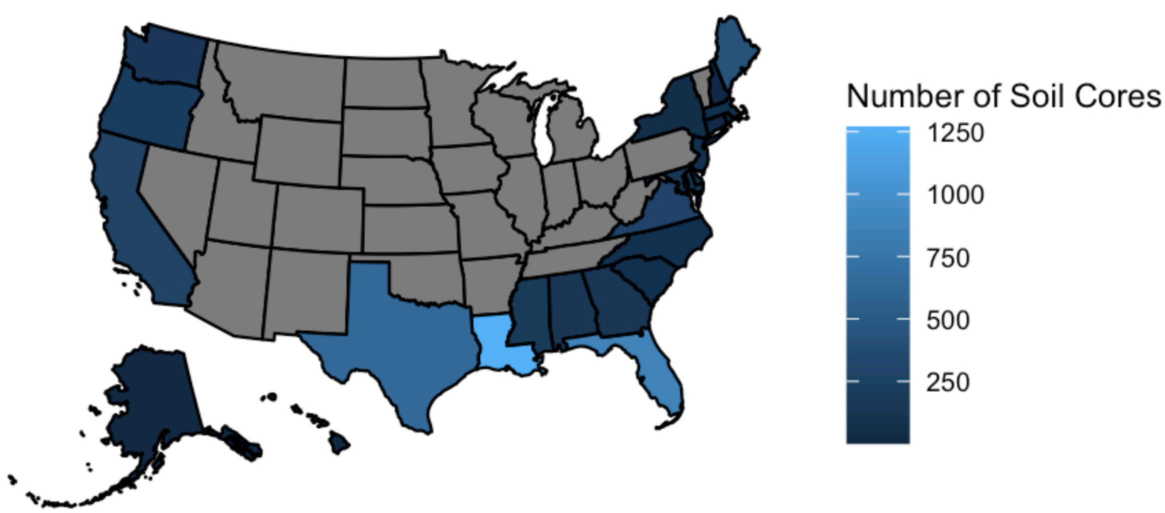

Figure 1. Map of soil cores in the United States included in the Coastal Carbon Data Library Version 1.2.0 by state.

Introduction

Within the United States, there is a large amount of state-to-state level variation in available blue carbon data. This variation not only includes data availability, but also how the data can be used in different analyses, how representative available data is of each state's wetland habitats and how well distributed sampling efforts are. In 2021, the Coastal Carbon Network (CCN) set out to use the data served through the Coastal Carbon Atlas to quantify these metrics for US states trying to integrate coastal wetlands into greenhouse gas indices.[7] This first analysis helped provide baseline insight for states, a 'report card', highlighting data strengths & areas for improvement. The results of this analysis report were able to raise awareness within states and incentivize greater investment in data stewardship in the following year.

Now, the CCN engages in ongoing monitoring of the CCN Data Library for change across metrics, allowing for more accessible tracking of progress through database updates. The most recent update published in March of 2024, Version 1.2.0, saw improvements in several states across multiple data metrics. Notably, these states improved in data utility, allowing newly included data in the Atlas and Library to be used for a more versatile set of applications. Although the Coastal Carbon Data Library is a global database, this report will focus on within-US data included in Version 1.2.0. For a global update of Version 1.2.0, the CCN has recently released a report detailing international data updates, found on our state-of-the-data reporting page.[5]

Data Highlights

- ❑ Number of new cores included within the United States: 1,393
- ❑ Quantity improvements in 21 states with coastal wetland (23 total - 91%)
- ❑ Quality improvements in 16 states with coastal wetland (23 total - 70%)
- ❑ States with the most improvement in quantity: Maine, New Hampshire, Alabama
- ❑ States with the most improvement in data quality: Oregon, Alabama, Mississippi

Blue Carbon Data Inventory

This update saw much improvement to the states which were previously underrepresented in their available data in Version 1.0.0 of the Data Library.[2] This improvement is largely due to targeted data stewardship efforts in East Coast states that contain a relatively large amount of coastal wetland habitat but had little publicly available data at the time of Version 1.0.0. The State-Level Blue Carbon Data Report Card analyzes US soil core data across four metrics;

