Plant root impacts on soil organic matter decomposition

Marie-Anne de Graaff

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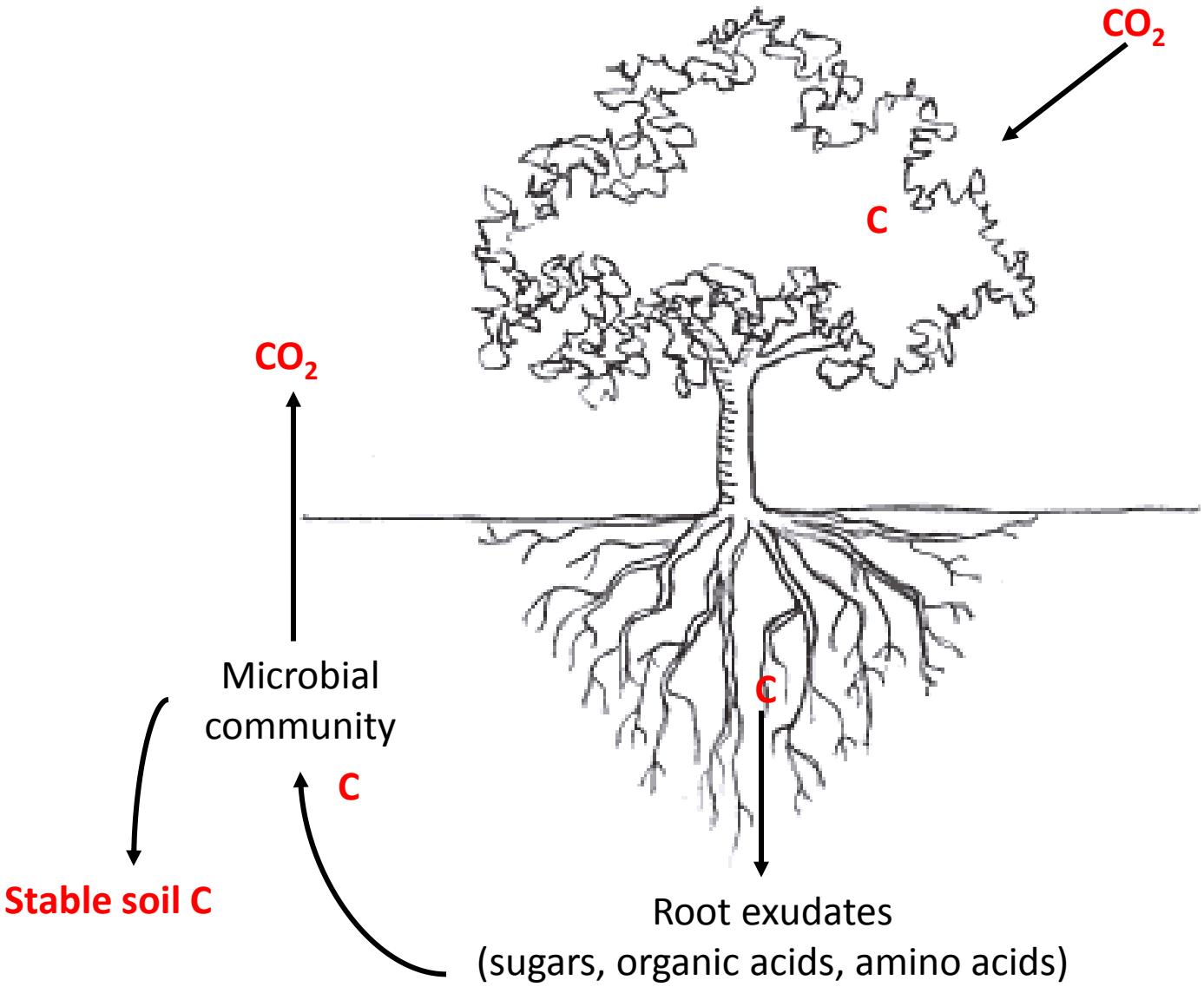
