BG4.1 - Vegetated coastal ecosystems:
Bridging disciplines to understand Blue carbon dynamics under global change
EGU24-2741

Functional organic matter components in mangrove soils revealed by density fractionation

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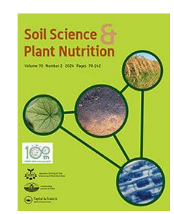

Mangroves are known for their high SOC stocks/area

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Mangroves among the most carbon-rich forests in the tropics

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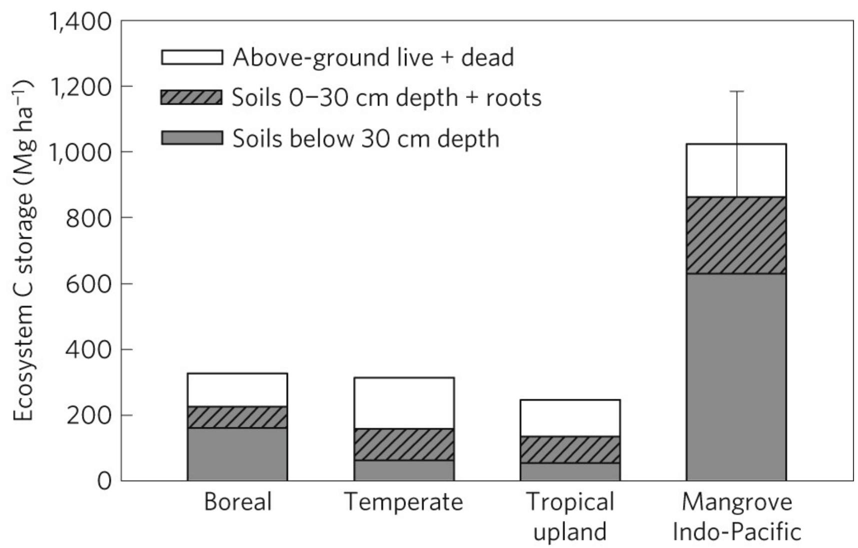
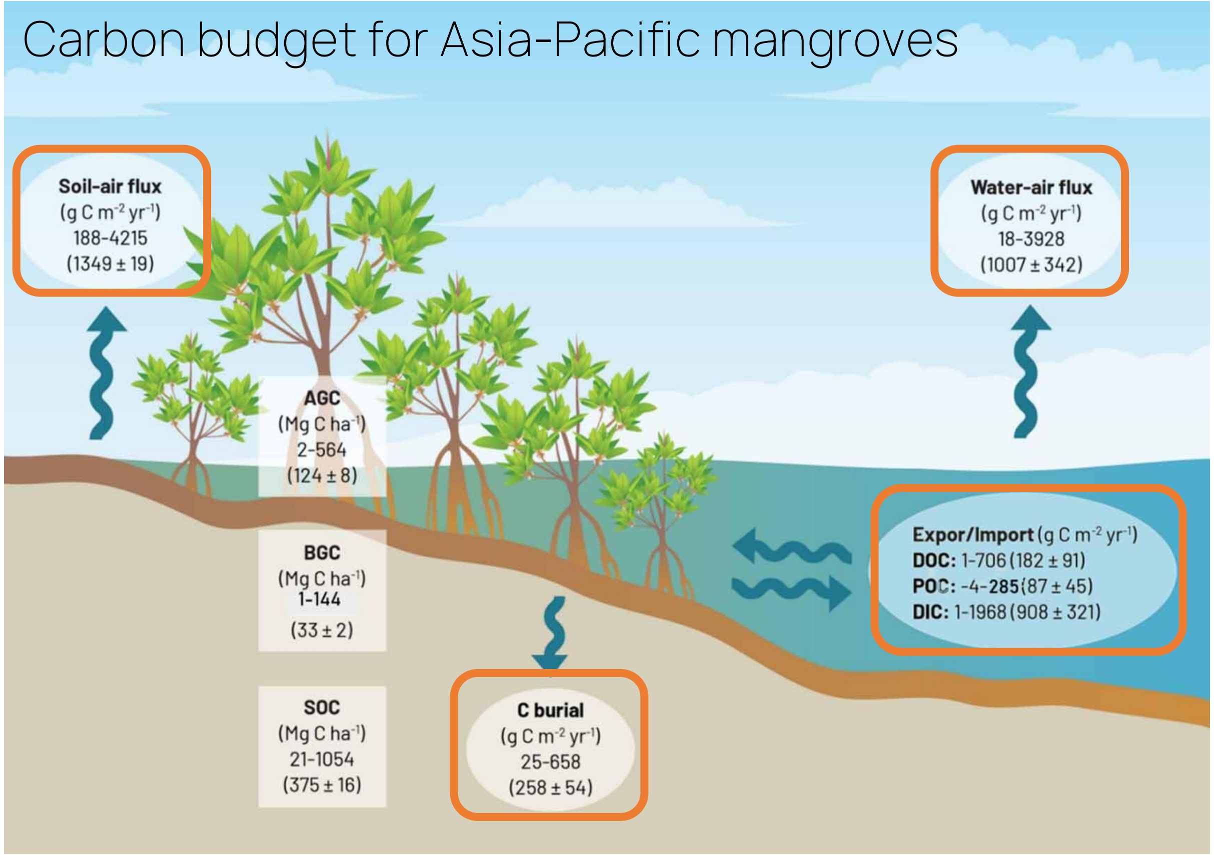