‘Quantity’, ‘Quality’, ‘Spatial coverage’, and ‘Habitat coverage’. With the publication of database version 1.2.0, all states included in the report card that have associated data have now reached the total ranking of at minimum ‘Fair’, across all metrics.[1] This is an improvement from Version 1.0.0 where 4 states, Rhode Island, Mississippi, Virginia, and Maine, had a total rank of below ‘Fair’. In addition to all states on the report card having a minimum rank of ‘Fair’, this update also improves the ‘Quality’ metric across a number of states. In this most recent update, only New Hampshire and New York are categorized as ‘Poor’ in the quality metric, relative to the updated level of data representation. This is an improvement in this category, from 7 states ranking ‘Poor’ in data quality in the 2021 State-Level Carbon Data Report Card.[4] Relative to all other coastal states included in the inventory, Massachusetts ranks highest across all metrics, with a rank of ‘Best’ overall and in ‘Quantity’, ‘Spatial coverage’ and ‘Habitat coverage’. This is consistent with the original 2021 report, even with the influx of new data from other coastal states. [7]

Blue Carbon Report Card (V1.2.0)

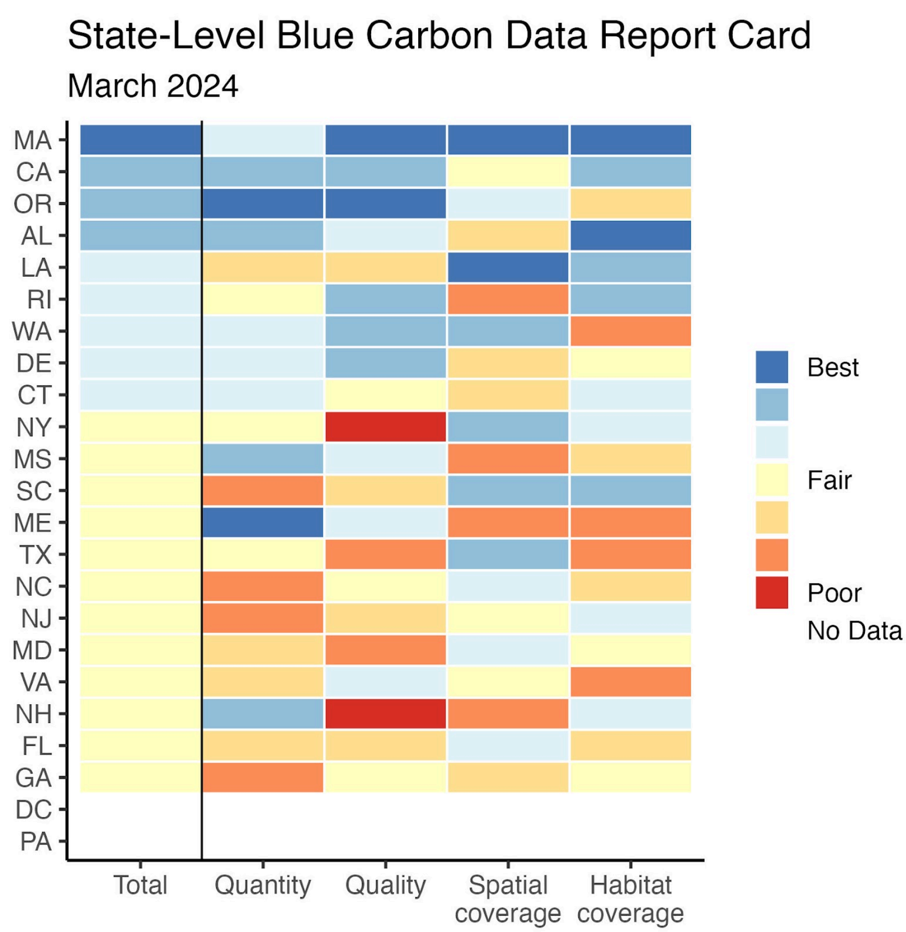

Figure 1. Updated State-Level Blue Carbon data report, analyzing US soil core data across metrics of data quantity, quality, spatial coverage, and habitat coverage.

