

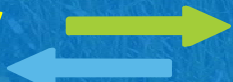
# Root production and methane dynamics: Impact of wetland functional group diversity and composition

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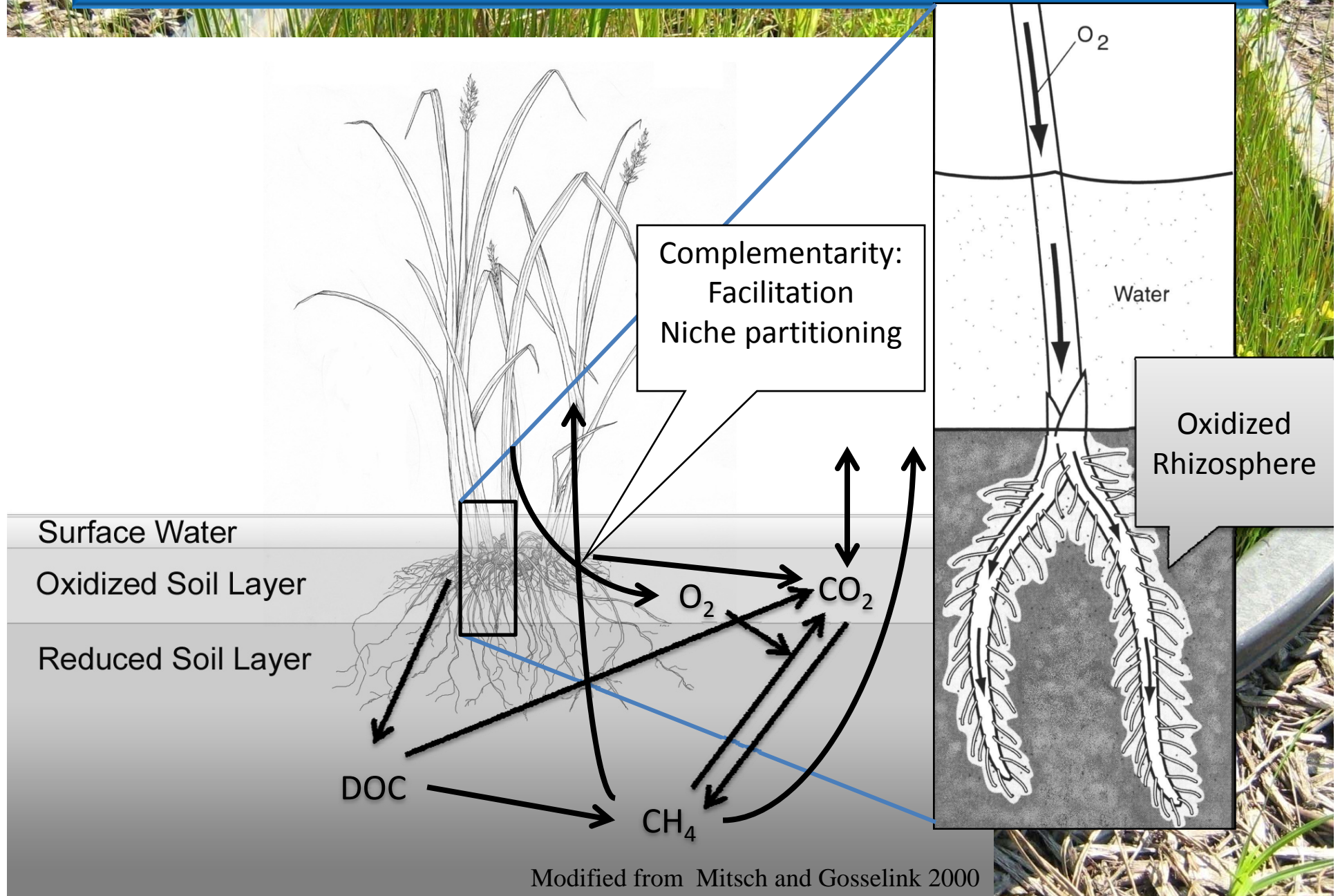


# Introduction

- Worldwide loss of biodiversity
- Biodiversity  Ecosystem Functioning (BEF)
  - Functional diversity
  - Different ecosystems & functions
- Belowground processes
  - Belowground productivity
    - Carbon cycling
    - Methane (CH<sub>4</sub>) dynamics in wetland s
  - Diversity effect?
  - Possible mechanism for decreased CH<sub>4</sub> emissions with higher diversity? (Bouchard et al. 2007)



