Controls on the fate of new carbon inputs to tundra soils

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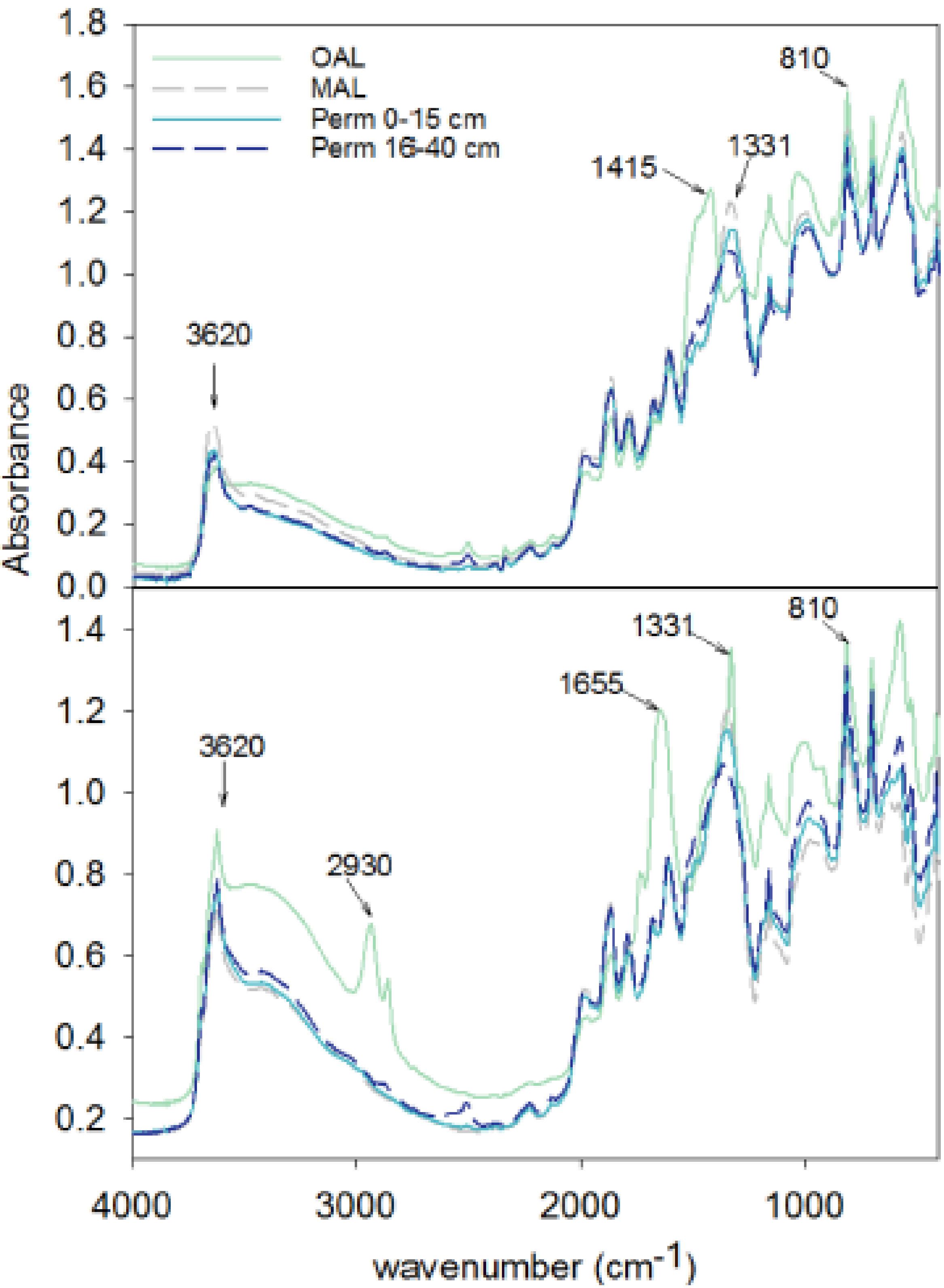
FACTS

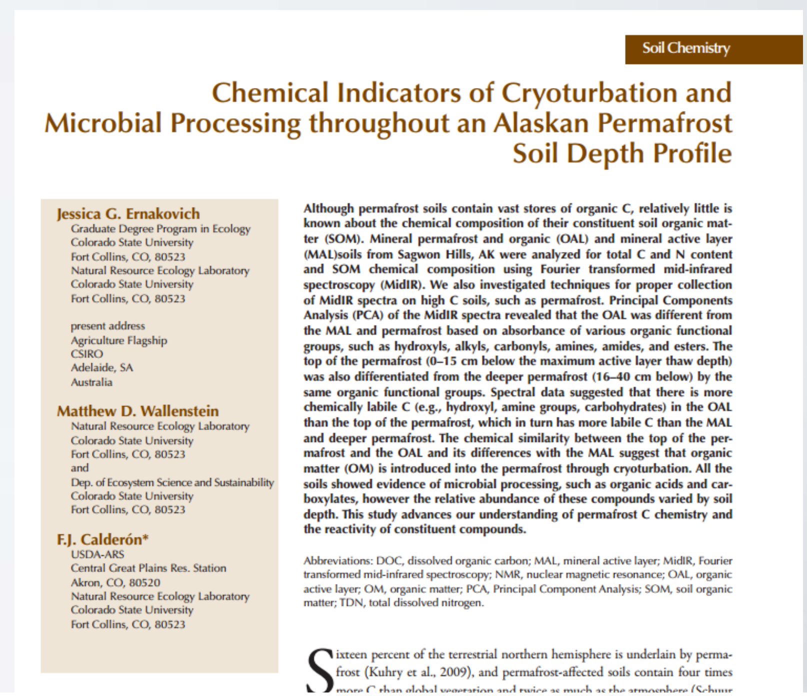
#alternativefacts

Physical

Chemical

Biological





Soil Chemistry

Chemical Indicators of Cryoturbation and Microbial Processing throughout an Alaskan Permafrost Soil Depth Profile