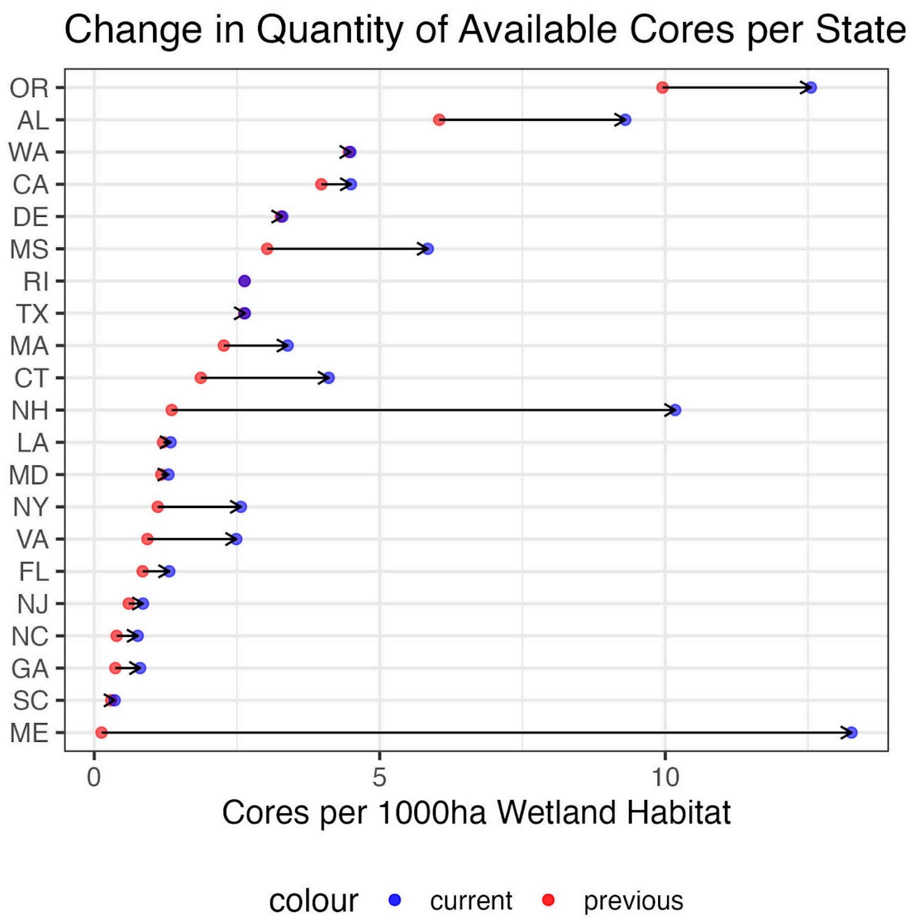

Figure 2. Change in number of cores per 1000ha wetland habitat in US states from Version 1.0.0 to Version 1.2.0 of the Coastal Carbon Data Library

Growth in data representation by state

In the Data Library Version 1.2.0, 21 of 23 coastal US states grew in data representation. Data representation by state is quantified by the total core count normalized by the total estimated tidal wetland area for each state.[1] Maine, New Hampshire, and Alabama are three states that gained the most new data representation by state from Version 1.0.0 to Version 1.2.0. All three of these states contain cores that were included as a result of the US Data Stewardship initiative, a project collaborating with a number of academic research groups within the United States. Representation in Maine has grown by more than a multiple of 10 since Data Library Version 1.0.0, from 27 cores to 415 in Version 1.2.0. In Version 1.2.0, it is the most represented state relative to state wetland habitat, in cores per 1000 hectares of wetland. This is an update from the 2021 report, in which Oregon is the state with the highest quantity of cores.[7] A large number of new cores located in Maine are from only a small number of new studies and include both marsh and seagrass habitat, increasing the quantity of available cores in Maine across multiple different wetland habitat types.