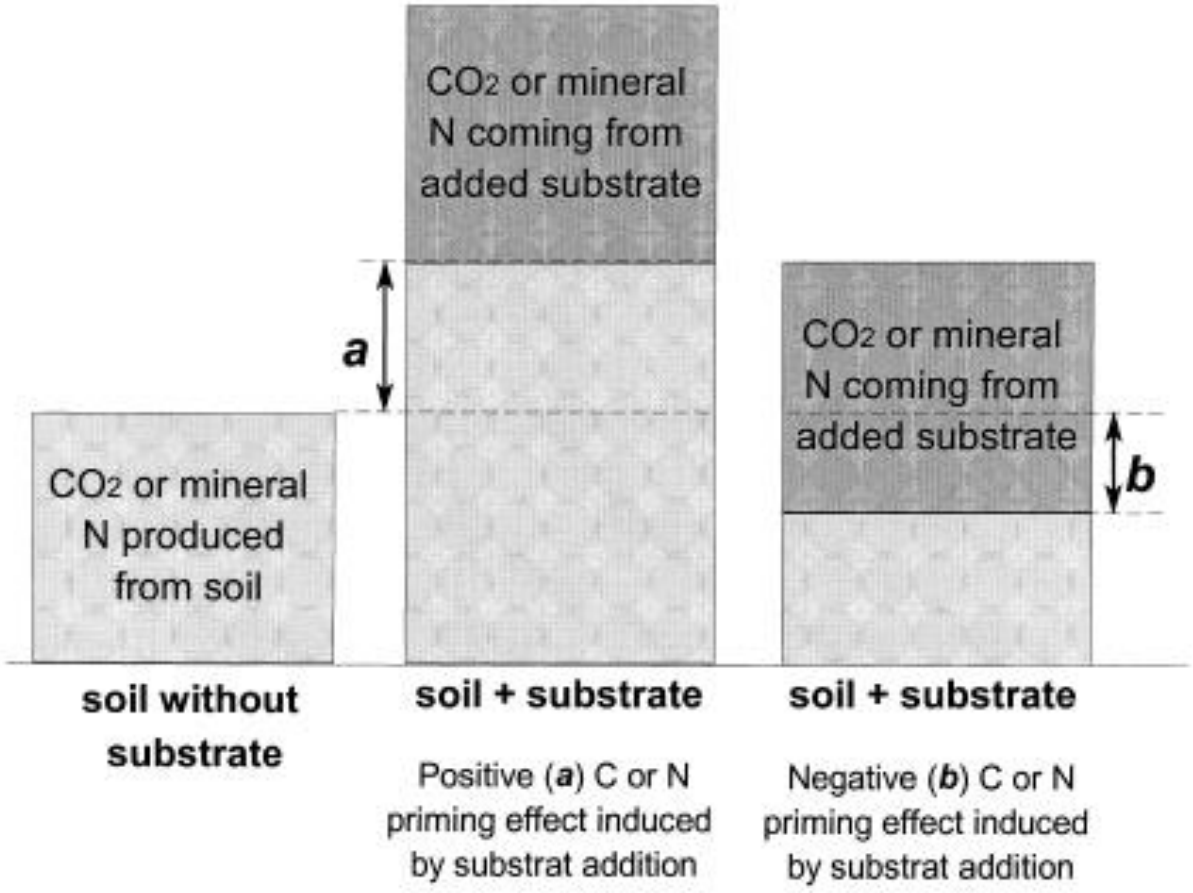
How do changes in root structure affect root-derived soil C inputs and SOM decomposition?