Globally, about 75% of its ecosystem C is stored as SOC

Donato et al. (2011)

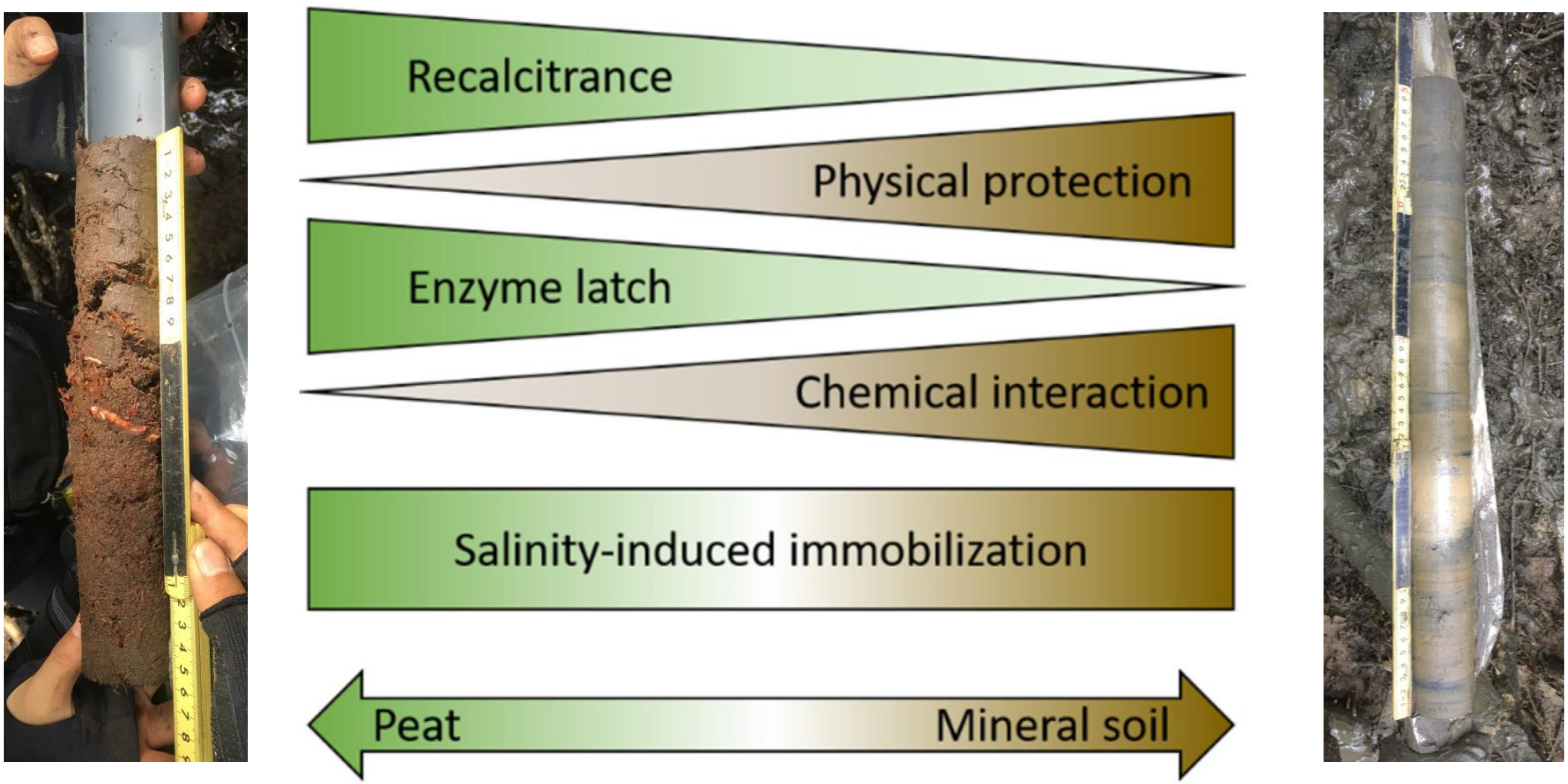
Reasons behind the long-term SOC stabilization are not clear



Estimated fluxes vary more than an order of magnitude
These differences can be partly explained by differences in SOC stabilization mechanisms among sites