Progress Report: Data Quality

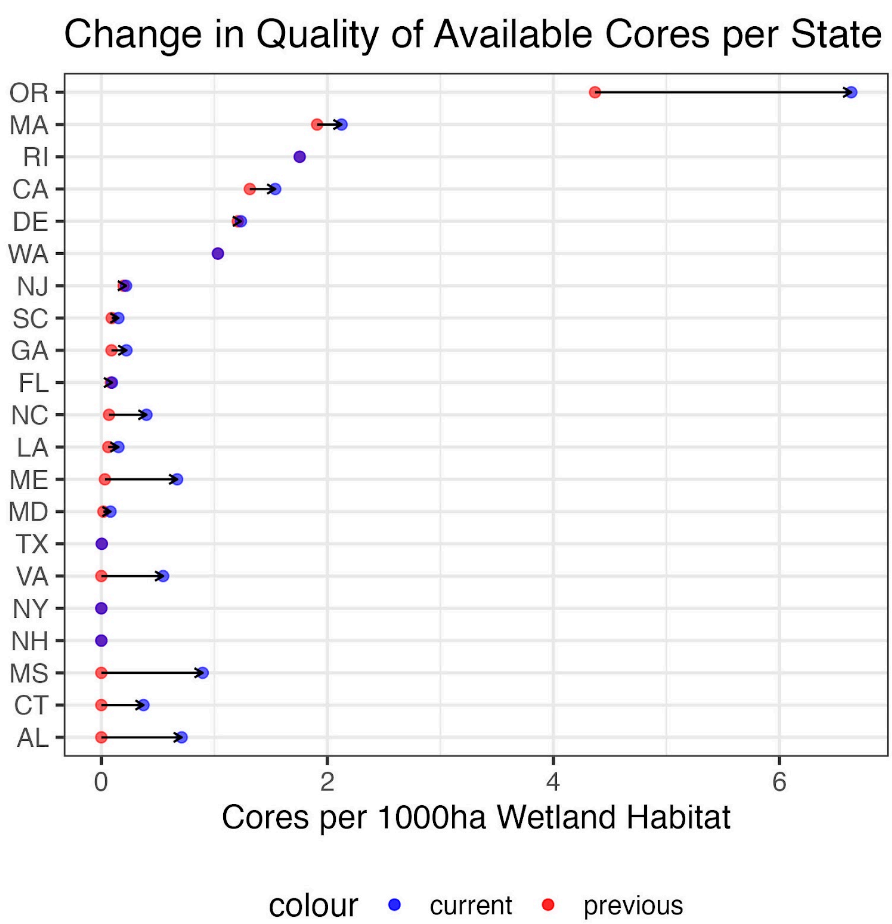

Figure 3. Change in quality of available cores per 1000ha wetland habitat in US states from Version 1.0.0 to Version 1.2.0 of the Coastal Carbon Data Library

Growth in data quality by state

By the metrics detailed in the CCN Blue Carbon Inventory, data quality is classified by what types of analysis the data can be used for and data completeness. Types of analysis include carbon stock data, carbon burial rate calculation, and modeling. Cores meeting the minimal inclusion criteria for carbon stocks include dry bulk density and either organic matter or organic carbon. For carbon stock, high-quality cores are categorized as cores confirmed to include all soil horizons and reach the bottom of the soil profile in the given habitat. In the case of age-depth analysis, a core is categorized as high-quality if dating information is present and complete, for samples along the depth profile of the core.

In its first version, 1.0.0, the Coastal Carbon Network Data Library housed 568 dated soil cores; the majority of those, 517, are from within the United States. 91 new cores in Version 1.2.0 were included through the US Data Stewardship initiative with associated dating information, bringing the total number of dated cores within the United States to 608. [2,3]

The majority of data in the CCN Data Library are data that can be used to calculate carbon stock assessments of soils. CCN data within the United States follows the same pattern, with most data meeting the minimum criteria for calculating stock assessments. Carbon stock assessments are important metrics which can be used to understand how particular regions, states, or habitats aid in determining carbon stock estimates and NDCs. The CCN continues to increase both the quantity and quality of soil core data within the CCN Data Library and Atlas with each version update, data which can then be applied to future stock assessments, inform policy decisions, and contribute to state, regional, and national soil carbon estimates.

Spotlight Efforts

US State Data Stewardship Initiative

Beginning in July of 2023, The Coastal Carbon Network, supported by the Smithsonian Institution's Big Data Pilot Program, collaborated with five research groups from the United States to curate and publish soil carbon data across multiple habitats along the east coast of the United States. This approach leveraged skill sharing and stewardship to elevate the availability of blue carbon data for underrepresented states (ME, MD, VA, NC, etc.) by partnering with researchers in academia who have unpublished data which could mitigate these data deficiencies. As an important part of this project, CCN data technicians worked to train student researchers in the data archival and publication process, as well as in CCN data processing workflows in R and GitHub.

Throughout this effort, CCN data technicians worked with three student researchers in undergraduate and graduate programs to complete the data publication process. Starting with original data values, the student researchers curated data through CCN data curation workflows, created ecological metadata, and utilized R and R Markdown to create data visualizations for each dataset. Student researchers had the opportunity to consult and collaborate with CCN technicians with weekly meetings, to answer process questions and solve coding problems.

