Spatial and Temporal Drivers of Soil Carbon Cycling in Semi-Arid Floodplains

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Introduction

Carbon cycling dynamics in floodplain soil, including the storage and respiration of carbon, are regulated by complex interactions between:
- **Temporal factors** (precipitation events, hydrograph, groundwater trends, air temperature, etc.)
- **Environmental factors** (soil temperature, soil water content, organic carbon content, etc.)
- Because soil carbon is the largest terrestrial reservoir of carbon untangling spatial and temporal drivers of carbon respiration has a direct impact on global carbon accounting.
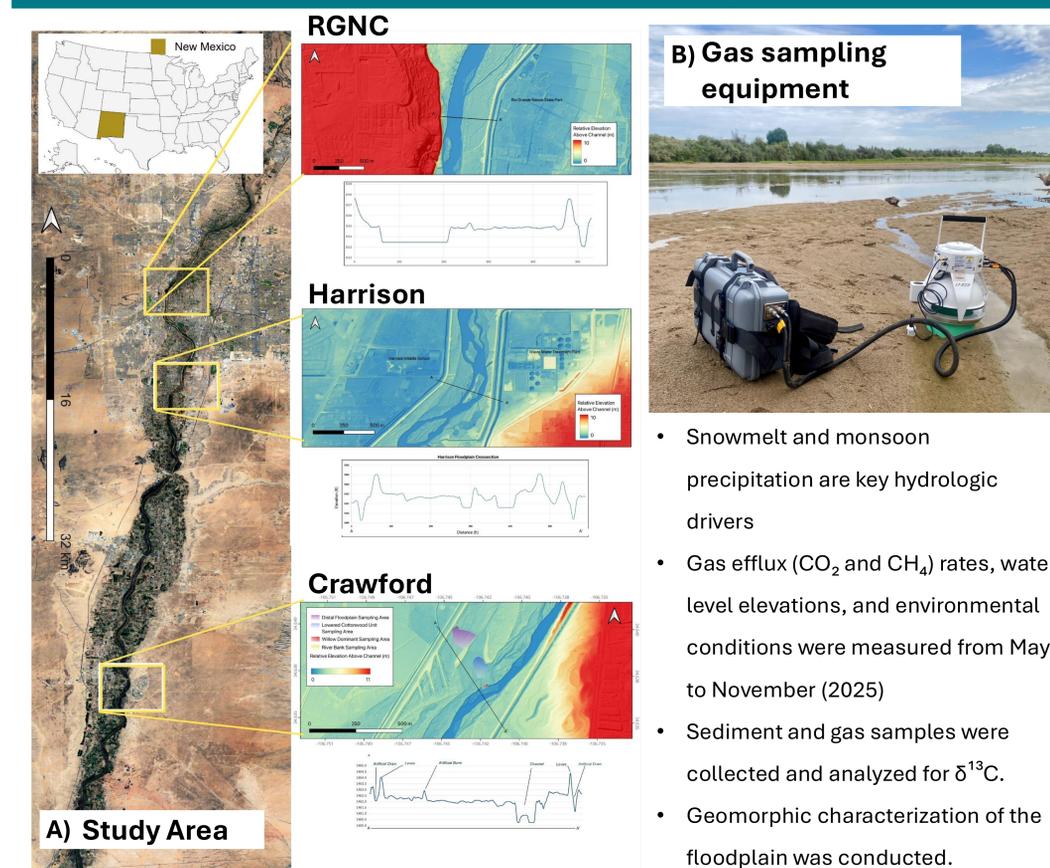
This work aims to:
- Quantify carbon respiration rates across varying temporal and spatial scales
- Determine the drivers of carbon loss in semi-arid floodplains

Floodplain Schematic
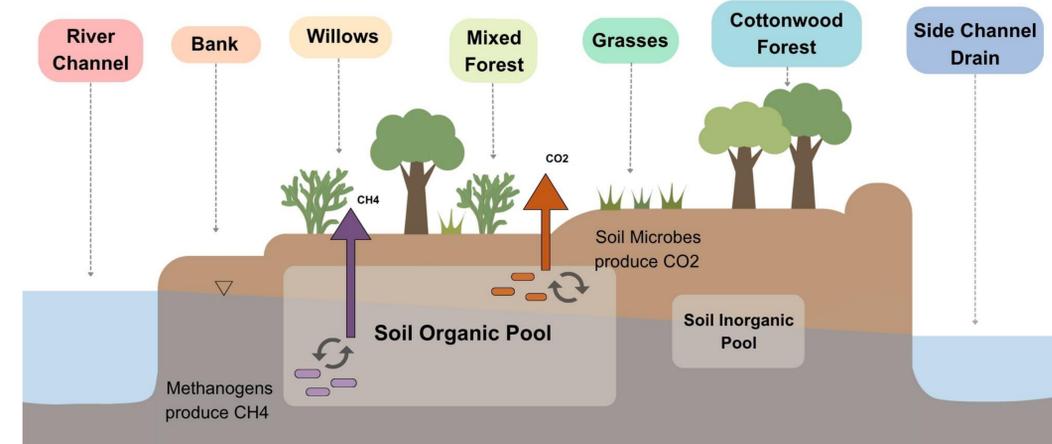
Schematic of a typical Rio Grande floodplain showing the main geomorphic and vegetation units.

