Organic matter in soil density fractions responds to 10 years of experimental field warming in a temperate forest

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"Deep C" project

Introduction

- Soils are the largest terrestrial carbon reservoir in permanent exchange with the atmosphere[1] and could become a source of CO_2 with warming[2]
- Soil organic matter (SOM) is commonly divided into particulate organic matter (POM) and mineral-associated organic matter (MAOM)[3]
- MAOM has a longer turnover time and is considered a key pool for carbon stabilization[4]
- MAOM is often assumed to be more resistant to warming, but direct experimental evidence remains limited

Research questions

After 10 years of whole-profile field soil warming, we combined density fractionation and Diffuse reflectance infrared Fourier transform spectroscopy (DRIFT) to address the following research questions:

1. How does warming change the **SOM distribution** in density fractions?
2. How does warming alter the **SOM composition** in bulk soil and individual soil fractions?

Methods

- Mediterranean climate, mixed coniferous forest, Alfisol with granitic origin, start in Jan. 2014
- + 4℃ down to 1 m
- 3 fractions: free and occluded POM (fPOM and oPOM), and MAOM at 3 depths: 10-20, 40-50, 80-90 cm.

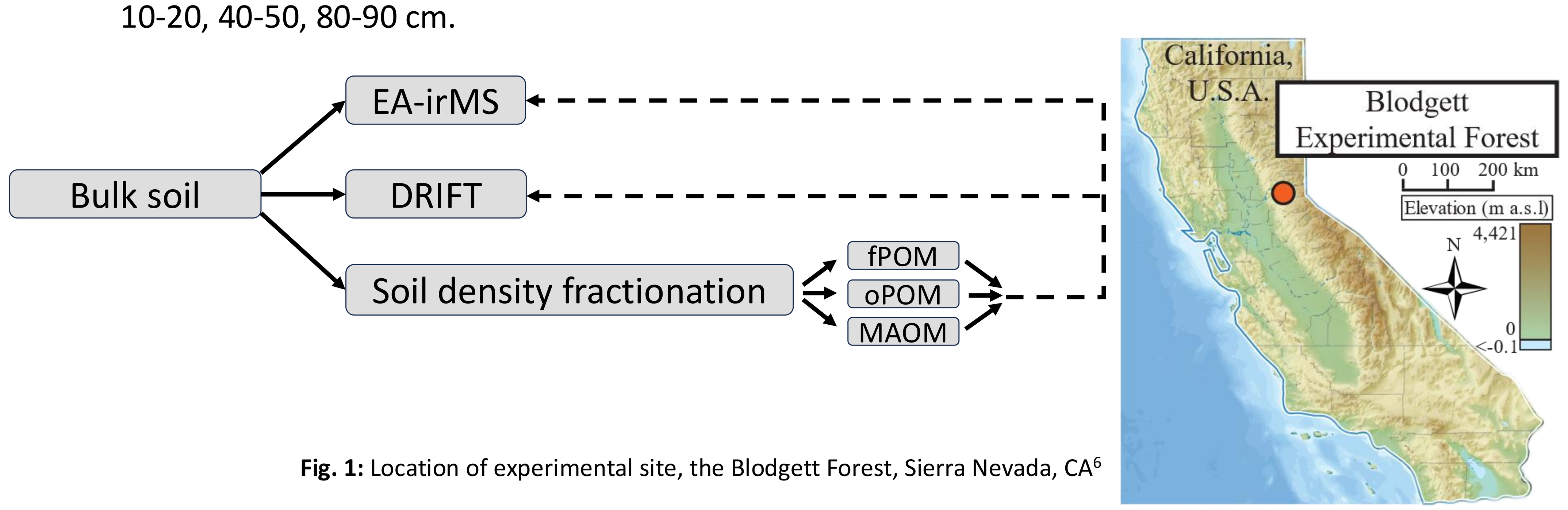

Fig. 1: Location of experimental site, the Blodgett Forest, Sierra Nevada, CA[6]