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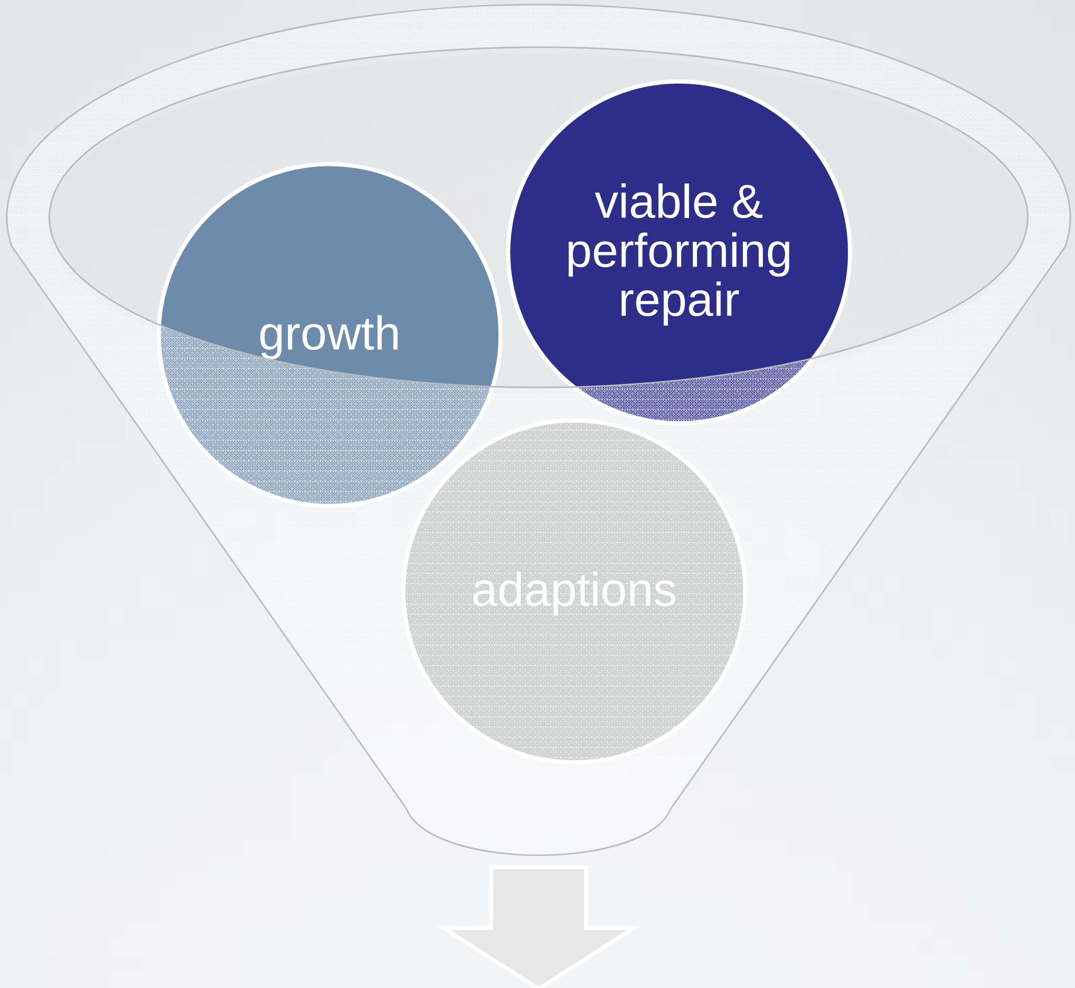
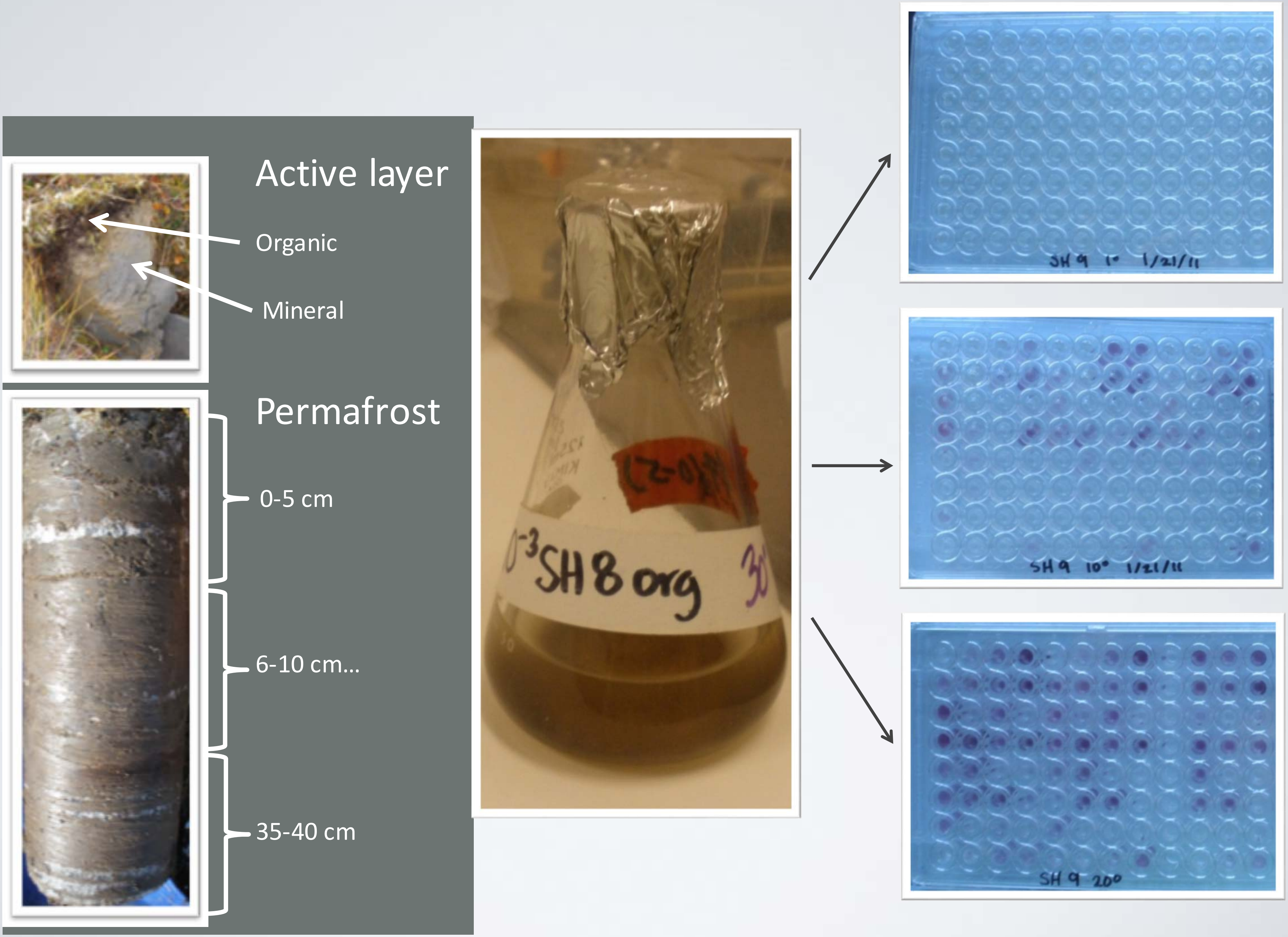
Although permafrost soils contain vast stores of organic C, relatively little is known about the chemical composition of their constituent soil organic matter (SOM). Mineral permafrost and organic (OAL) and mineral active layer (MAL)soils from Sagwon Hills, AK were analyzed for total C and N content and SOM chemical composition using Fourier transformed mid-infrared spectroscopy (MidIR). We also investigated techniques for proper collection of MidIR spectra on high C soils, such as permafrost. Principal Components Analysis (PCA) of the MidIR spectra revealed that the OAL was different from the MAL and permafrost based on absorbance of various organic functional groups, such as hydroxyls, alkyls, carbonyls, amines, amides, and esters. The top of the permafrost (0–15 cm below the maximum active layer thaw depth) was also differentiated from the deeper permafrost (16–40 cm below) by the same organic functional groups. Spectral data suggested that there is more chemically labile C (e.g., hydroxyl, amine groups, carbohydrates) in the OAL than the top of the permafrost, which in turn has more labile C than the MAL and deeper permafrost. The chemical similarity between the top of the permafrost and the OAL and its differences with the MAL suggest that organic matter (OM) is introduced into the permafrost through cryoturbation. All the soils showed evidence of microbial processing, such as organic acids and carboxylates, however the relative abundance of these compounds varied by soil depth. This study advances our understanding of permafrost C chemistry and the reactivity of constituent compounds.

Abbreviations: DOC, dissolved organic carbon; MAL, mineral active layer; MidIR, Fourier transformed mid-infrared spectroscopy; NMR, nuclear magnetic resonance; OAL, organic active layer; OM, organic matter; PCA, Principal Component Analysis; SOM, soil organic matter; TDN, total dissolved nitrogen.