At present, a total of 16 datasets have been curated, with 14 of these currently published and 12 included in the Version 1.2.0 Database update. These datasets include soil cores from sites in Maine, New Hampshire, New York, New Jersey, Maryland, Virginia, North Carolina, Georgia, and South Carolina. At present, 163 new soil cores have been included in the Library as a result of this program, with more in review for publication. This brings the total number of soil cores representing habitats within the United States to 5,485 in Version 1.2.0. The states with the most improvement in quantity of available cores as a result of this effort are Maine, Alabama, and New Hampshire, which are also the three states with the most improvement in the 'Quantity' metric overall.

The CCN would like to acknowledge the Principal Investigators and student researchers involved in this initiative, along with their collaborators that helped to produce and publish data releases included in the CCN Data Library Version 1.2.0. These collaborators and research groups include:

- Dr Christopher Craft and student researcher Madeleine Thompson from Indiana University
- Dr. Cindy Palinkas and student researcher Summer Walker from the University of Maryland Center for Environmental Studies
- Dr. Reide Corbett and student researcher Thi Tran from Eastern Carolina University
- Dr. Matt Kirwan and collaborators from the Virginia Institute for Marine Science (VIMS)
- Dr. Beverly Johnson, Department of Earth and Climate Sciences, Bates College
- Claire Enterline, Research Associate with the Gulf of Maine Research Institute

Data Applications

Data from the Coastal Carbon Data Library and Atlas has a number of applications in the wider scope of Blue Carbon projects, coastal land management, and policy.

Inventorying Applications: Carbon Stocks and Accumulation Rates

As more research has come out in recent years, it has become increasingly important and relevant to incorporate these findings into national inventories of GHG which inform the country's NDCs (Nationally Determined Contributions). [6]

The CCN sought to answer the question: How can estimates of carbon accumulation be derived from soil core data in the Coastal Carbon Atlas (CCA)? This was approached from two angles: (1) Harmonize the Coastal Carbon Atlas with previous literature review on carbon burial rates, so that raw data in the CCA will be connected to derivative emissions factors from the literature review. And (2) Leverage the CCA to calculate estimates and summary statistics of carbon accumulation rates (CAR).

This analysis developed a report on literature-reviewed values of carbon accumulation rate, which were contributed to the recent U.S National Greenhouse Gas Inventory to update emissions factors.[6] Methodology was based on the previous inventory conducted by Lu et al 2017.[5] Before the analysis, a literature review of CAR values was conducted to extract sediment accretion or carbon accumulation rate values from literature that had come out since the 2017 inventory. The resulting compiled table of values was used in a scripted workflow which computed updated emissions factors. [5]

Acknowledgements

The CCN would like to acknowledge The Pew Charitable Trusts, all collaborators and student researchers in the US Data Stewardship program, and the following authors and collaborators who contributed data and intellectual input to the Coastal Carbon Data Library from the publication of Version 1.0.0 to Version 1.2.0. We recognize both authors who published original data through the CCN, and externally published data included in Version 1.2.0 of the Data Library.

CCN Published Datasets Added

Brown et al 2024: Brown, Cheryl A.; Mochon Collura, T Chris; DeWitt, Ted (2024). Dataset: Accretion rates and carbon sequestration in Oregon salt marshes. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.25024448

Craft 2024: Craft, Christopher (2024). Dataset: Tidal freshwater forest accretion does not keep pace with sea level rise. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24895293

Darienzo and Peterson 1990: Darienzo, Mark; Peterson, Curt (2024). Dataset: Episodic Tectonic Subsidence of Late Holocene Salt Marshes, Northern Oregon Central Cascadia Margin. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.25270099

Dontis et al 2023: E. Dontis, Emma; Radabaugh, Kara R.; R. Chappel, Amanda; E. Russo, Christine; P. Moyer, Ryan (2023). Carbon Storage Increases with Site Age as Created Salt Marshes Transition to Mangrove Forests in Tampa Bay, Florida (USA). Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24467947

Drake et al 2024: Drake, Katherine; Halifax, Holly; Adamowicz, Susan, C.; Craft, Christopher (2024). Dataset: Carbon Sequestration in Tidal Salt Marshes of Northeast United States. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24518770