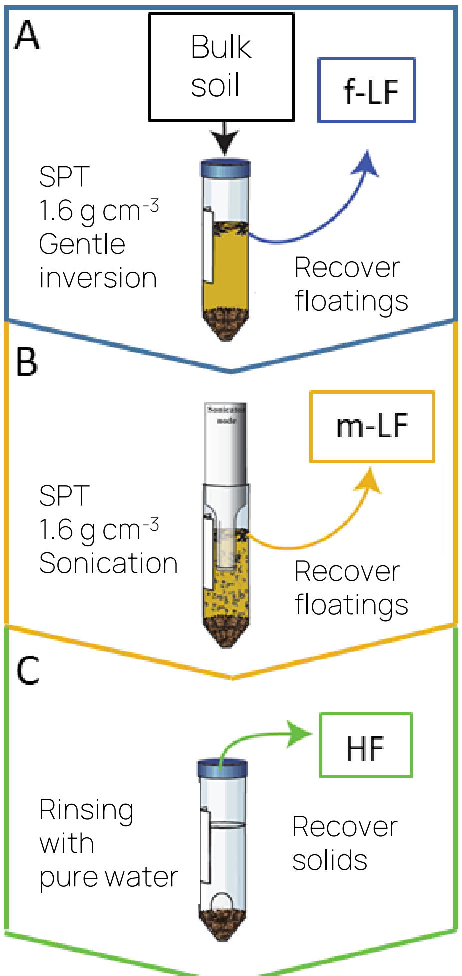
Sharma et al. (2023)

At least, we must consider two different types of soils

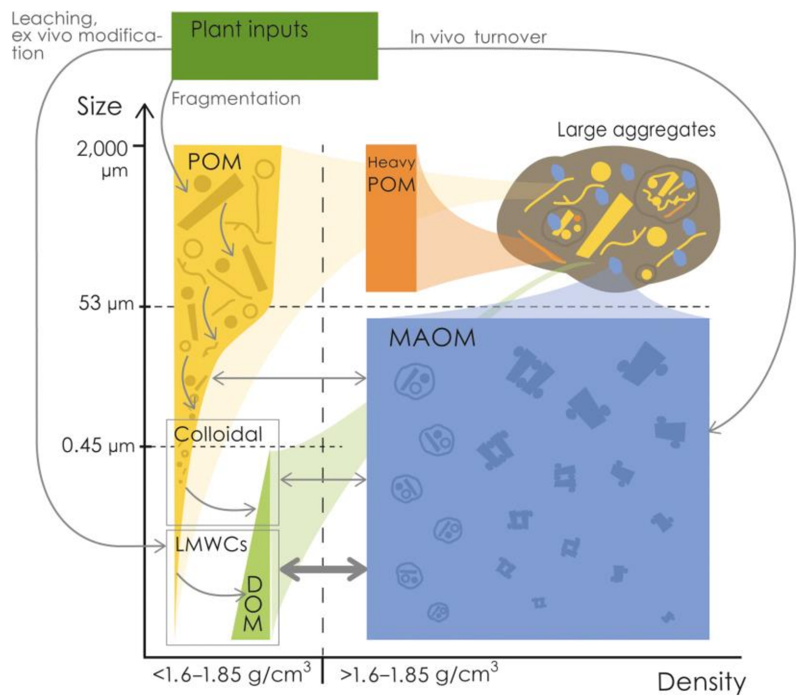


Kida et al. (2017); Kida & Fujitake (2020)

Density fractionation to reveal functional components of SOC



Quantification of SOC fractions with different stability/biodegradability



f-LF ≈ POM

m-LF ≈ Heavy POM

HF ≈ MAOM

modified from Rowley et al. (2021)

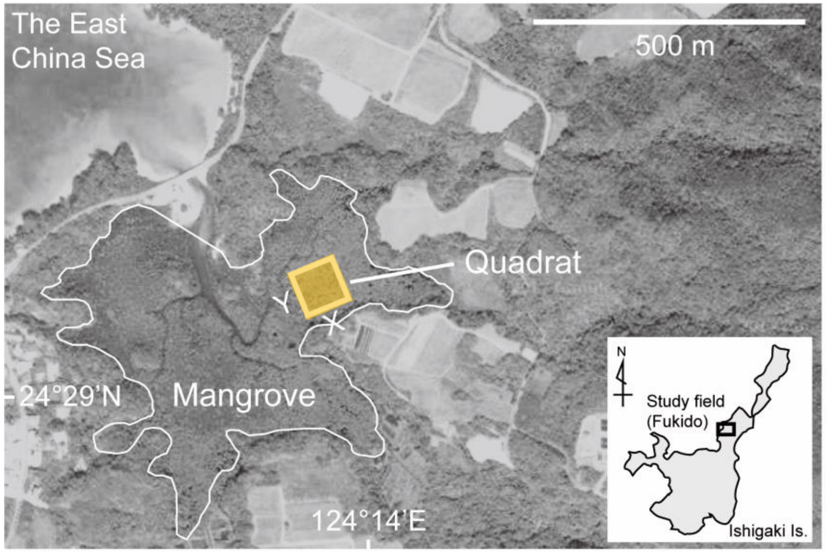
Lavallee et al. (2019)