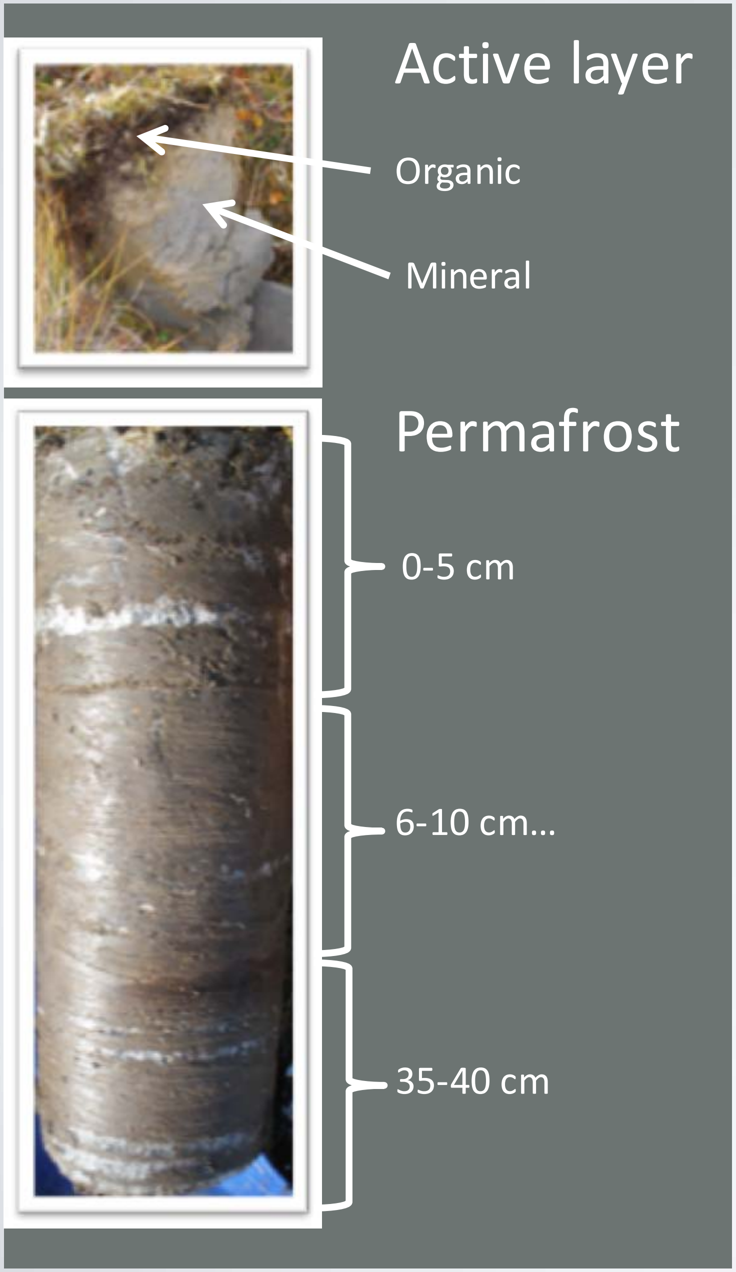
Sixteen percent of the terrestrial northern hemisphere is underlain by permafrost (Kuhry et al., 2009), and permafrost-affected soils contain four times

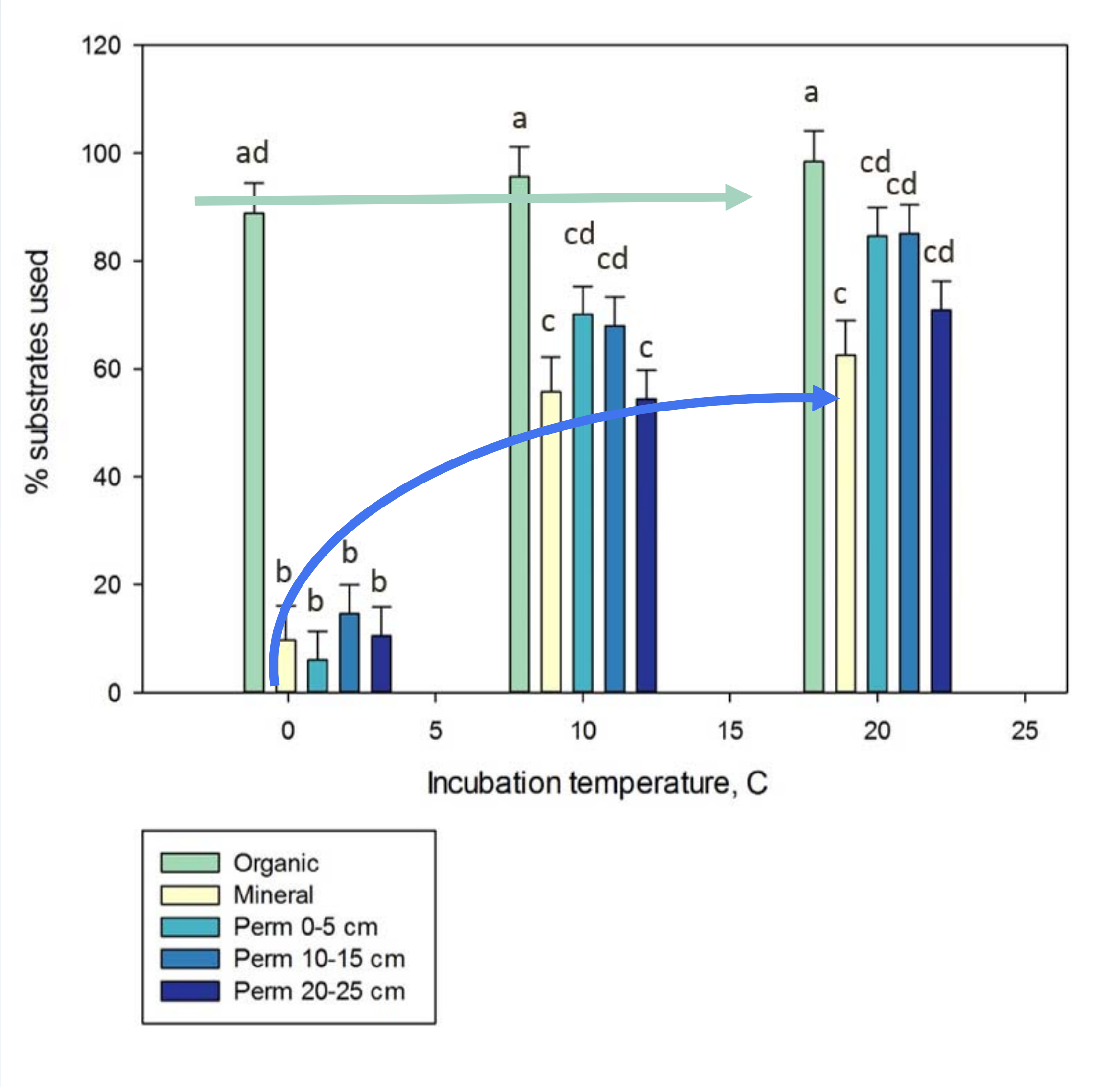


permafrost microbes are adapted for function under cold temperatures


Active layer
Organic
Mineral
Permafrost
0-5 cm
6-10 cm…
35-40 cm
SH8 org
SH 9 1/21/11
SH 9 1/21/11
SH 9