Density fractions: relative contribution and content

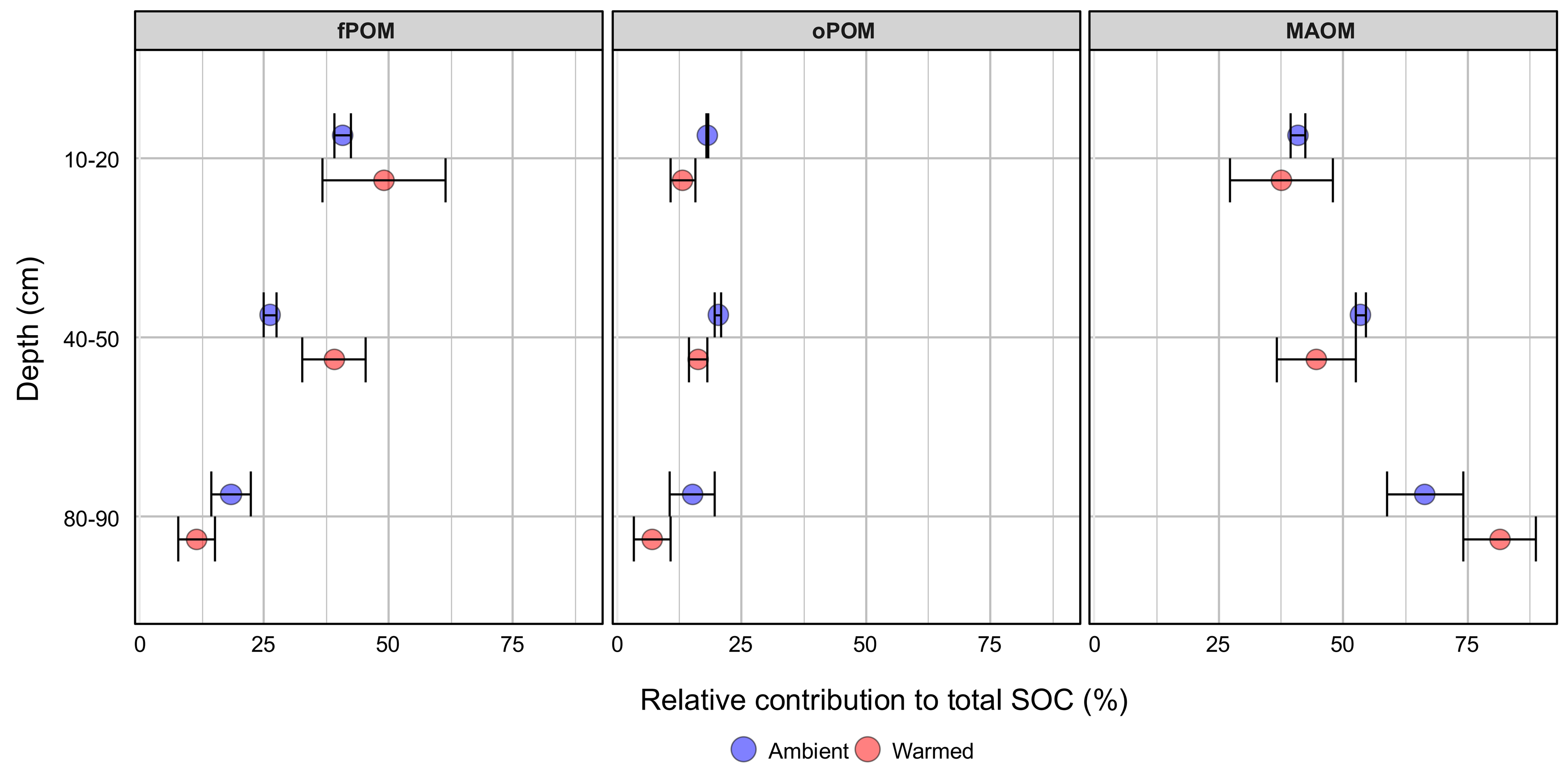

Fig. 3: Relative contribution of soil fractions to total soil organic carbon (SOC) (%), mean ± SE (n = 3). Warming increased the proportion of **fPOM** in **topsoil** and at **mid-depth**, while reducing its proportion in the deep soil. In contrast, the relative contribution of **MAOM** increased with warming **at depth**.