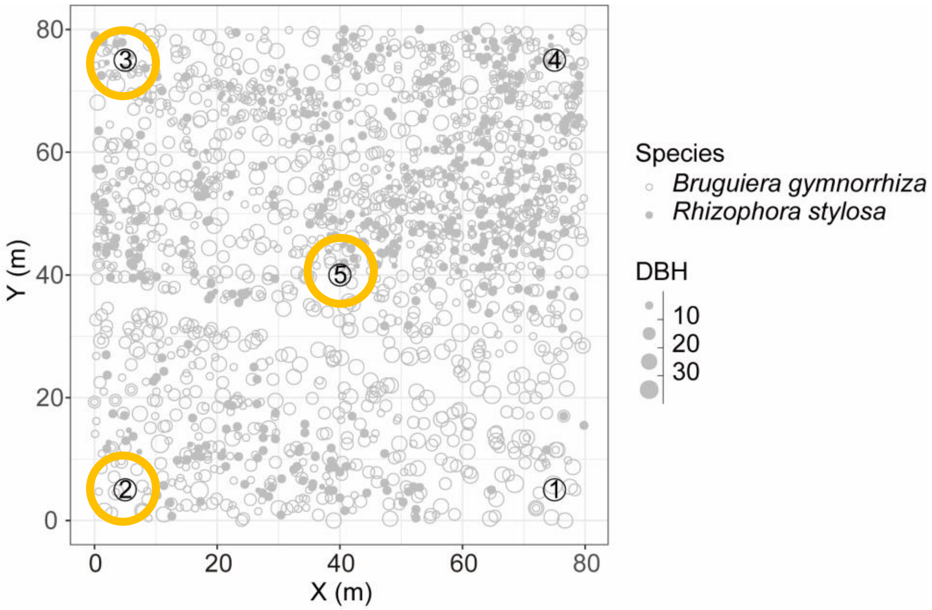
Fukido mangrove, Ishigaki Isl. Japan

Samples collected from a permanent quadrat in a matured mangrove forest

Three cores were sampled down to 1 m, and sectioned into 10-cm intervals

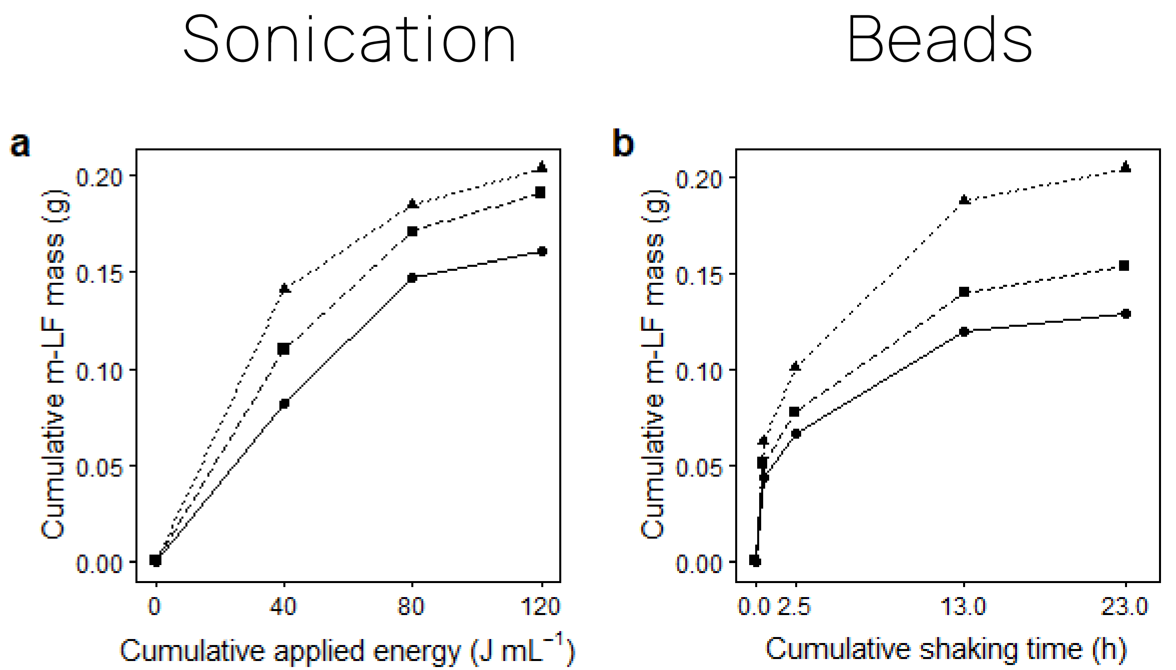
After air-drying and 2-mm sieved, samples were analyzed by density fractionation after optimization of m-LF recovery