Kemp et al 2024: C. Kemp, Andrew; P. Horton, Benjamin; J. Culver, Stephen; Corbett, D. Reide; van de Plassche, Orson; Gehrels, W. Roland; et al. (2024). Dataset: Timing and magnitude of recent accelerated sea-level rise (North Carolina, United States). Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24910587

Loomis and Craft 2024: Loomis, Mark, J.; Craft, Christopher (2024). Dataset: Carbon Sequestration and Nutrient (Nitrogen, Phosphorus) Accumulation in River-Dominated Tidal Marshes, Georgia, USA.. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24518755

Morgan et al 2024: Morgan, Pamela; Burdick, David; Short, Frederick (2024). Dataset: Soil organic matter in fringing and meadow salt marshes in Great Bay, New Hampshire and southern Maine. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.25222124

Palinkas and Cornwell 2024: Palinkas, Cindy M.; Cornwell, Jeffrey (2024). Dataset: A Preliminary Sediment Budget for the Corsica River (MD): Improved Estimates of Nitrogen Burial and Implications for Restoration. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24467977

Palinkas and Engelhart 2024: Palinkas, Cindy M.; Engelhardt, Katharina A. M. (2024). Dataset: Spatial and temporal patterns of modern sedimentation in a tidal freshwater marsh. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24470152

Radabaugh et al 2017: Radabaugh, Kara R.; E. Powell, Christina; Bociu, Ioana; C. Clark, Barbara; P. Moyer, Ryan (2023). Plant size metrics and organic carbon content of Florida salt marsh vegetation. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24602130

Radabaugh et al 2018: R. Radabaugh, Kara; P. Moyer, Ryan; R. Chappel, Amanda; E. Powell, Christina; Bociu, Ioana; C. Clark, Barbara; et al. (2023). Coastal Blue Carbon Assessment of Mangroves, Salt Marshes, and Salt Barrens in Tampa Bay, Florida, USA. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.23960784

Radabaugh et al 2021: R. Radabaugh, Kara; E. Dontis, Emma; R. Chappel, Amanda; E. Russo, Christine; P. Moyer, Ryan (2023). Early indicators of stress in mangrove forests with altered hydrology in Tampa Bay, Florida, USA. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.23960811

Radabaugh et al 2023: R. Radabaugh, Kara; P. Moyer, Ryan; R. Chappel, Amanda; L. Breithaupt, Joshua; Lagomasino, David; E. Dontis, Emma; et al. (2023). A Spatial Model Comparing Above- and Belowground

Blue Carbon Stocks in Southwest Florida Mangroves and Salt Marshes. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.23960826

Schieder and Kirwan 2019: Schieder, Nathalie; Kirwan, Matthew (2024). Dataset: Sea-level driven acceleration in coastal forest retreat. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.25259983

Smith and Kirwan 2021: Smith, Alexander; Kirwan, Matthew (2024). Sea Level-Driven Marsh Migration Results in Rapid Net Loss of Carbon. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24916407

Stahl et al 2024: Strand, Jessica; Corbett, D. Reide (2024). Dataset: Examining Coastal Marsh Sedimentation in Northeastern North Carolina. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.24991359

Stevens et al 2024: Stevens, Luke; Corbett, D. Reide; Culver, Stephen (2024). Sediment Accumulation in Salt Marshes Across the Southeastern United States. Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.25289635

Externally Published Data Added

Bost et al 2024: Molly C. Bost, Antonio B. Rodriguez, Brent A. McKee, Impact of land-use change on salt marsh accretion, Estuarine, Coastal and Shelf Science, Volume 299, 2024, 108693, ISSN 0272-7714, https://doi.org/10.1016/j.ecss.2024.108693

Everhart et al 2020: Everhart, C.S., Smith, C.G., Ellis, A.M., Marot, M.E., Coleman, D.J., Guntenspergen, G.R., and Kirwan, M.L., 2020, Sediment radiochemical data from Georgia, Massachusetts, and Virginia coastal marshes: U.S. Geological Survey data release, https://doi.org/10.5066/P926MS6T

Vinent and Kirwan: Vinent, O. and M. Kirwan. 2018. Upper Phillips Creek soil organic content and bulk density April, 2017 ver 2. Environmental Data Initiative. https://doi.org/10.6073/pasta/0f1cceb5f013643be08dbc5386f073ac

References

1. Coastal Carbon Atlas (2024. Coastal Carbon Atlas, Smithsonian Environmental Research Center. https://shiny.si.edu/coastal_carbon_atlas/.