Priming: a change in decomposition of organic C following addition of easily-decomposable organic substances to the soil



Kuzyakov et al., 2000

Questions

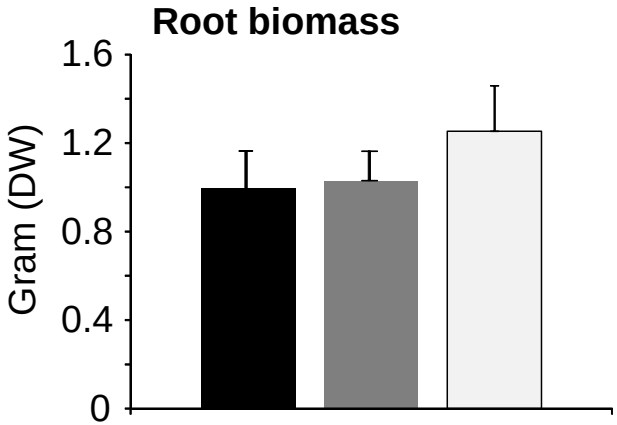
1. How may an environmental change impact root structure?

2. How may a change in root structure impact soil C input?

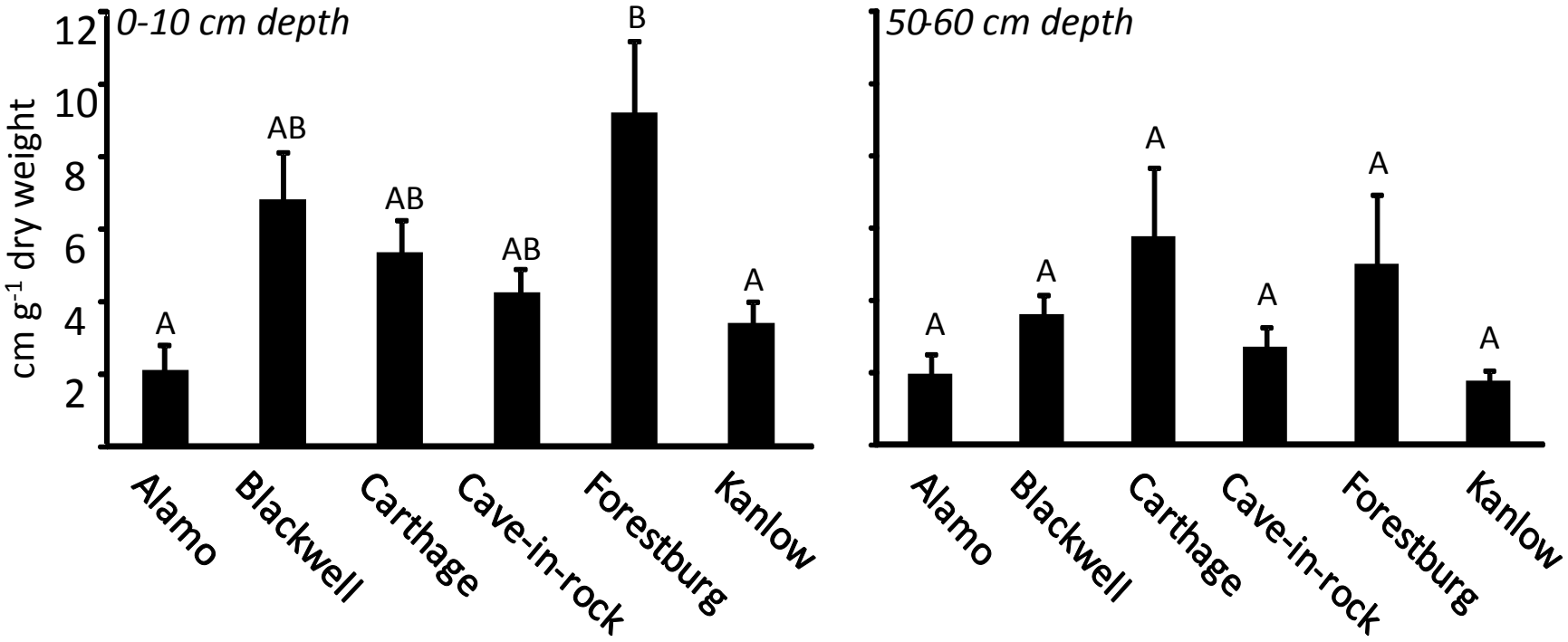
3. How may a change in soil C input affect SOM decomposition?