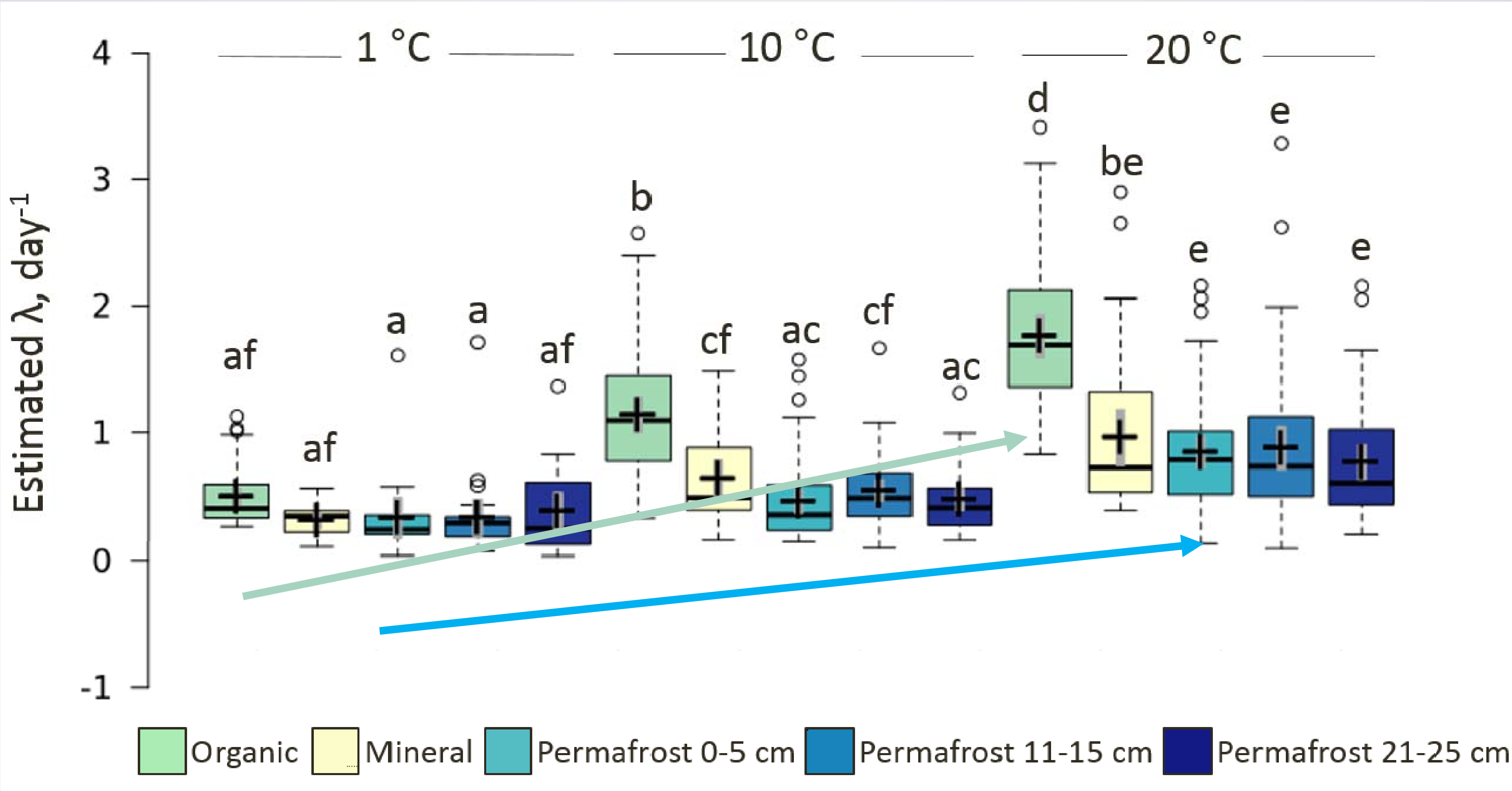
Permafrost: low functional diversity



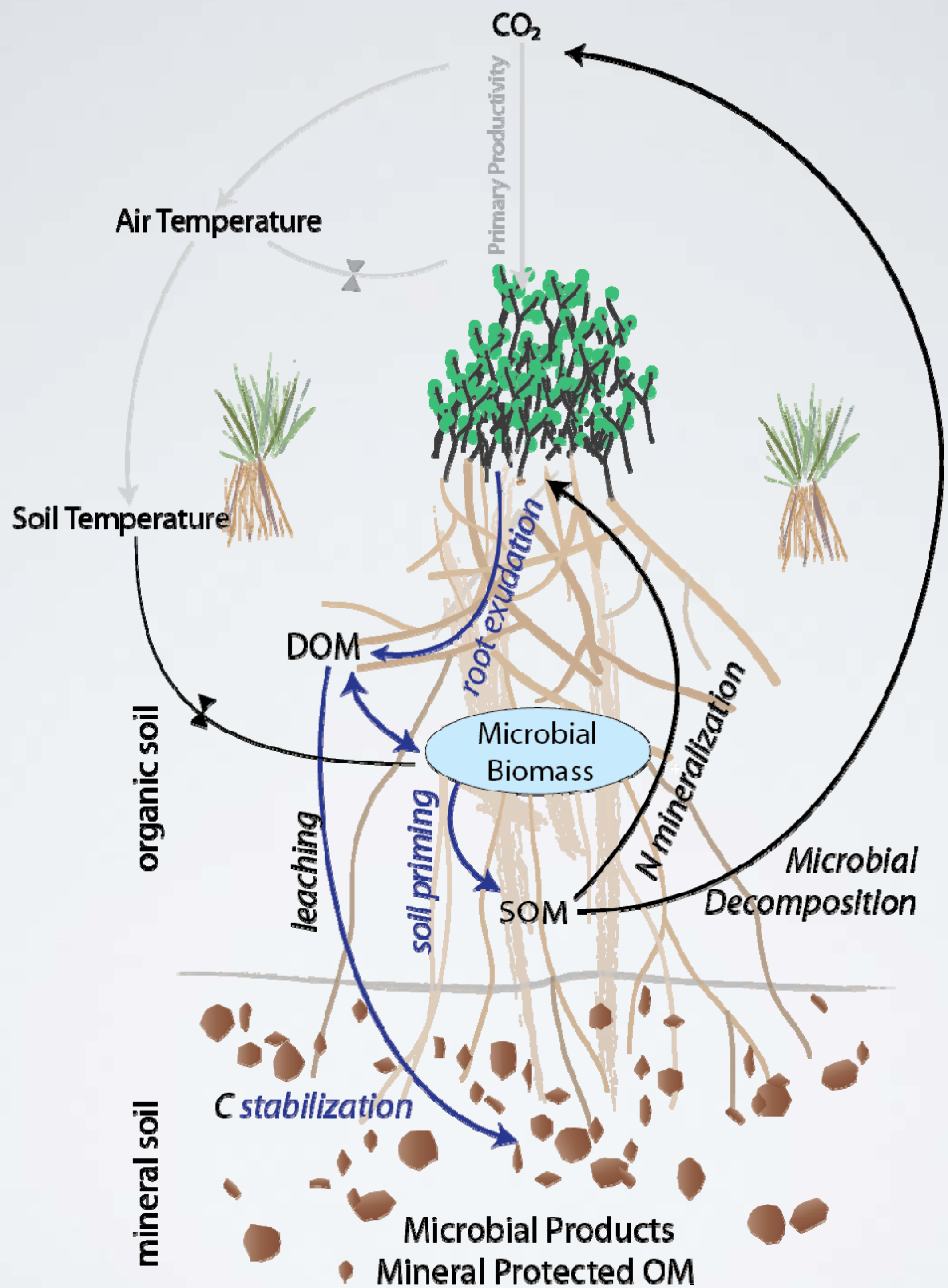


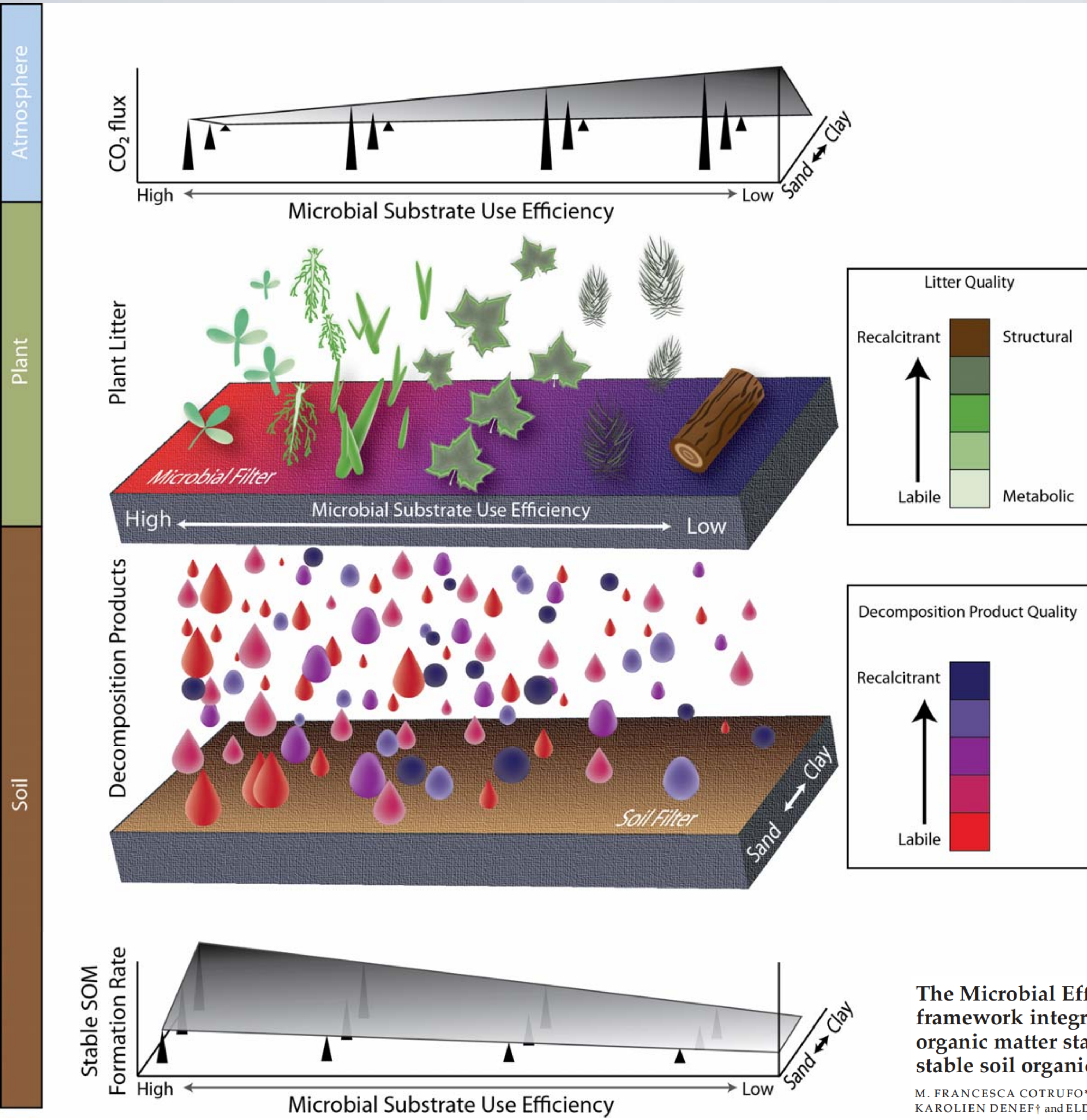
Ernakovich and Wallenstein, 2015 SBB

Permafrost: low growth rate



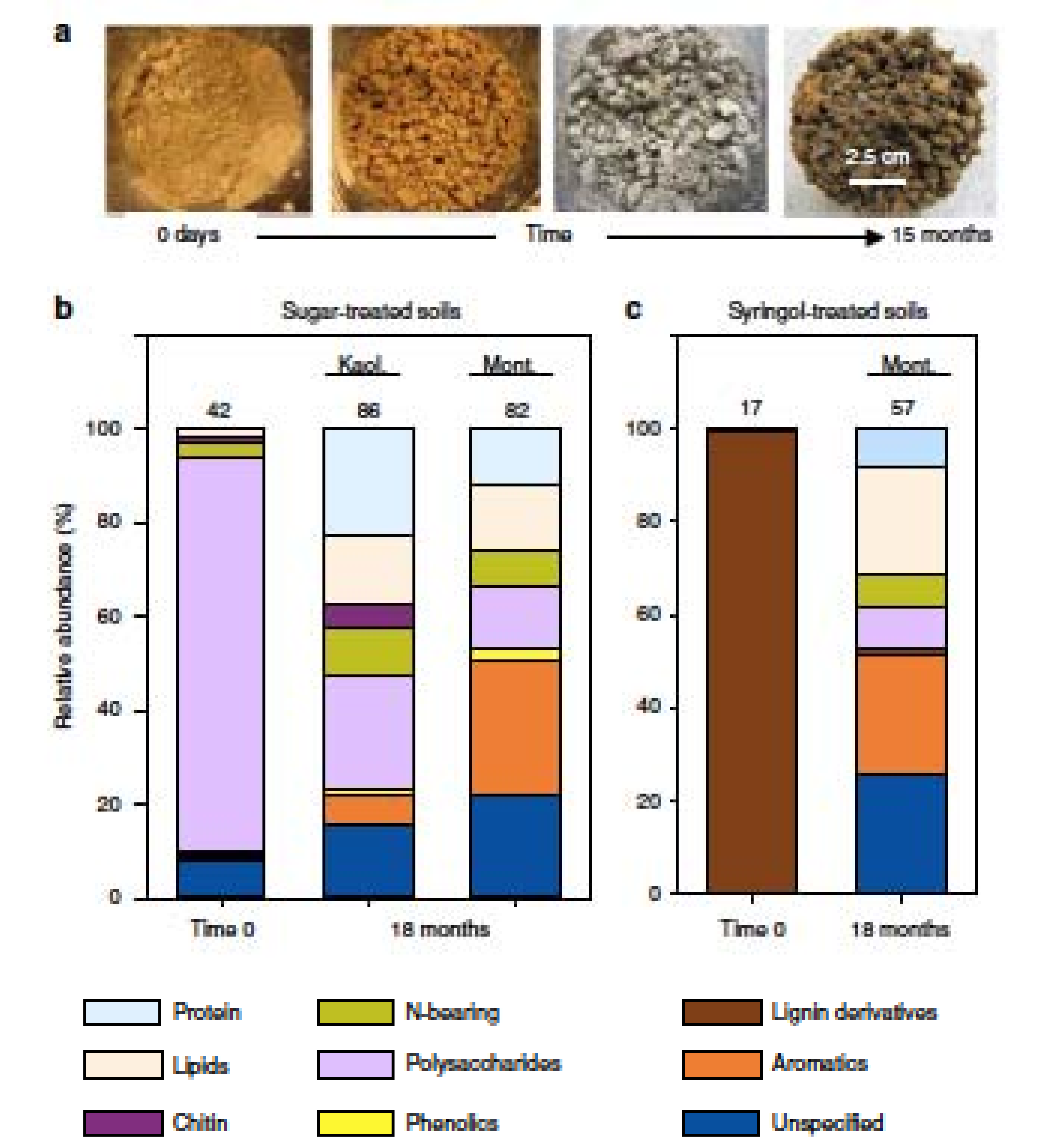
Ernakovich and Wallenstein, 2015 SBB


CO_2
Primary Productivity
Air Temperature
Soil Temperature
root exudation
DOM
Microbial Biomass
N mineralization
organic soil
leaching
soil priming
SOM
Microbial Decomposition
C stabilization
mineral soil
Microbial Products
Mineral Protected OM



The Microbial Efficiency-Matrix Stabilization (MEMS) framework integrates plant litter decomposition with soil organic matter stabilization: do labile plant inputs form stable soil organic matter?

M. FRANCESCA COTRUFO*†, MATTHEW D. WALLENSTEIN†, CLAUDIA M. BOOT†, KAROLIEN DENEF† and ELDOR PAUL†



Direct evidence for microbial-derived soil organic matter formation and its ecophysiological controls

Cynthia M. Kallenbach[1,2], Serita D. Frey[1] & A. Stuart Grandy[1]