Hamada et al. (2024)

Optimization of m-LF recovery

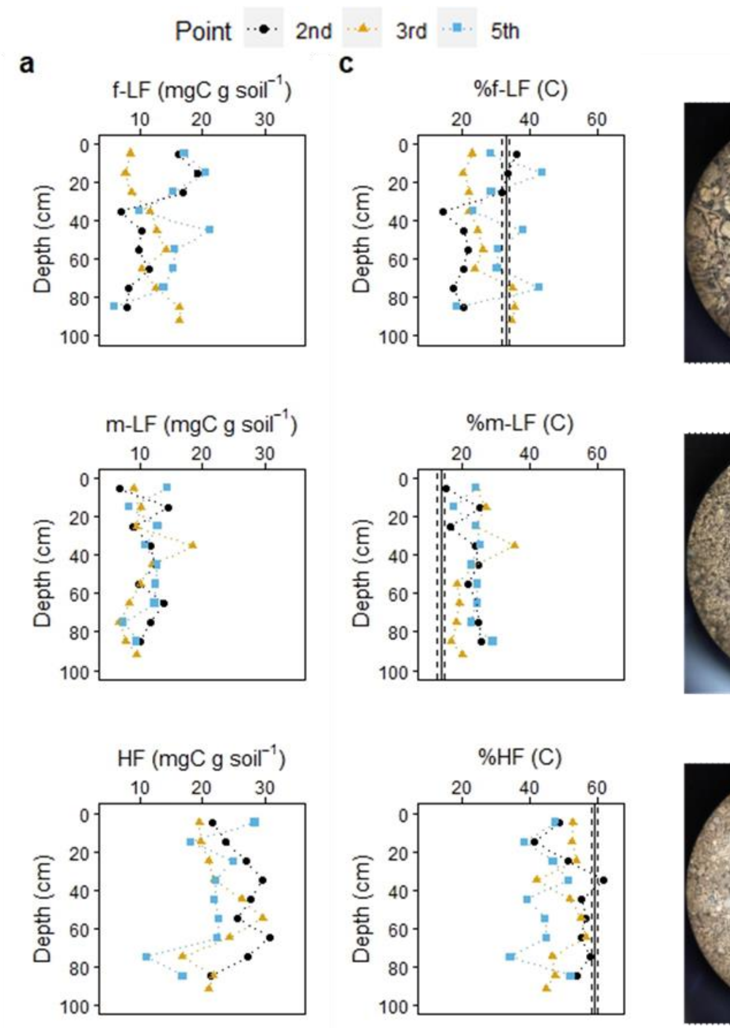


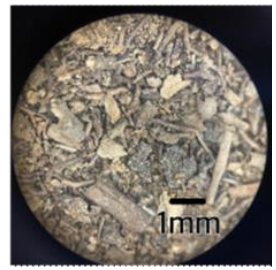
Energy of 120 J mL^{-1} or mechanical shaking with beads of 24 hours is sufficient to achieve maximum m-LF recovery

The beads method was used this time

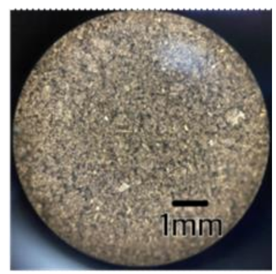
Hamada et al. (2024)