Rio Grande Floodplain Study Sites

A) Study Area

B) Gas sampling equipment

- Snowmelt and monsoon precipitation are key hydrologic drivers
- Gas efflux (CO_2 and CH_4) rates, water level elevations, and environmental conditions were measured from May to November (2025)
- Sediment and gas samples were collected and analyzed for $\delta^{13}C$.
- Geomorphic characterization of the floodplain was conducted.

CO2 Flux Varies Temporally

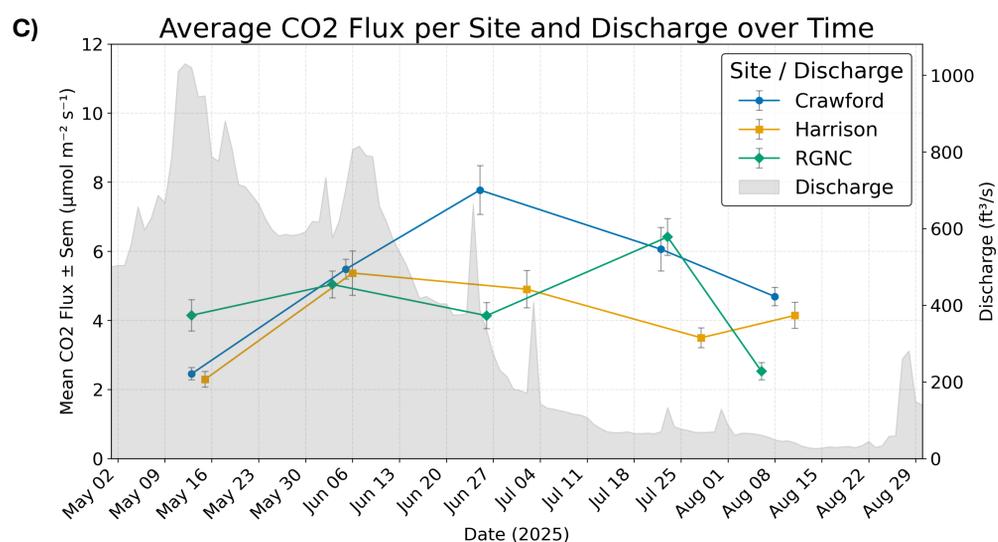**Figure C. Average CO_2 flux (μmol m^{-2} s^{-1}) by site across the sampling period (May–August 2025).** Fluxes vary through time and between sites, with Crawford peaking mid-season, Harrison fluctuating throughout, and RGNC showing a delayed peak.
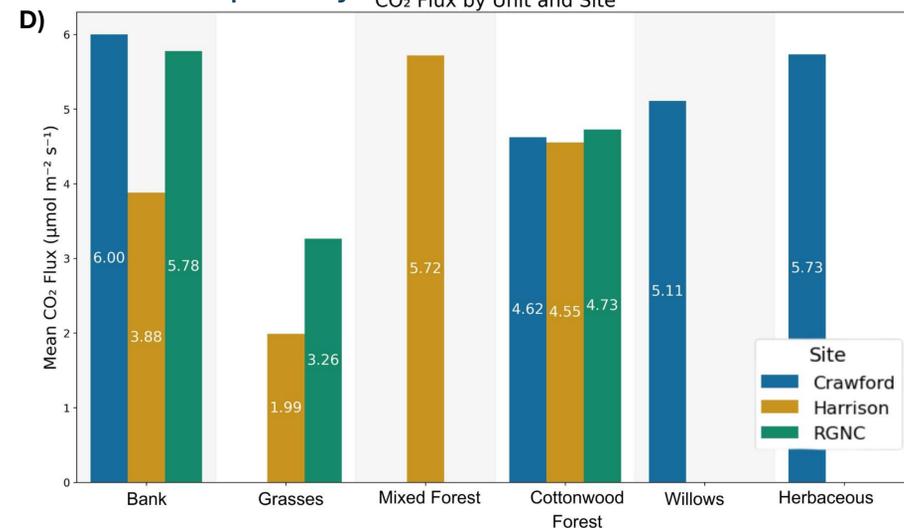
CO2 Flux Varies Spatially