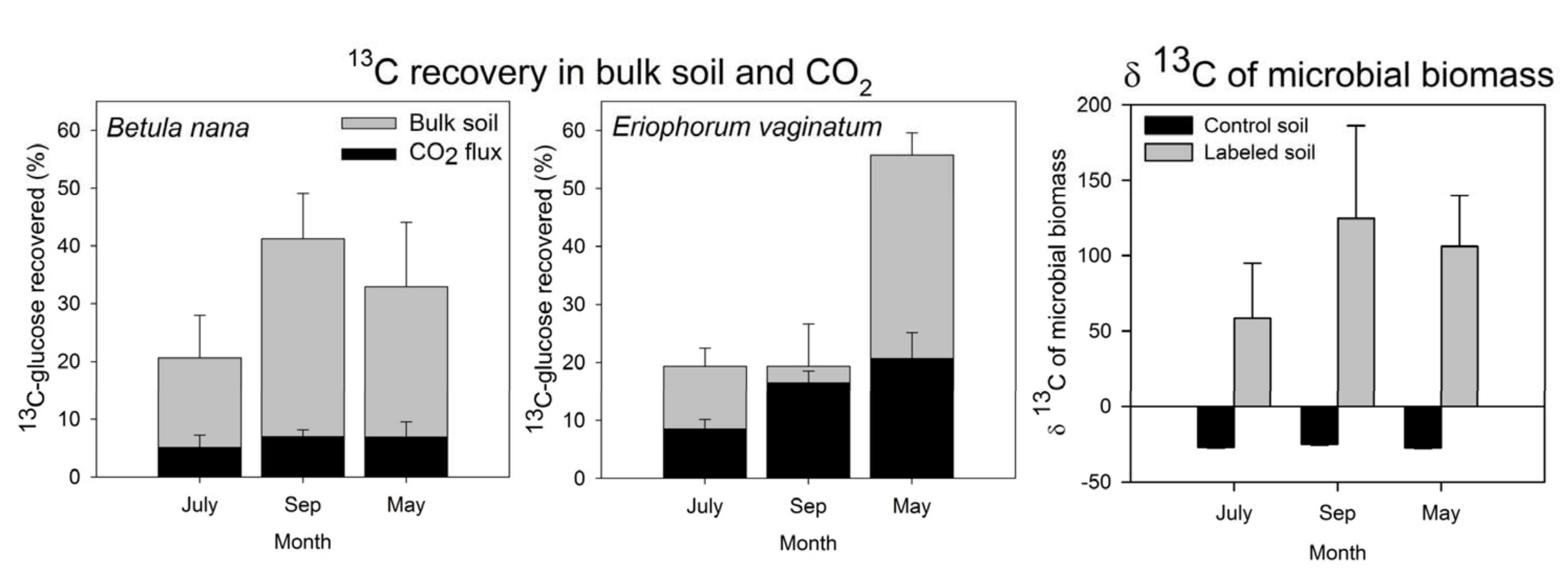
Isotope tracing

^{13}C-glucose application

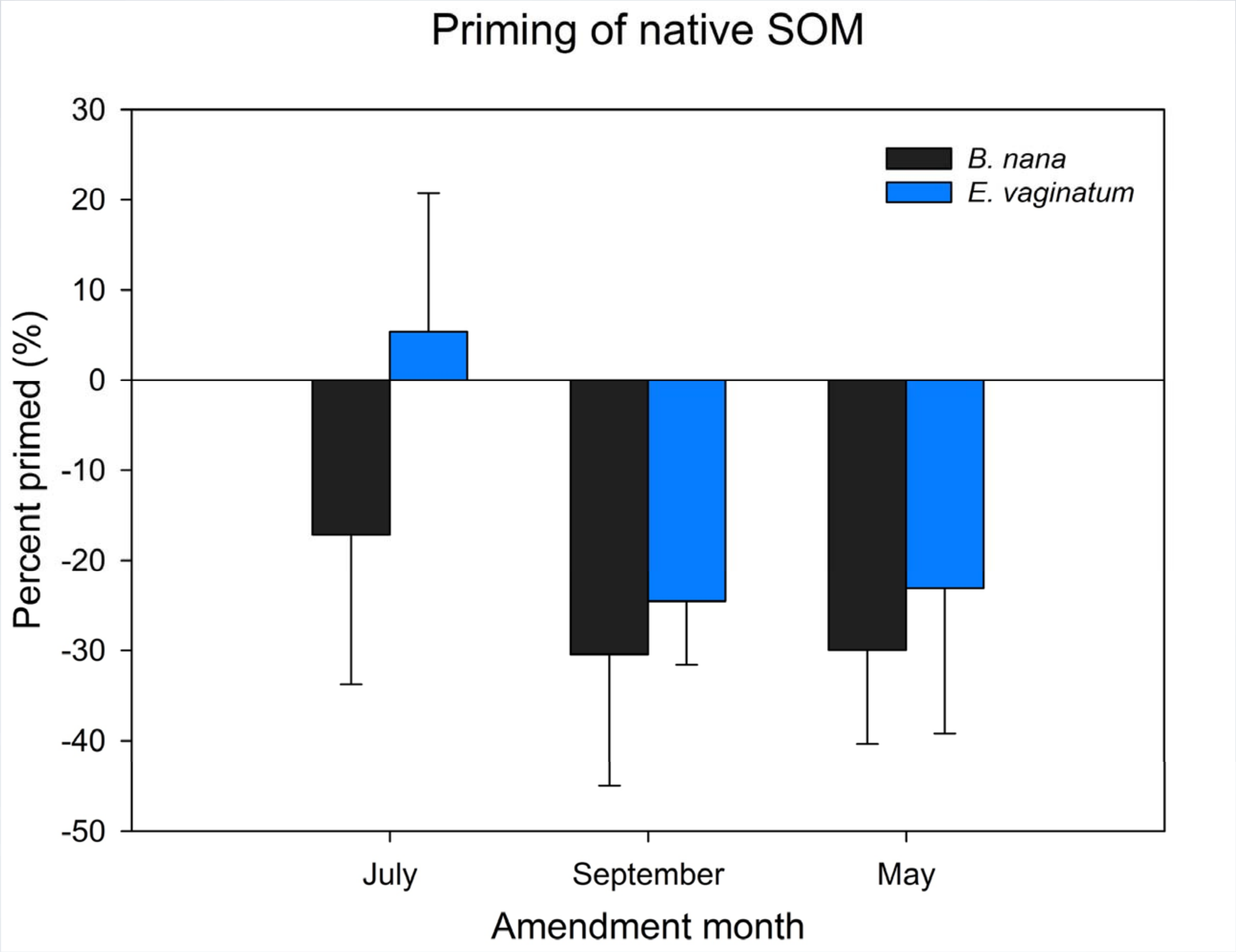
Background $^{13}CO_2$: -26‰

$^{13}CO_2$ measurements

^{13}C-glucose: +1,529‰

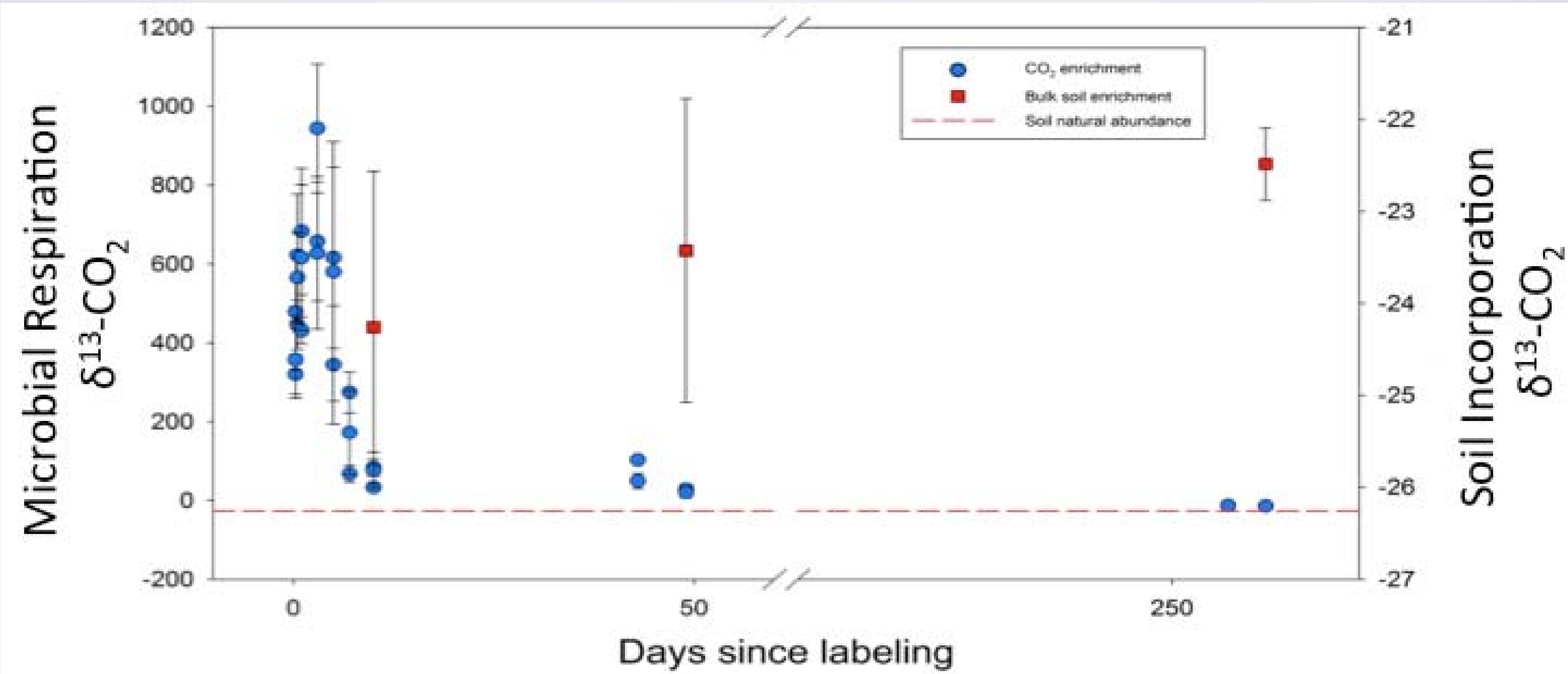


^{13}C recovery in bulk soil and CO_2
Betula nana
Bulk soil
CO_2 flux
^{13}C-glucose recovered (%)
0
10
20
30
40
50
60
July
Sep
May
Month
Eriophorum vaginatum
^{13}C-glucose recovered (%)
0
10
20
30
40
50
60
July
Sep
May
Month
δ ^{13}C of microbial biomass
Control soil
Labeled soil
δ ^{13}C of microbial biomass
-50
0
50
100
150
200
July
Sep
May
Month