HF accounts for 40-60% of SOC, but m-LF is also relatively abundant



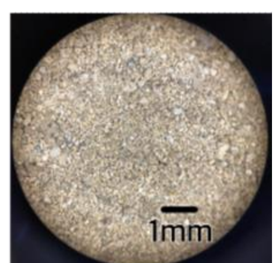


free-LF
Fine roots & plant debris



mineral-associated LF
Decomposed plant debris

1.6 times more abundant than in terrestrial soils

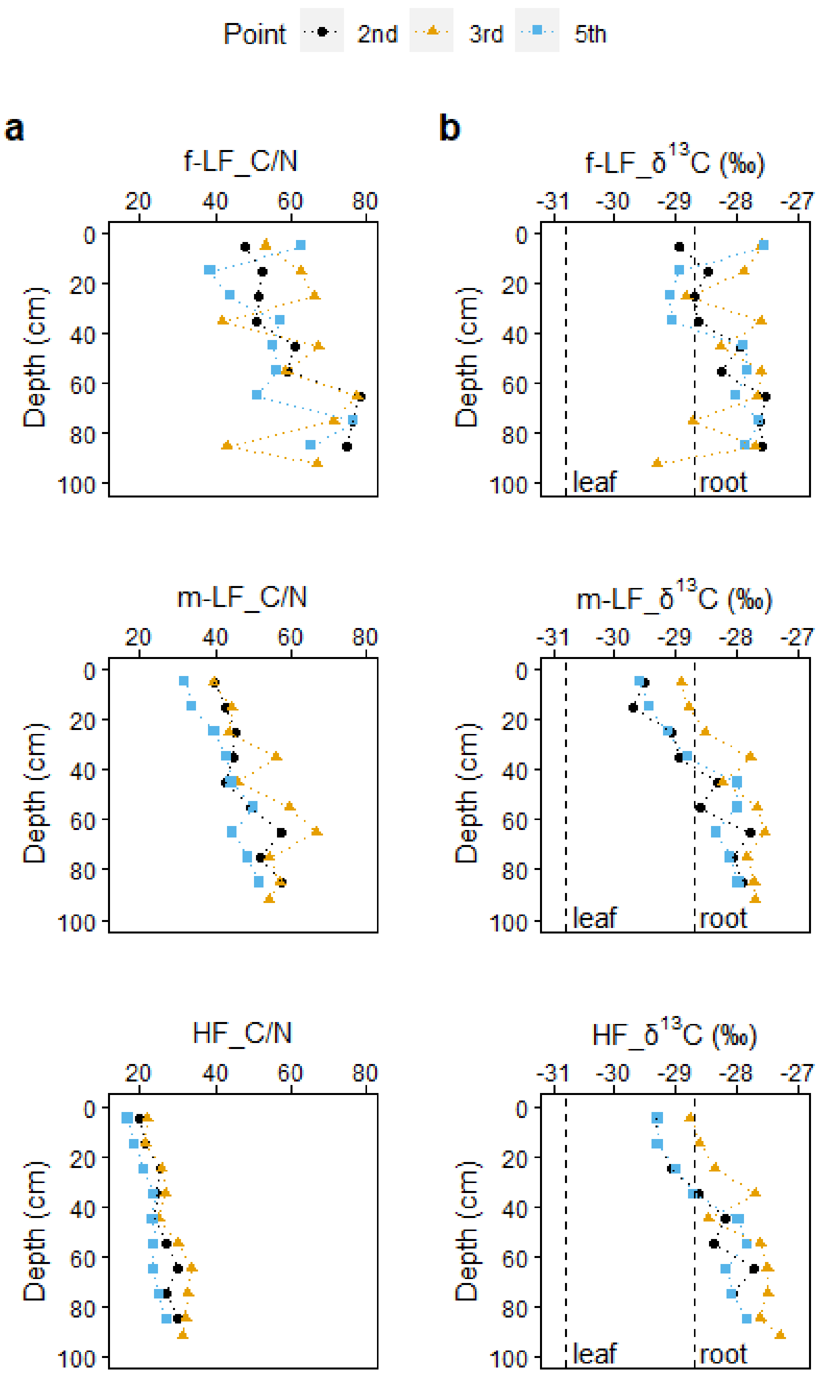


HF
OM chemically bound to minerals (MAOM)

Dashed line indicates the average of terrestrial soils (n = 1222, Heckman et al. 2022).

Hamada et al. (2024)

Elevated δ^{13}C & C/N with depth



	Increase downward?	
Increased contribution downward	C/N ratio	δ^{13}C
Roots	✓	✓
Lignin	✓	✕
Microbes	✕	variable
Marine	✕	✓

Increased contribution upward	C/N ratio	δ^{13}C
Suess effect	variable	✓

※fossil-fuel derived CO_2 depleted in $^{13}CO_2$

Hamada et al. (2024)

Only elevated contribution from (fine) roots can solely explain the increase in C/N and $\delta^{13}C$

