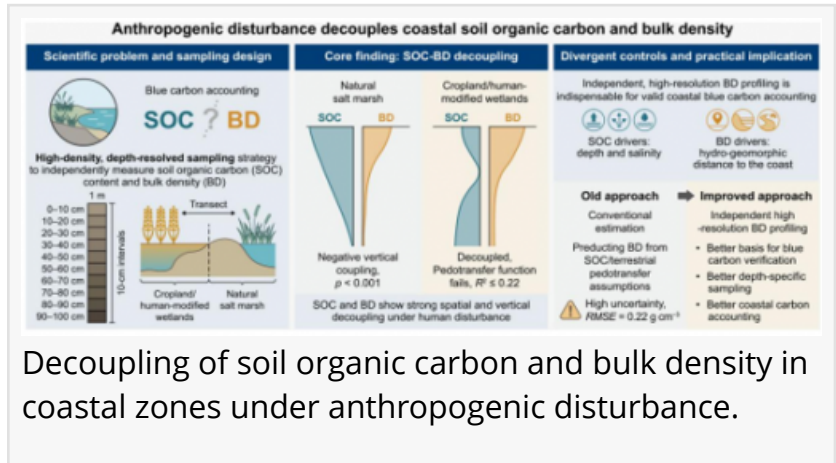


Hidden uncertainty: Human activity severs critical link between soil carbon and density in coastal zones

FAYETTEVILLE, GA, UNITED STATES, July 12, 2026 /EINPresswire.com/ -- [Coastal wetlands](#) are among the most powerful carbon sinks on the planet, but a new study reveals that the standard methods used to measure this stored carbon may be systematically underestimating uncertainty in coastal zones. Researchers found that human activities, such as farming, are breaking the fundamental relationship between soil organic carbon and bulk density in coastal zones. This decoupling throws significant uncertainty into blue carbon accounting—a key tool in global climate strategies. The findings challenge the widespread reliance on traditional land-based formulas to estimate carbon in these dynamic, human-impacted environments.



Accurate carbon accounting depends on two intertwined soil properties: soil organic carbon (SOC) content and bulk density (BD), a measure of soil compaction. In terrestrial ecosystems, these properties usually exhibit a predictable negative correlation. However, coastal environments are inherently more complex and are rarely sampled with sufficient vertical detail. This complexity has led to a systematic neglect of BD variations, with researchers often using “pedotransfer functions” (PTFs)—empirical equations originally developed for dry land to predict missing data. Due to these issues, a comprehensive, high-resolution investigation into how these properties interact—or fail to—across different depths and land-use types in coastal zones is urgently needed.

A research team from Nanjing University, Renmin University of China, the Key Laboratory of Coastal Salt Marsh Ecosystems and Resources, Hubei University of Arts and Science and other institutions has published (DOI: [10.1016/j.esa.2026.100728](https://doi.org/10.1016/j.esa.2026.100728)) a high-resolution study in [Environmental Science and Ecotechnology](#). The team collected 123 soil profiles across the Jiangsu coastal zone in China, sampling down to one meter at 10-centimeter intervals. Their comprehensive dataset allowed them to map the spatial and vertical distribution of carbon content and bulk density with unprecedented precision.

The results reveal a striking divergence in how these two properties behave. Machine learning models showed that SOC is primarily controlled by depth and ocean salinity, while BD is governed by a more complex set of factors, most notably the distance to the coastline. In healthy, natural salt marshes dominated by *Spartina alterniflora*, a strong negative correlation existed; as carbon increased, density decreased. However, this tight vertical coupling was completely absent in croplands. The study found that anthropogenic disturbance, including tillage and compaction, effectively “decouples” the carbon-density relationship. Consequently, traditional PTFs performed poorly in human-modified areas, yielding a mean baseline prediction uncertainty of 0.22 g cm⁻³ for BD. The research also produced 30-meter resolution maps of both properties across ten depth layers, showing that while carbon content varies considerably with depth, the spatial pattern of bulk density becomes surprisingly uniform below 40 centimeters.

“Our findings demonstrate that we cannot keep treating coastal soils as if they were just wetter versions of terrestrial ones,” the authors said. “The mechanisms driving carbon storage and soil structure are fundamentally different here, and human activity is disrupting them in ways we are only beginning to understand. If we continue to rely on outdated equations that don’t account for these coastal-specific processes, our carbon budgets for these vital ecosystems will remain highly uncertain. We need a new, context-dependent approach to sampling and modeling.”

The findings offer a clear, actionable path forward for improving blue carbon assessments. The researchers advocate for a land-cover-based sampling strategy. In deep-rooted, vegetated wetlands, high-resolution vertical sampling is critical to capture the strong carbon-density gradient. In non-vegetated areas, such as tidal flats, where properties change little with depth, sampling can be less intensive. Crucially, for human-modified lands where standard formulas fail, the team recommends directly measuring BD to ensure accuracy. By refining where and how soil is sampled, this research provides a framework to reduce uncertainty in coastal climate mitigation projects and support more informed management of these ecologically and economically valuable zones.

References

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