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Assessing Carbon Pools and Stability in Coastal Prairie Soils Using Programmed Pyrolysis

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Understanding the distribution and stability of terrestrial carbon reservoirs is needed for constraining carbon–climate feedbacks and designing practices that enhance soil carbon storage. Coastal prairie ecosystems represent understudied yet potentially significant soil carbon reservoirs that may function as localized carbon “hotspots” within regional carbon budgets.

This study evaluates carbon pools in remnant (unplowed native vegetation) and restored (managed following invasive species removal) coastal prairies soils to assess their sensitivity to disturbance and restoration. A total of 35 samples (top- and sub-soil) were collected at the University of Houston Coastal Center. Samples were analyzed using programmed pyrolysis with a Rock-Eval 6 system (RE-6), a method that thermally resolves and quantifies distinct carbon fractions.

Measured total organic carbon (TOC) ranged from 0.16% to 4.05%, demonstrating significant spatial heterogeneity in soil carbon distribution. S1 values (0.02–0.13 mg/g) indicate readily pyrolyzable organic matter, whereas S2 pyrolysates, generated at higher temperatures, exhibit broader variability (0.17–6.63 mg/g) and represent more thermally stable carbon fractions. Remnant prairies exhibited higher TOC concentrations and a greater proportion of S2 fractions relative to restored sites, highlighting ecosystem management as a key control on carbon stability and persistence.

In addition to reporting standard RE-6 parameters (TOC, S1, S2), we evaluate two machine-learning frameworks recently developed for use with RE-6 data to assess soil carbon: (1) a TOC–TIC correction model designed to reduce systematic bias in RE-6–derived soil organic carbon (SOC) and soil inorganic carbon (SIC) estimates,[1] and (2) the $PARTY_{SOC}$ model, which partitions SOC into centennially stable and active carbon fractions based on RE-6 pyrolysis signatures.[2] Applying these models to coastal prairie soils provides an opportunity to assess their transferability beyond initial calibration datasets and across distinct pedoclimatic conditions.

Together, these results contribute to identifying terrestrial carbon hotspots, improving assessments of soil carbon permanence, and evaluating emerging analytical tools for broader application in regional and global carbon management frameworks.

References

[1] Stojanova et al., 2024, Biogeosciences, 21, 4229–4237.
[2] Cécillon et al., 2021, Geosci. Model Dev., 14, 3879–3898.