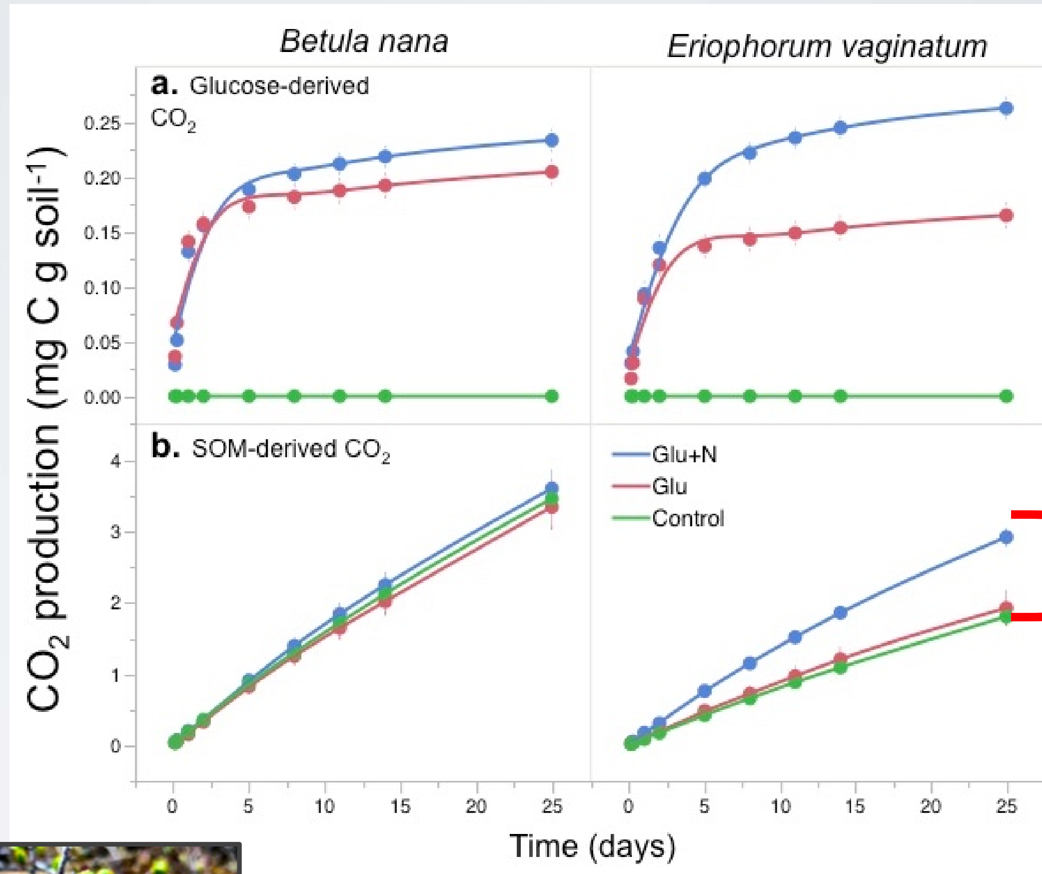


Priming of native SOM
B. nana
E. vaginatum
Percent primed (%)
30
20
10
0
-10
-20
-30
-40
-50
July
September
May
Amendment month

New C Persists



Nutrient limitation to priming?