# Wetland biogeochemical cycling - Belowground





# Alternative hypotheses

Root biomass will increase with # of FGs due to complementarity

Functional Group Richness

H1 +

Functional Group Composition

+ / - H2

Root biomass will be greater in treatments containing FGs with high productivity

Root Biomass

+ H3

DOC will increase with root biomass

CH<sub>4</sub> will decrease with root biomass

H5 -

DOC

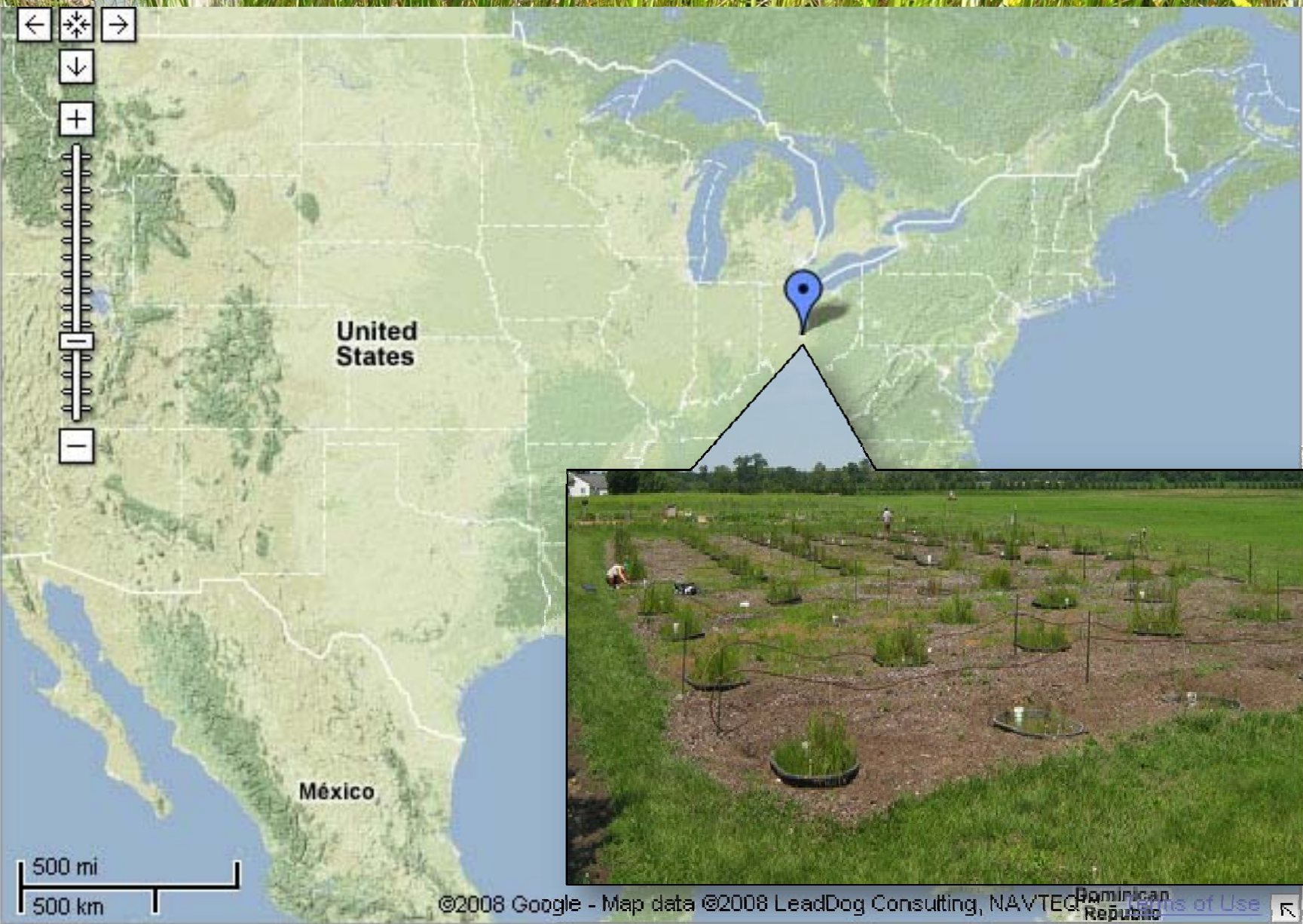
+ H4

CH<sub>4</sub> will increase with DOC

CH<sub>4</sub>



# Study Site: Columbus, OH





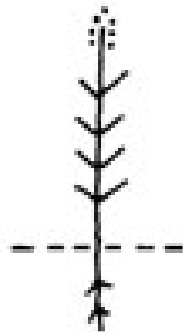
# Experimental Design

Functional Groups (FGs)  
(Boutin and Keddy 1993)

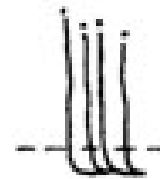
4 species planted per FG



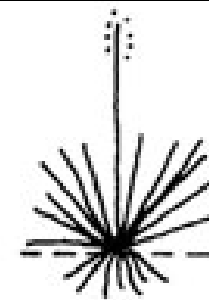
Obligate annuals (OA)



Facultative annuals (FA)