Changes in the timing and amount of precipitation (20 years) affect specific root length

20 yr. precipitation manipulation experiment in ID, USA to assess altered precipitation impacts on root architecture

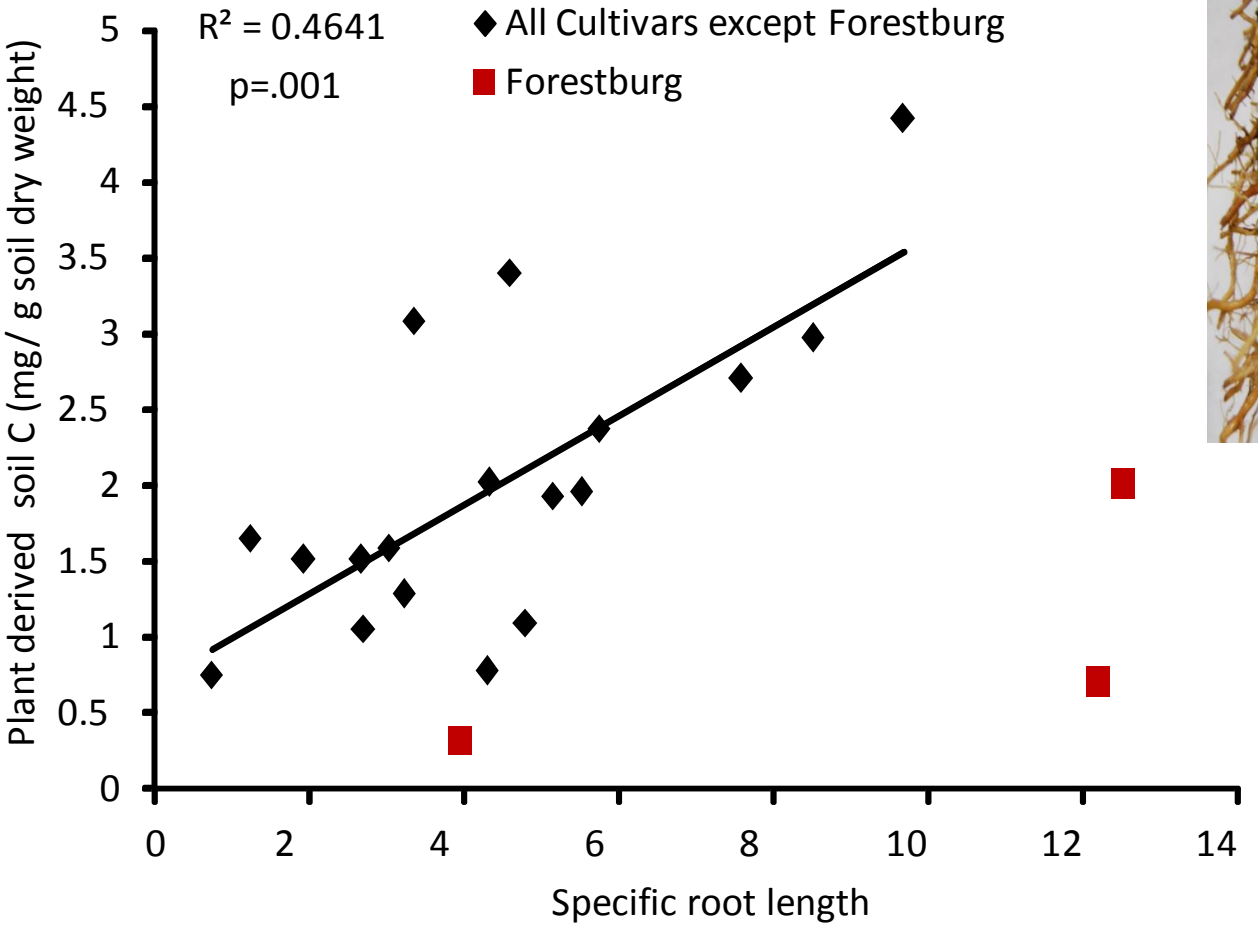


Variation in specific root length among switchgrass cultivars



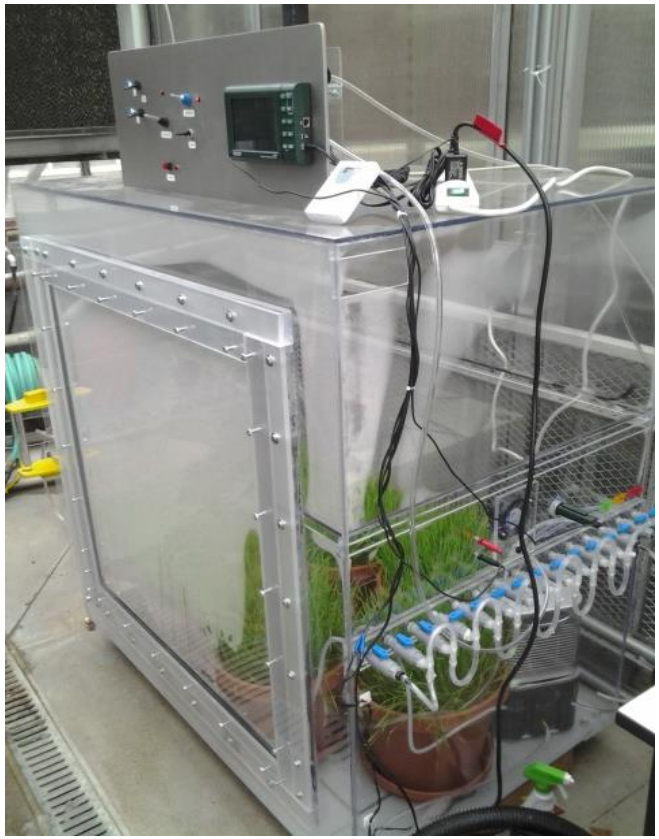
De Graaff *et al*., 2013 and 2014