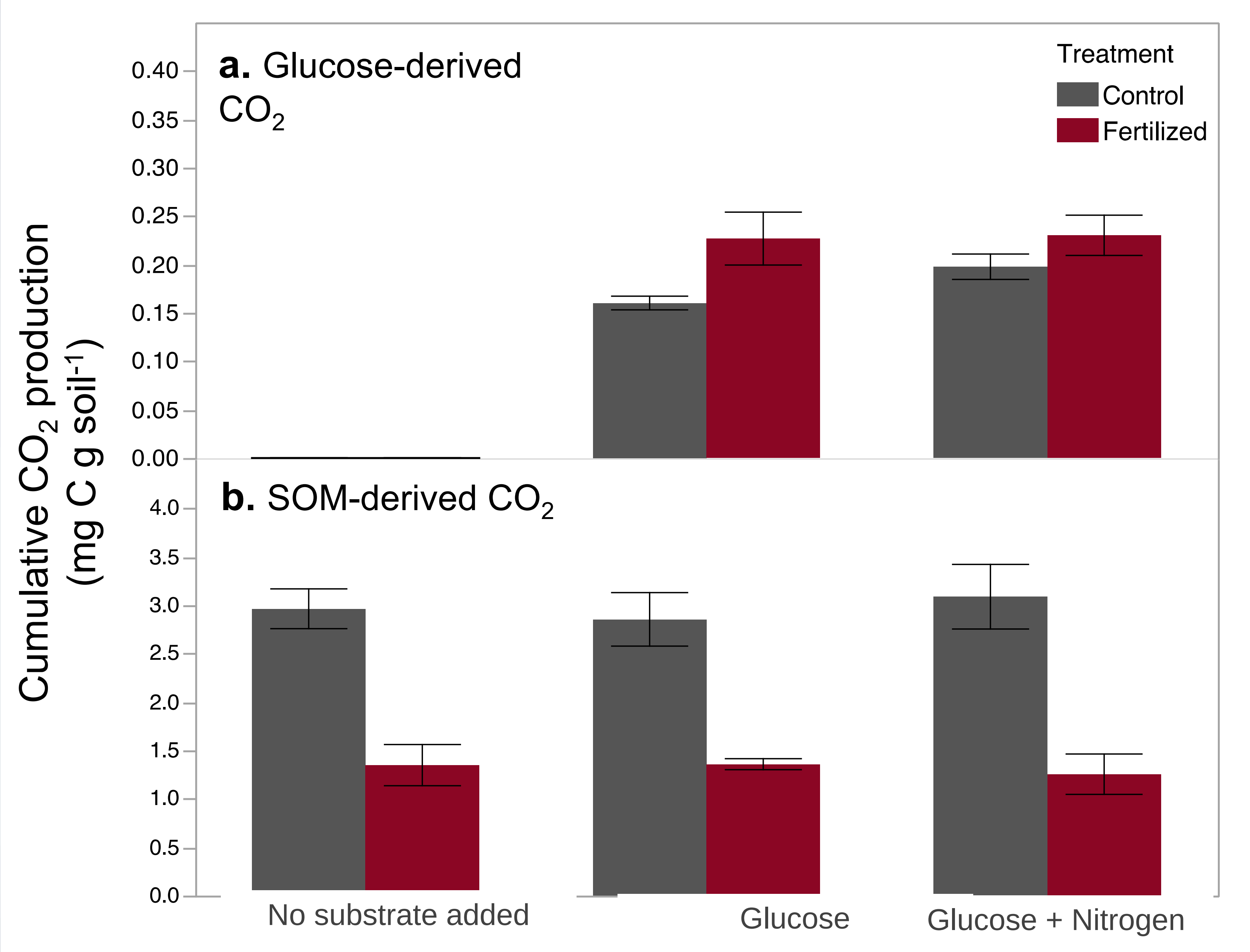


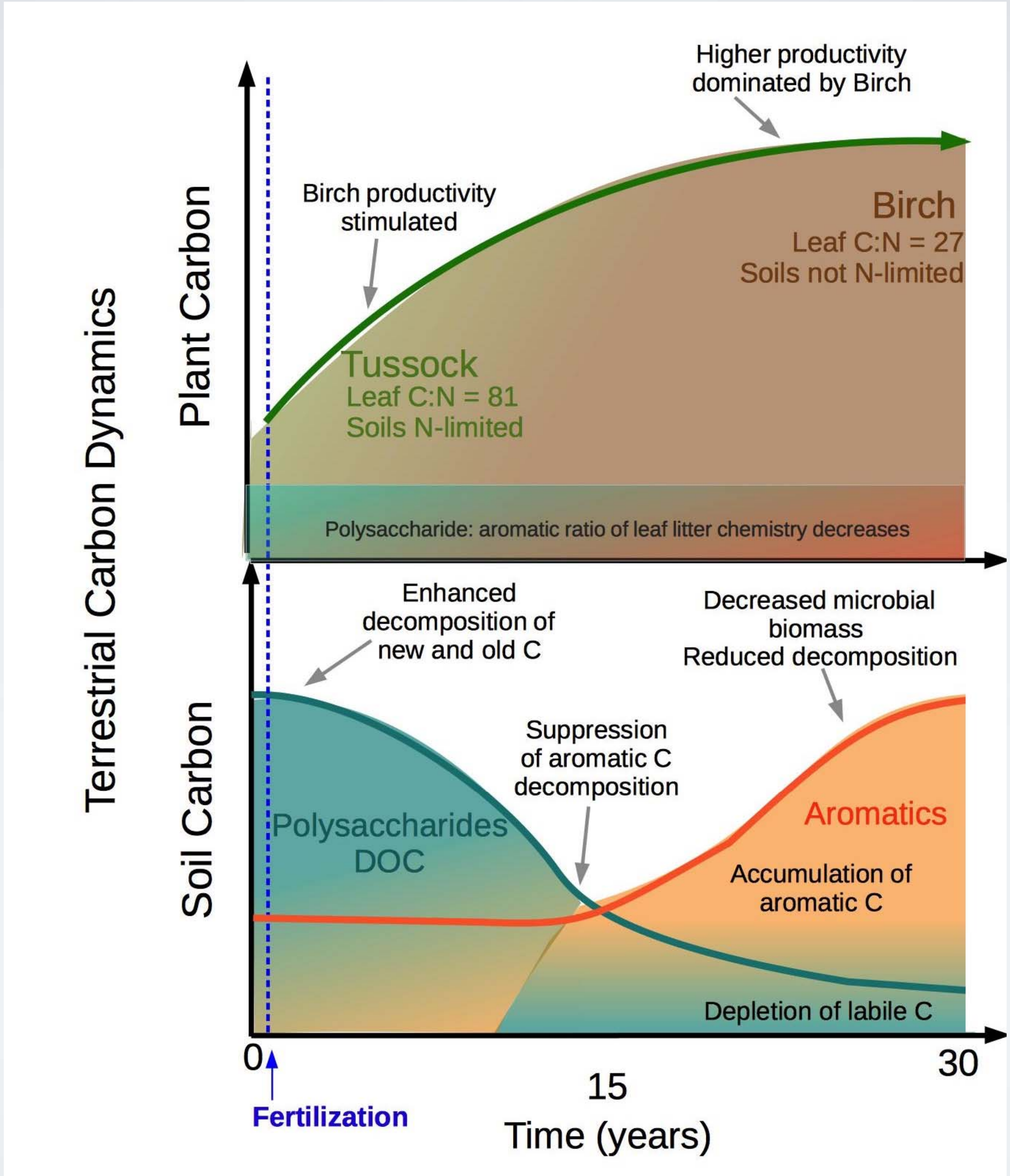
SOM Priming

E. vaginatum

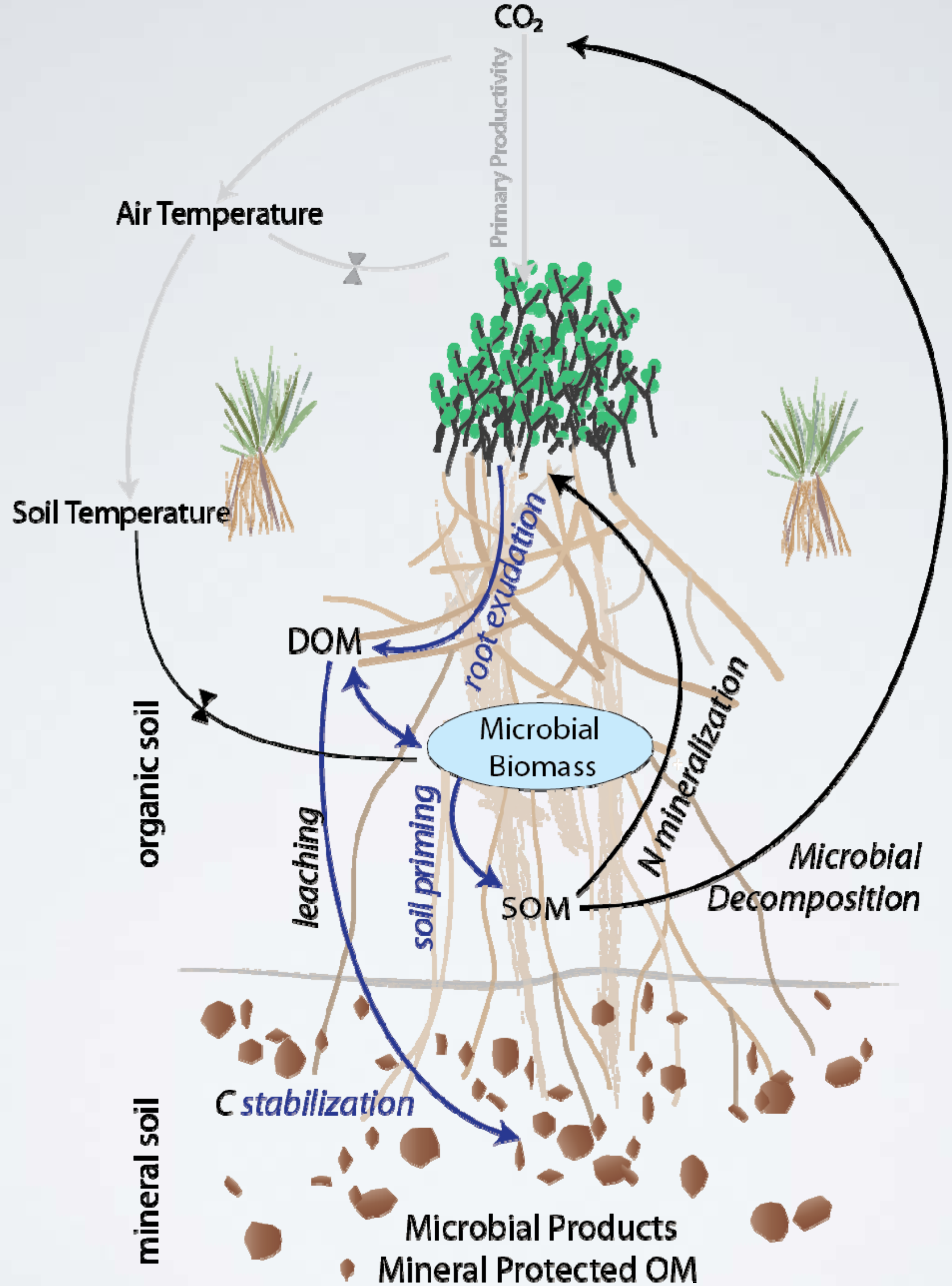
B. nana

Same effect after long-term (36 years) fertilization?





Terrestrial Carbon Dynamics
Plant Carbon
Higher productivity dominated by Birch
Birch productivity stimulated
Birch
Leaf C:N = 27
Soils not N-limited
Tussock
Leaf C:N = 81
Soils N-limited
Polysaccharide: aromatic ratio of leaf litter chemistry decreases
Soil Carbon
Enhanced decomposition of new and old C
Decreased microbial biomass
Reduced decomposition
Suppression of aromatic C decomposition
Polysaccharides DOC
Aromatics
Accumulation of aromatic C
Depletion of labile C
0
15
30
Fertilization
Time (years)


CO2
Primary Productivity
Air Temperature
Soil Temperature
DOM
root exudation
N mineralization
Microbial Biomass
organic soil
leaching
soil priming
SOM
Microbial Decomposition
mineral soil
C stabilization
Microbial Products
Mineral Protected OM