Reeds (R)



Tussocks (T)

- **1 Functional group** fa; oa; r; t (20 mesocosms)
- **2 Functional groups** fa+oa; t+r; fa+t; fa+r; oa+t, oa+r (30)
- **3 Functional groups** fa+oa+t; fa+oa+r; t+r+oa; t+r+fa (20)
- **4 Functional groups** t+r+oa+fa (5)
- **Control** with no plants (5)
- **Established** in 2006 and sampled 2007-2008

\*Planted with low organic soil in order to eliminate the carbon artifact from previous vegetation



# Methods: Root Biomass

- Post-clipping: 2, 7 cm diameter cores
  - every 10 cm to 30 cm and homogenized
- Soil washed using a 1 mm sieve
- Live roots manually separated from detritus and algae
- Roots dried at 55 °C for 36 hours





# Methods: Porewater

- Porewater samplers at 5, 15, and 25 cm depths
- 20-25 ml of porewater injected into N<sub>2</sub> flushed vials
- Headspace analyzed on a gas chromatograph for CH<sub>4</sub>
- Filtered (0.4 µm) and acidified samples analyzed for DOC (Dohrmann TOC analyzer)





# Data Analysis

- **Standard least squares regression (REML method)**
  - Replicate ID as a random effect
  - Fixed effects
    - # of functional groups
    - Composition of functional groups within diversity levels
    - Depth
    - Year or time
    - Root biomass for CH<sub>4</sub> and DOC
    - DOC for CH<sub>4</sub>



## Data analysis (cont.)

### Partitioning of diversity effects (Loreau and Hector 2001)

- Net diversity effect =  $\sum Y_i - M_i$ , also CE + SE
- Complementarity effect (CE) =  $N * \overline{\Delta RY} * \overline{M}$
- Selection effect (SE) =  $N \text{ cov}(\Delta RY, M)$

where:

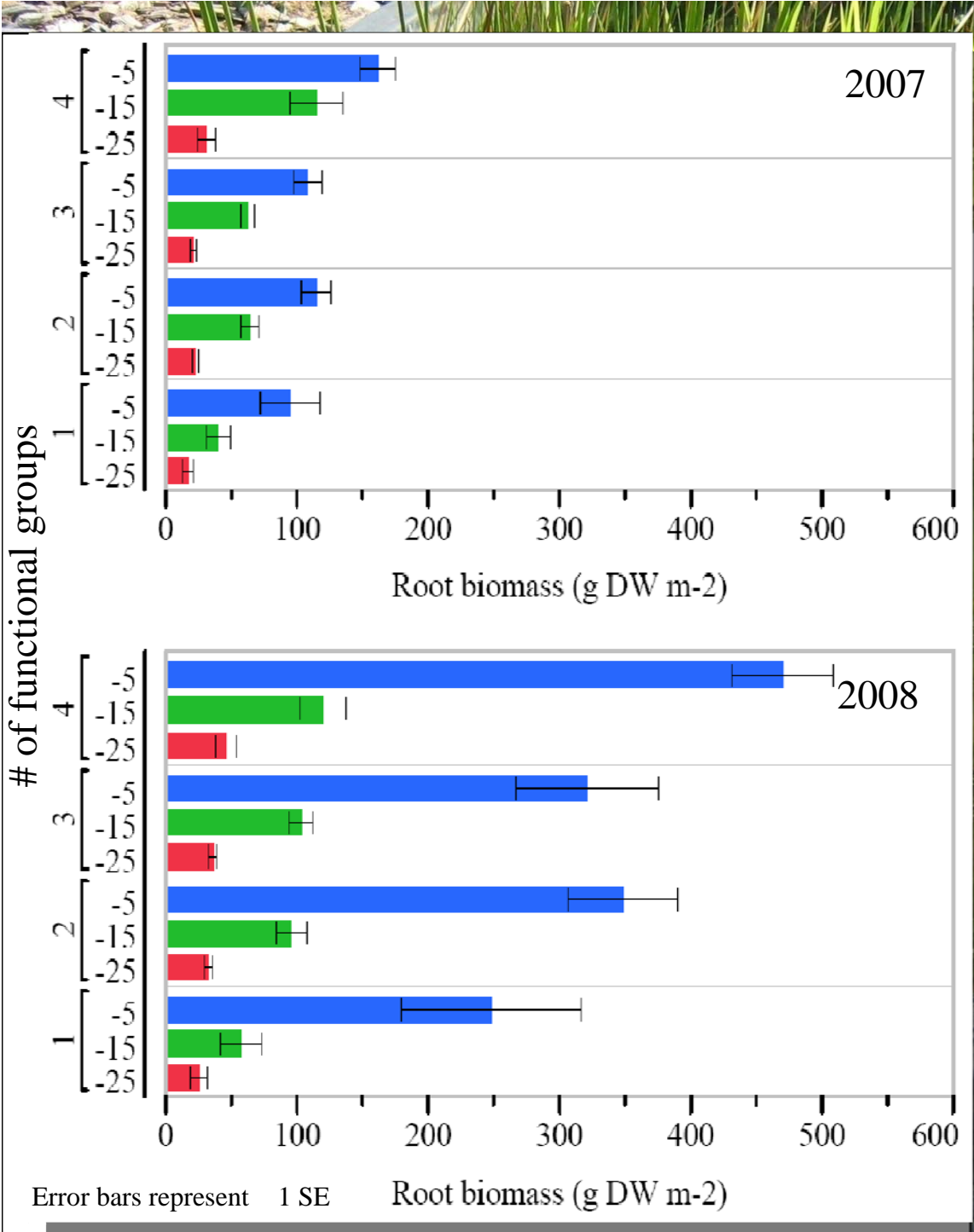
$Y_i$  = Observed yield (i.e., root biomass  $\text{g m}^{-2}$ ) for functional group  $i$