Linking SRL with root-derived soil C: implications for stabilization?



Does a change in root derived soil C inputs affect soil C decomposition?

FACE experiment to assess the impact of elevated [CO_2] on soil C sequestration



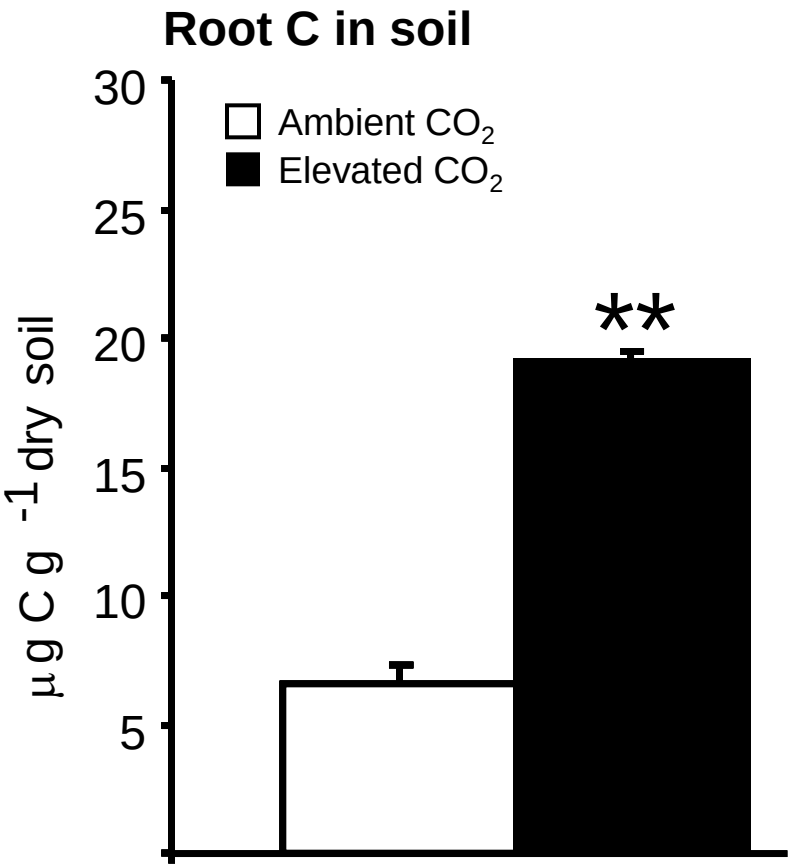
^{13}C labeling experiment to assess changes in SOC decomposition under elevated [CO_2]