2. Coastal Carbon Network (2023). Database: Coastal Carbon Library (Version 1.0.0). Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.21565671.v1.
3. Coastal Carbon Network (2024). Database: Coastal Carbon Library (Version 1.2.0). Smithsonian Environmental Research Center. Dataset. https://doi.org/10.25573/serc.21565671.v4.
4. *Coastal Carbon Network: State-of-the-Data Reporting.* Smithsonian Environmental Research Center. Accessed 7 June 2024. https://serc.si.edu/coastalcarbon/reports
5. *'Coastal-Wetland-NGGI-Data-Public'*. Smithsonian Institution. Github. Accessed June 7 2024. https://github.com/Smithsonian/Coastal-Wetland-NGGI-Data-Public
6. EPA (2024). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 U.S. Environmental Protection Agency, EPA 430R-24004. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022.
7. Holmquist, J., Wolfe, J., Megonigal P. (2021). *CCRCN Blue Carbon Inventory.* https://smithsonian.github.io/CCRCN-Pew-Project/index.html

Tables

Table: New Cores in US States

state	total cores	dated cores	habitat	sources
Alabama	55	12	marsh	Marot_et_al_2020
Alaska	24	0	marsh	Beers_et_al_2023
California	30	0	marsh, scrub/shrub, seagrass	Cahoon_et_al_1996, Patrick_and_DeLaune_1990, Curtis_et_al_2022, Beers_et_al_2023

Connecticut	18	3	marsh	Weston_et_al_2023, Anisfeld_et_al_1999, Orson_et_al_1998
Delaware	1	1	marsh	Weston_et_al_2023
Florida	306	5	seagrass, swamp, mangrove, marsh, unvegetated	Saunders_2013, Rovai_et_al_2022, Radabaugh_et_al_2023, Radabaugh_et_al_2021, Radabaugh_et_al_2018, Yando_et_al_2016, Howard_and_Fourqurean_2020, Beers_et_al_2023
Georgia	82	79	marsh, swamp	Weston_et_al_2023, Turck_2014, Stevens_et_al_2024, Stahl_et_al_2024, Loomis_and_Craft_2024, Everhart_et_al_2020, Craft_2024
Louisiana	126	111	marsh	Snedden_2021, Snedden_2018, Piazza_et_al_2020, Bryant_and_Chabreck_1998, Markewich_et_al_1998, Rybczyk_and_Cahoon_2002, Yando_et_al_2016
Maine	409	23	marsh	Weston_et_al_2023, Vincent_and_Dionne_2023, van_Ardenne_et_al_2018, Morgan_et_al_2024, Drake_et_al_2024
Maryland	14	7	scrub/shrub, marsh	Smith_and_Kirwan_2021, Shaw_et_al_2020,

				Palinkas_and_Cornwell_2024, Beers_et_al_2023
Massachusetts	29	26	marsh	Weston_et_al_2023, Roman_et_al_1997, Everhart_et_al_2020, Drake_et_al_2024
Mississippi	91	29	marsh	Marot_et_al_2020
New Hampshire	26	0	marsh	Morgan_et_al_2024
New Jersey	23	23	marsh	Weston_et_al_2023, Drake_et_al_2024, Kemp et al 2024
New York	32	32	marsh	Wang_et_al_2023, Drake_et_al_2024
North Carolina	33	20	marsh	Weston_et_al_2023, Stevens_et_al_2024, Miller_et_al_2022, Craft_et_al_1993
Oregon	47	41	marsh	Darienzo_and_Peterson_1990, Brown_et_al_2024
South Carolina	13	13	marsh	Weston_et_al_2023, Stevens_et_al_2024
Texas	3	0	marsh	Yando_et_al_2016

Virginia	182	63	marsh, scrub/shrub, unvegetated, seagrass, mudflat	Weston_et_al_2023, Vinent_and_kirwan_2017, Smith_and_Kirwan_2021, Schieder_and_Kirwan_2019, Palinkas_and_Engelhardt_2024, Messerschmidt_et_al_2020, McGlathery_et_al_2018, Langston_et_al_2022, Gillen_et_al_2018, Everhart_et_al_2020, Beers_et_al_2023
Washington	1	1	marsh	Thom_1992