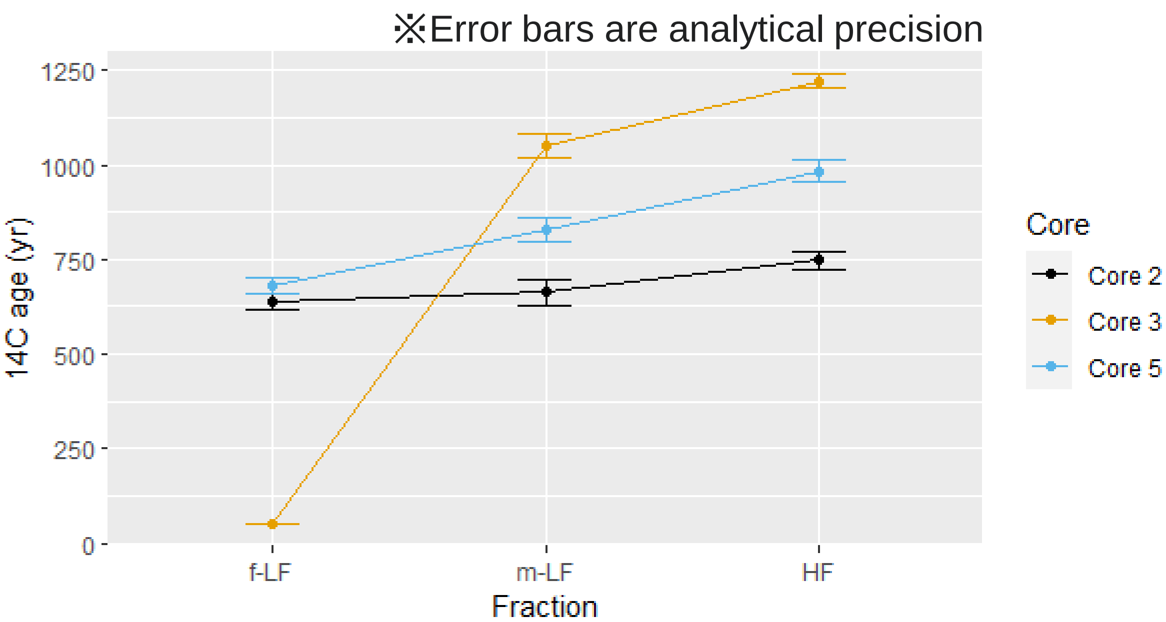
Increased contribution downward	C/N ratio	$\delta^{13}C$
Roots	✓	✓
Lignin	✓	×
Microbes	×	variable
Marine	×	✓

C/N ratios of *Bruguiera gymnorrhiza*
n = 4

Leaves	31.6 to 42.6 (36.0 ± 4.9)
Fine roots	47.9 to 57.6 (52.3 ± 4.3)

Furthermore, decomposed mangrove roots can exhibit a high C/N ratio. For instance, after one-year of decomposition, mangrove leaves decreased in C/N ratio (from 32 to 18) while roots considerably increased it (from 36 to 66) in a mangrove forest on Pohnpei Island (Ono et al., 2015).

The first evidence of the importance of mineral association in mangrove soils

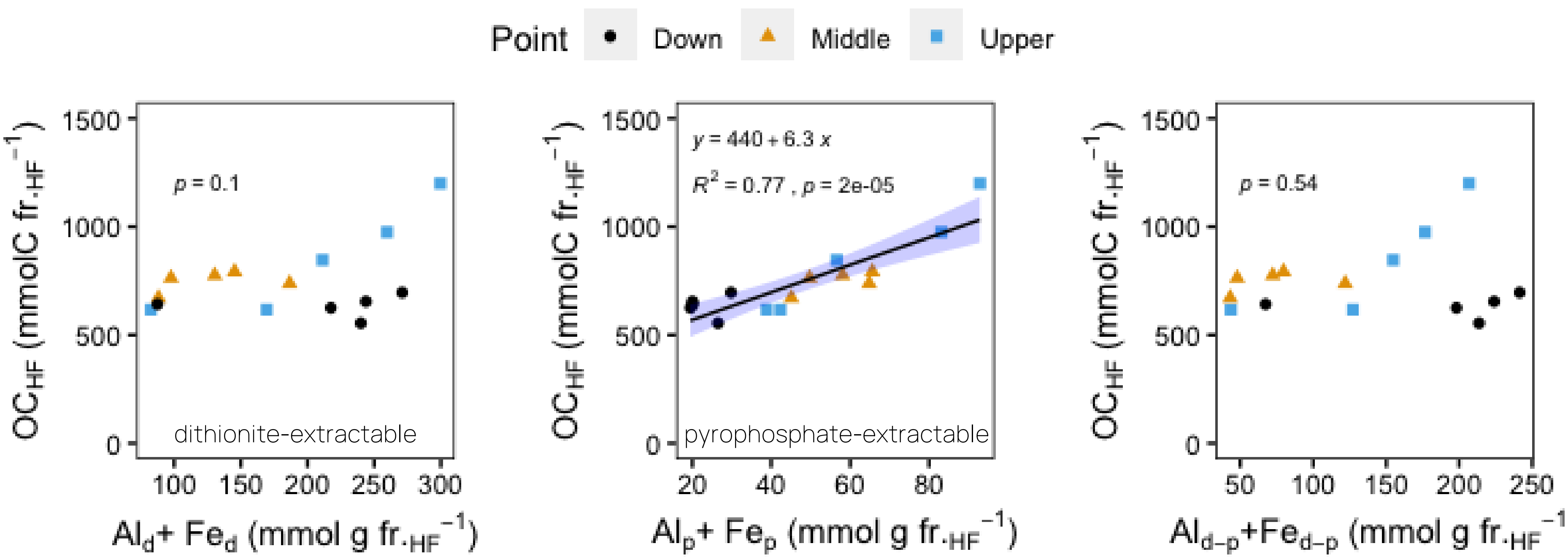


Contribution of old DIC from carbonates incorporated into marine endmember can be ignored based on the low $\delta^{13}C$ values in all samples

Yet, reasons for the variability in f-LF ages await further studies.