$M_i$  = Monoculture yield for functional group  $i$

$N$  = # of functional groups in mixture

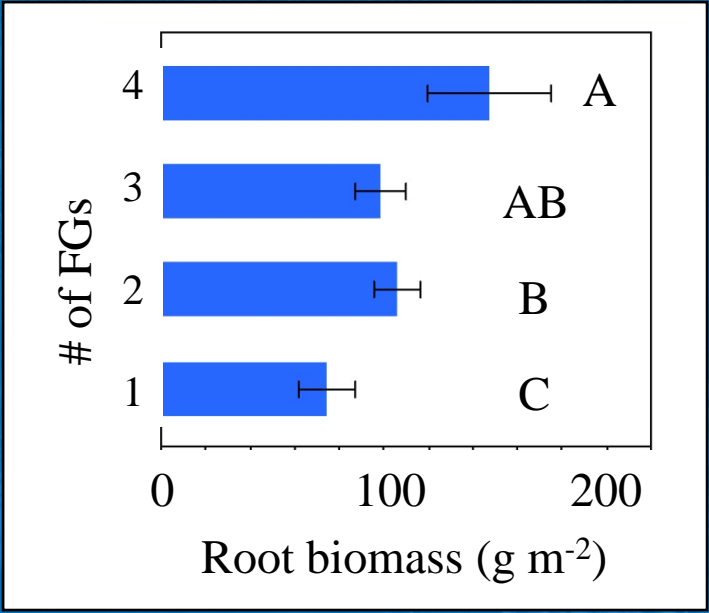
$\Delta$ Relative yield ( $\Delta RY$ ) =  $(Y_i / M_i) - 1/N$