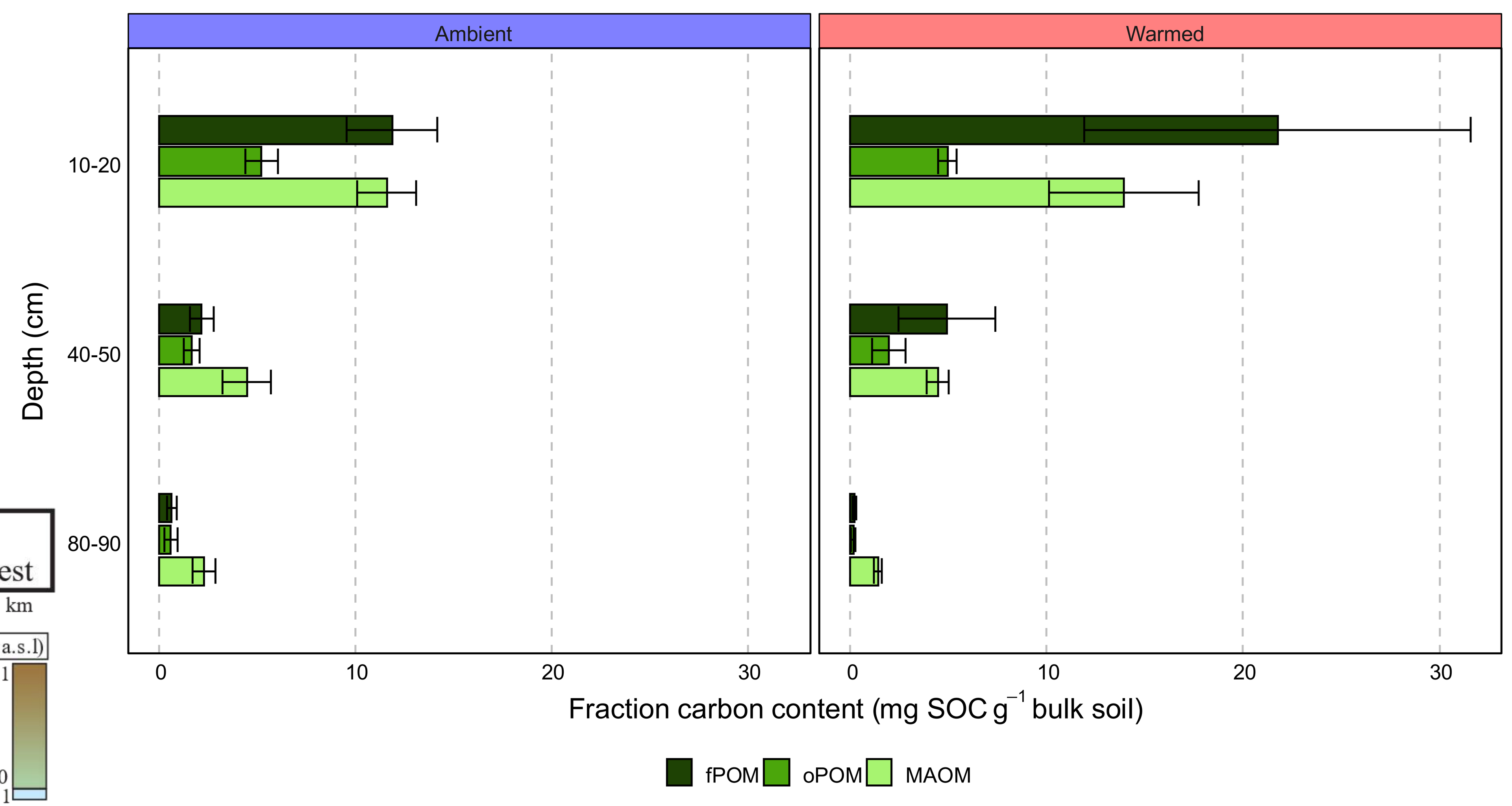

Fig. 4: Carbon content of soil fractions across soil profile, mean ± SE (n = 3). Warming increased the content of fPOM in topsoil and at mid-depth but decreased it in the deep soil. **MAOM content remained relatively consistent** across soil depths, with only a slight decrease observed at 80-90 cm.