Figure D. Spatial variability of mean CO_2 flux across riparian units and sites. Bars show average CO_2 flux (μmol m^{-2} s^{-1}) by vegetation unit and site. Labels inside bars indicate mean flux values.
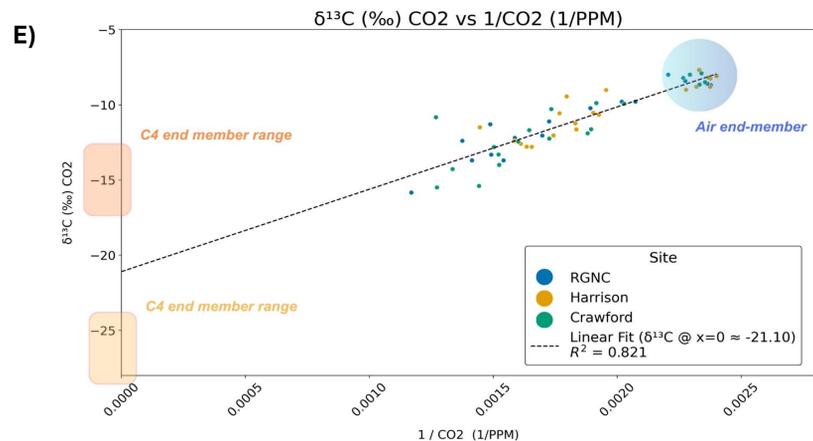
Gas Source from Carbon Isotopes

Figure E. The relationship $\delta^{13}C$ values and inverse CO_2 concentrations. The linear trend ($R^2 = 0.821$) suggests mixing between distinct carbon end-members (C3 and C4 vegetation types) and atmospheric air.

Does Higher Soil Moisture Mean Higher Fluxes at Crawford?
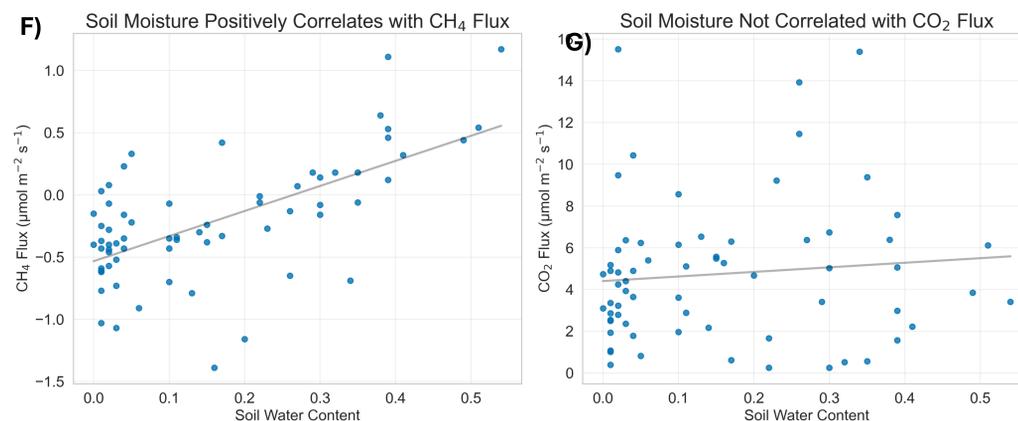

Figure F-G. Relationships between soil moisture and gas fluxes at the Crawford site. (E) Soil moisture vs. CH_4 flux shows a significant positive correlation ($r = 0.63$, $p < 0.001$). (F) Soil moisture vs. CO_2 flux shows a weak, non-significant relationship ($r = 0.10$, $p = 0.43$).

Conclusion

- CO_2 fluxes vary across spatially across vegetation units and sites as well as temporally influenced by hydrologic events.
- Methane (CH_4) fluxes at the Crawford site showed a strong positive correlation with soil moisture, CO_2 fluxes were less correlated.
- Isotopic Analysis suggest gas samples represent a mix between atmospheric air and C_3 and C_4 vegetation.
- These findings underscore the importance of geomorphic context, vegetation type, and seasonality in understanding drivers of carbon loss in semi-arid floodplains.