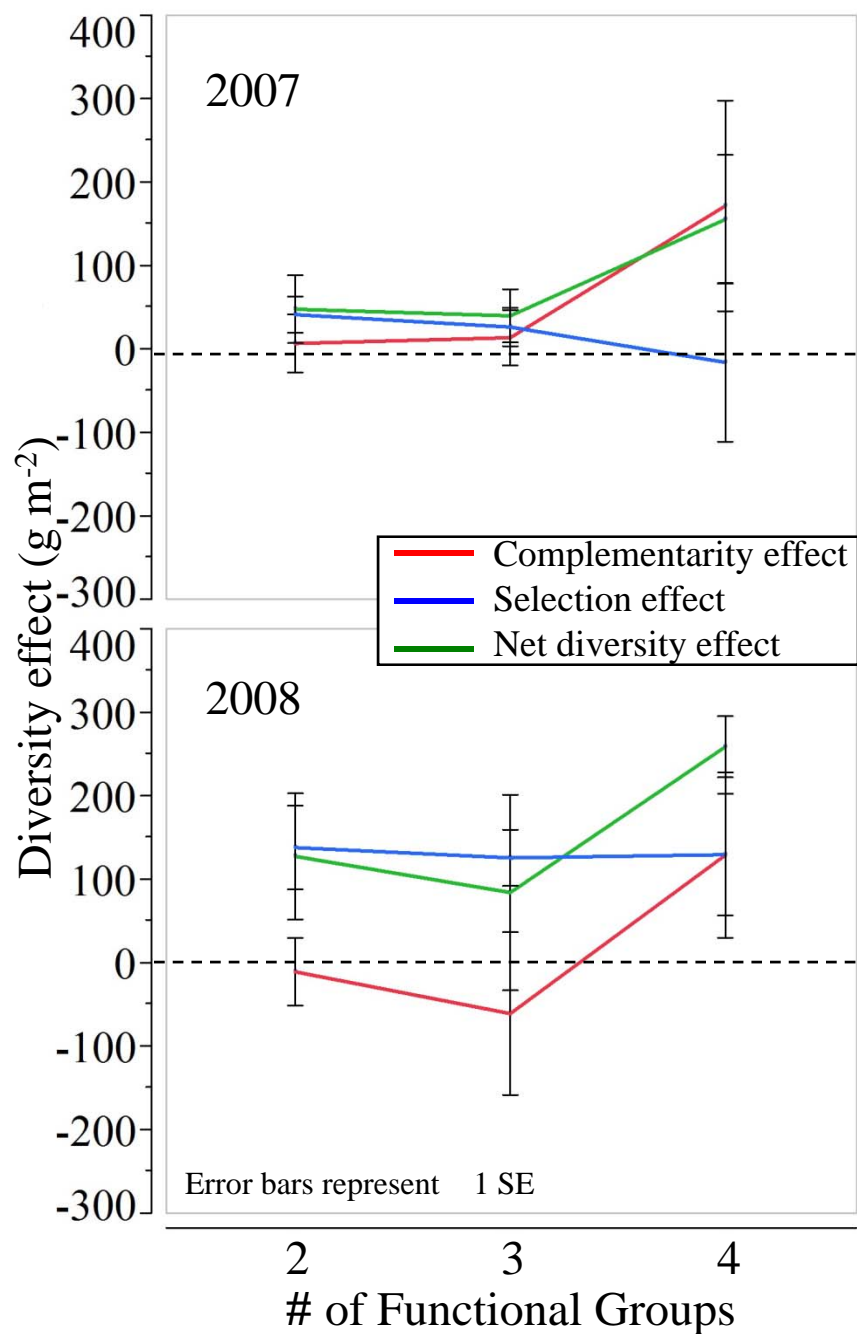
# Root Biomass

Source	DF	F-ratio
# of FGs	3	55.45***
Composition	11	51.09***
Depth	2	526.65***
Year	1	197.78***





# Diversity effects



## Complementarity Effect

Source	DF	<i>F</i> -ratio
# of FGs	2	11.407***
Year	1	4.064*
Composition	8	3.025**

## Selection Effect

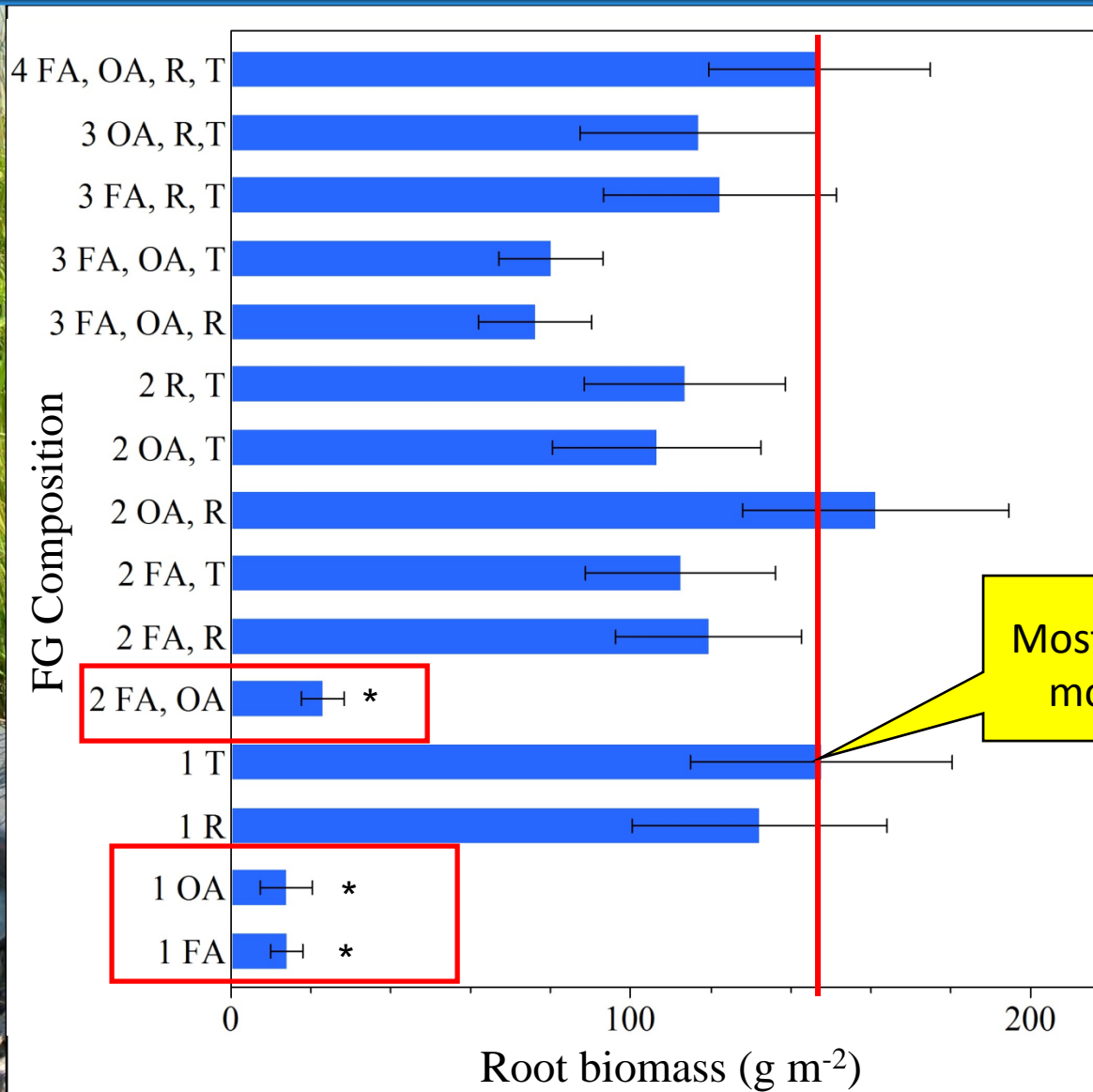
Source	DF	<i>F</i> -ratio
# of FGs	2	1.82
Year	1	62.50 ***
Composition	8	14.14 ***