SOM composition of bulk and fractions

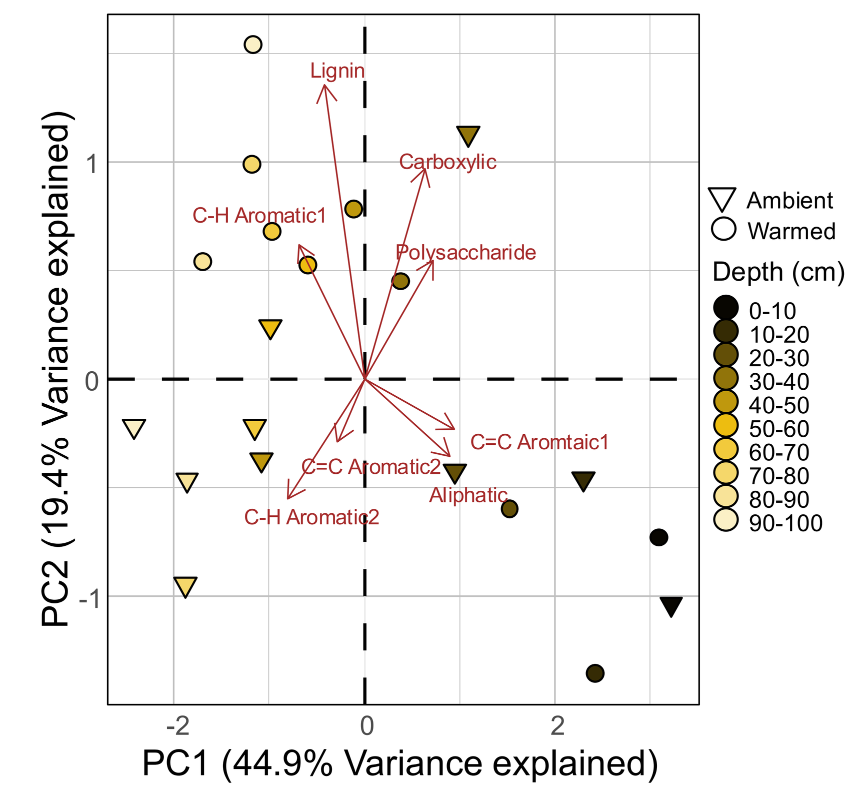

Fig. 5: Principal component analysis (PCA) of bulk soil DRIFT spectra.
A shift in SOM composition is observed with soil depth. Warming has limited impact on SOM composition in topsoil. Warming shifted subsoil SOM composition toward **lignin-like** and **aromatic** compounds.

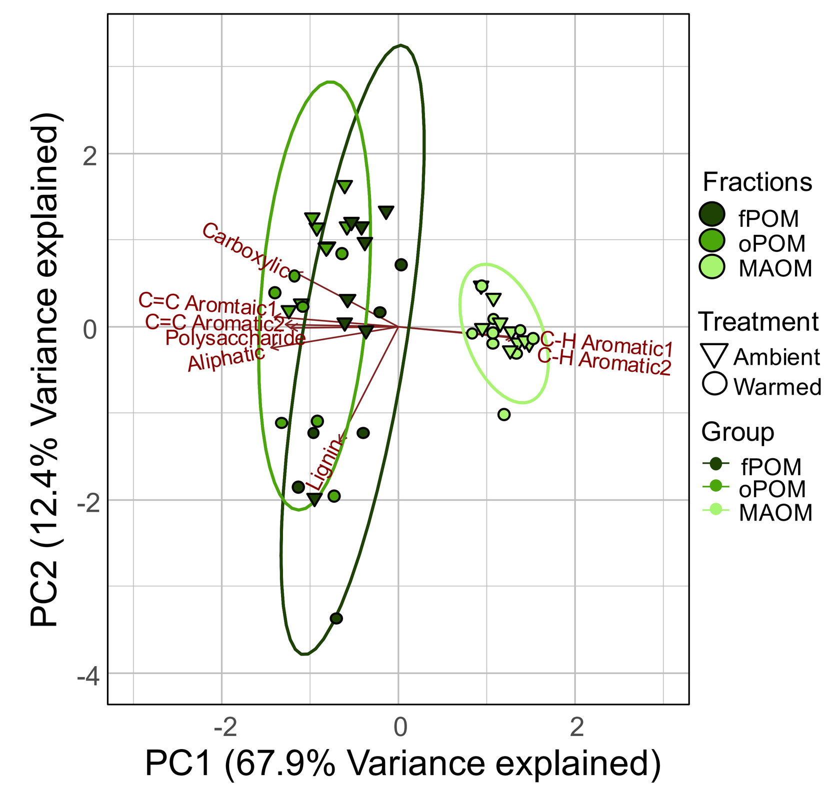

Fig. 6: PCA of SOM composition across density fractions and depths with confidence ellipses (α = 0.05).
MAOM had distinct SOM composition compared to POM fractions and changed less with warming. In contrast, **fPOM** and **oPOM** had similar SOM composition. Warming tended to shift fPOM composition toward **lignin-like** compounds.

Conclusions

1. **Warming changed the SOM distribution between fractions** and fPOM was more affected. MAOM was more stable and resistant to elevated temperature.
2. **Warming altered the SOM composition only in the bulk subsoil** but not within individual fractions. The composition of MAOM was particularly resistant to warming.

Overall, our study demonstrates that **MAOM was both quantitatively and qualitatively resistant to warming,** highlighting its potential role as a stable carbon pool for mitigating climate change.

References

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