Hamada et al. (2024)

Organically complexed metals may be the strongest predictor of OC concentrations in HF



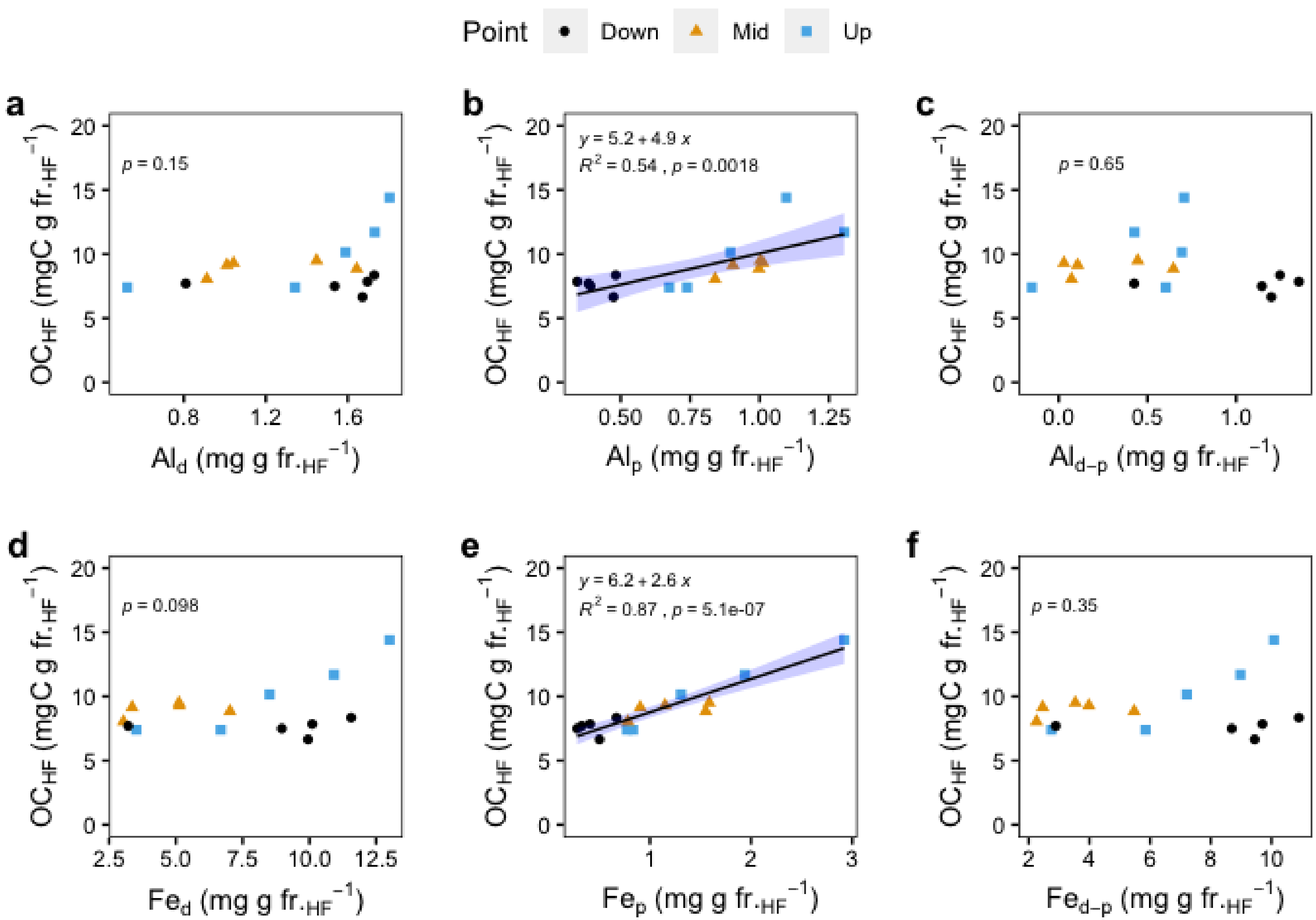
All reactive metals extracted by sodium dithionite

Organically complexed metals extracted by sodium pyrophosphate

Crystalline & nano-crystalline (SRO) metals

Hamada et al. in prep.

Fe is more important than Al? What about redox oscillation?



Hamada et al. in prep.

Summary

- Density fractionation was introduced to mangrove soils
- Functional components wrt stabilization was revealed
- Though HF was most abundant, m-LF was also interesting
- The more mineral associated, the older OM was
- OC concentrations in the oldest and most abundant faction (HF) may be determined by coprecipitation with reactive metals (Al & Fe)
- Further studies considering redox oscillation are necessary, particularly for Fe