## Net Diversity Effect

Source	DF	<i>F</i> -ratio
# of FGs	2	5.37**
Year	1	6.25*
Composition	8	4.74***



# Functional Group Composition

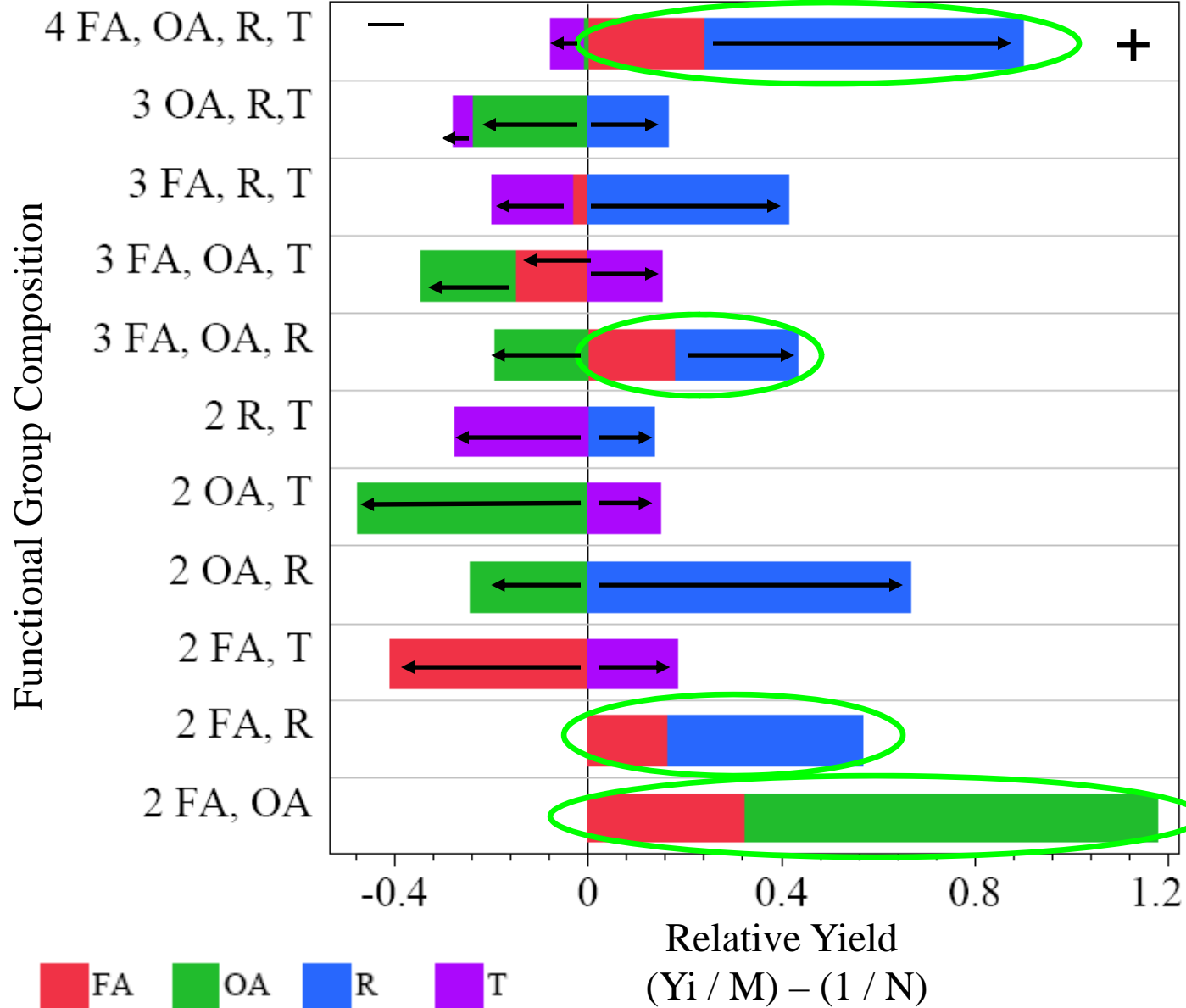


Most productive monoculture

\* Indicates a significant difference,  $P < 0.05$

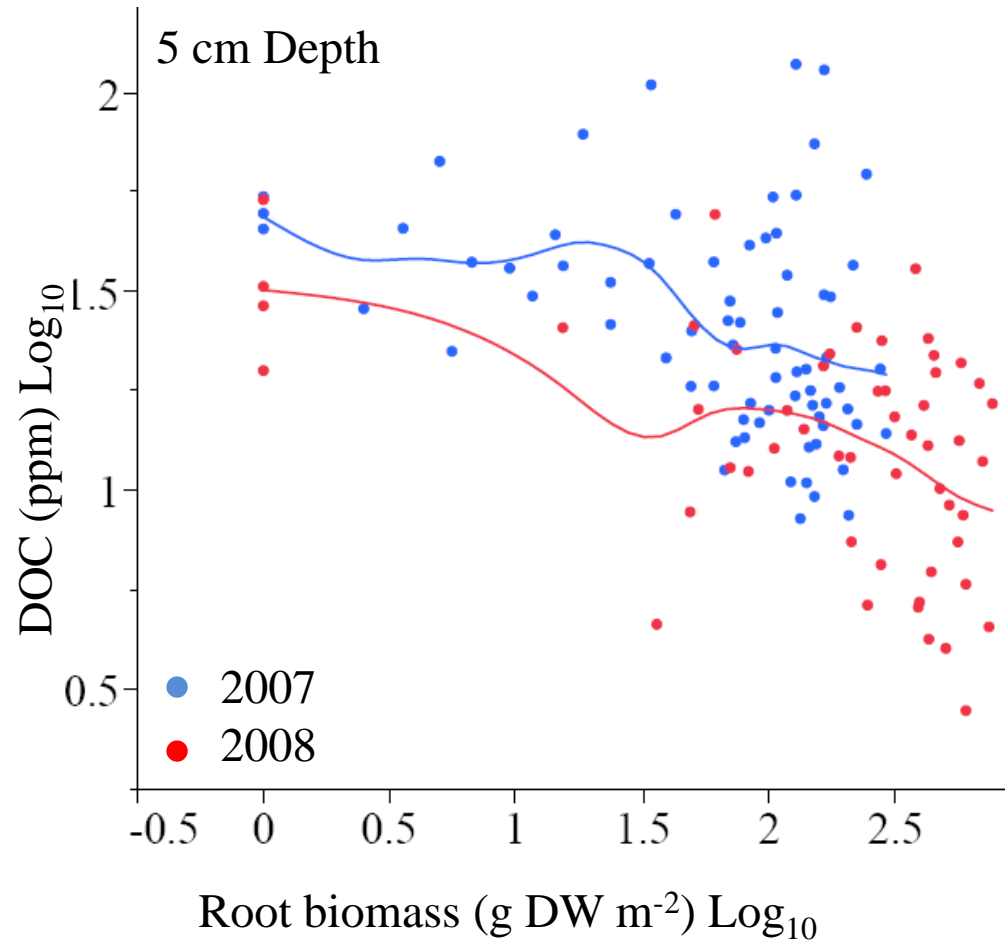


# Functional Group Composition: Relative Yield





# Dissolved organic carbon (DOC)



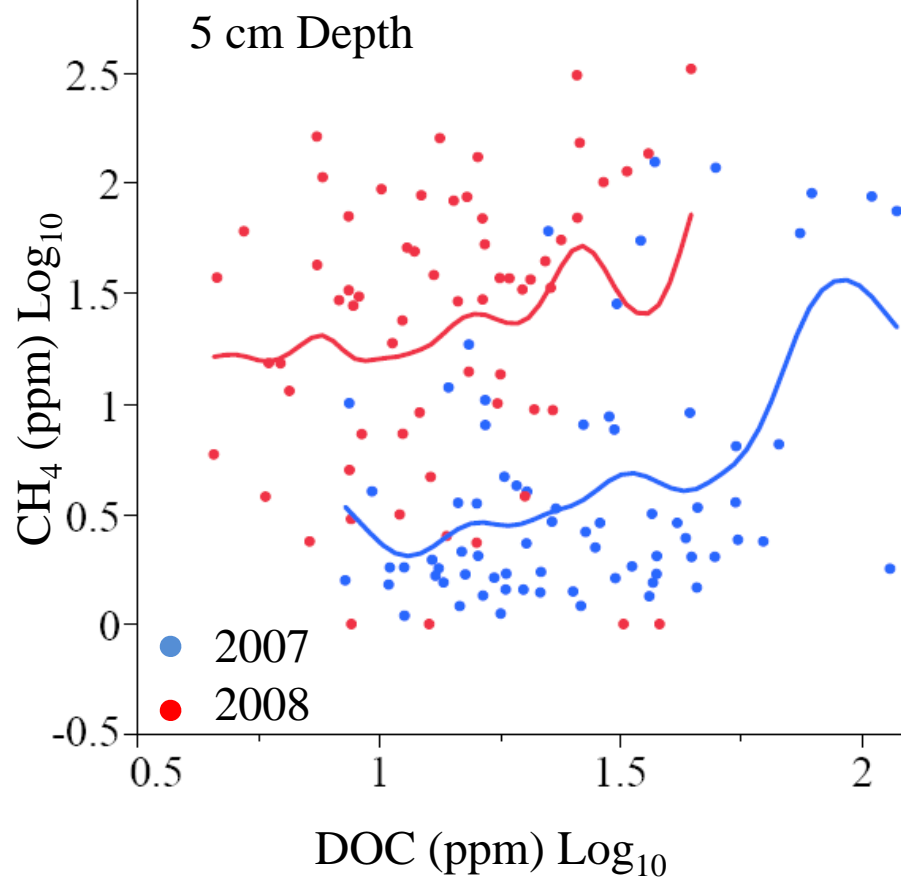
DOC

Source	DF	<i>F-ratio</i>
Root biomass	1	3.53.
Year	1	15.75***
Depth	2	2.67.
# of FGs	4	0.67
Composition	11	1.73.

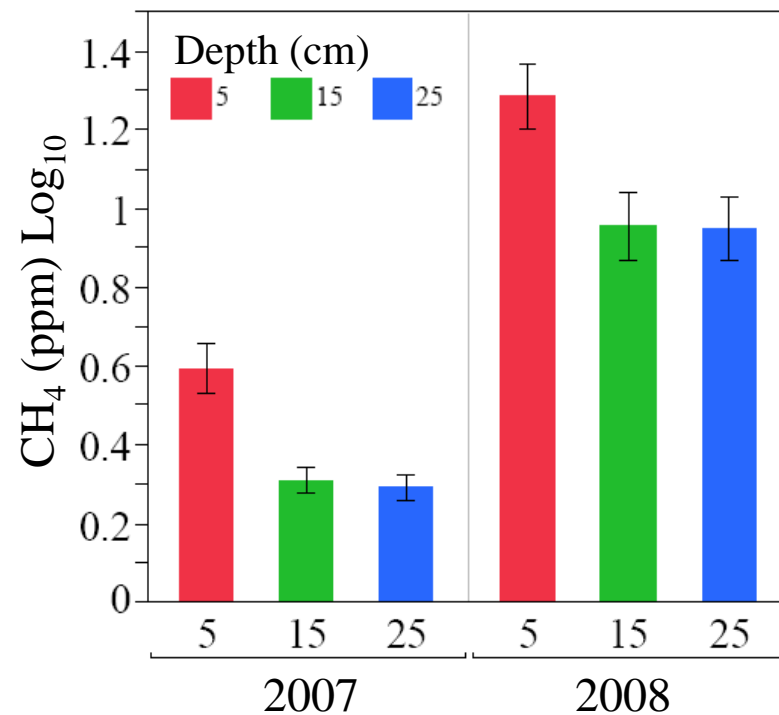
Smoothing line represented



# Dissolved CH<sub>4</sub>



CH <sub>4</sub> Source	DF	F-ratio
Root biomass	1	0.25
DOC	1	13.38***
Year	4	97.23***
Depth	2	7.96***
# of FGs	4	0.31
Composition	11	0.41





# Summary

Root biomass will increase with # of FGs due to a complementarity effect

Functional Group Richness

H1 +

Functional Group Composition

+ / - H2

Root biomass will be greater in treatments containing FGs with high productivity

Root Biomass

+ H3

DOC will increase with root biomass

CH<sub>4</sub> will decrease with root biomass

H5 -

DOC

+ H4

CH<sub>4</sub> will increase with DOC

CH<sub>4</sub>



# Discussion

- Belowground productivity
  - Complementarity effect at highest diversity level
  - Non-transgressive overyielding
- Trend: DOC decreased with root biomass
  - Labile carbon is being used up in a low carbon system
  - Root surface area vs. biomass (fine roots)
- CH<sub>4</sub> dynamic driven by carbon limitation
  - The availability of DOC is directly correlated to the sediment pool of CH<sub>4</sub>
  - Fe and S also taking up DOC (reduction by bacteria)



# Acknowledgements

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**Thank you for your attention!**