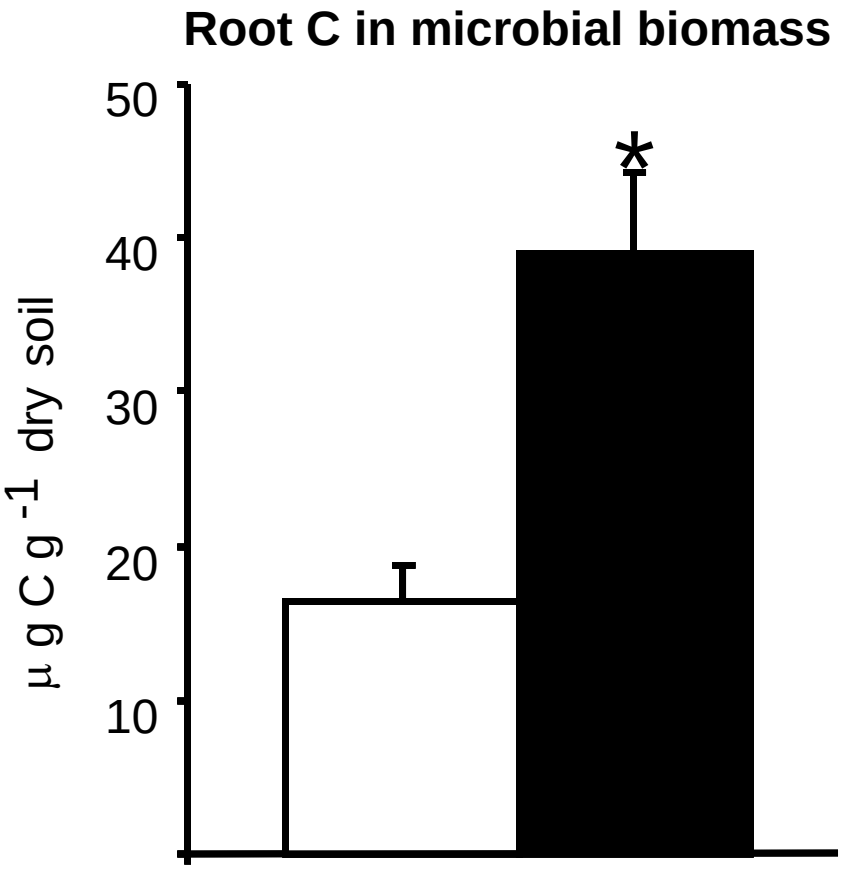
No net soil C sequestration in fertilized Swiss grasslands exposed to 10 years of elevated [CO_2]

		Total soil C (Mg ha^{-1})	
Depth	**Species**	**Ambient [CO_2]**	**Elevated [CO_2]**
0-10 **NO NET C STORAGE**	*L. perenne*	27.3	27.2
	T. repens	25.0	26.3
	L. Perenne + T. repens	25.9	27.2
10-25 **NO NET C STORAGE**	*L. perenne*	18.6	19.6
	T. repens	19.2	18.5
	L. Perenne + T. repens	18.6	19.6
25-50 **NO NET C STORAGE**	*L. perenne*	9.9	6.7
	T. repens	8.3	7.1
	L. Perenne + T. repens	9.0	7.1
50-75 **NO NET C STORAGE**	*L. perenne*	5.0	2.8
	T. repens	3.6	2.3
	L. Perenne + T. repens	4.3	2.4

Van Kessel *et al*., 2006 (*Global Change Biology*)

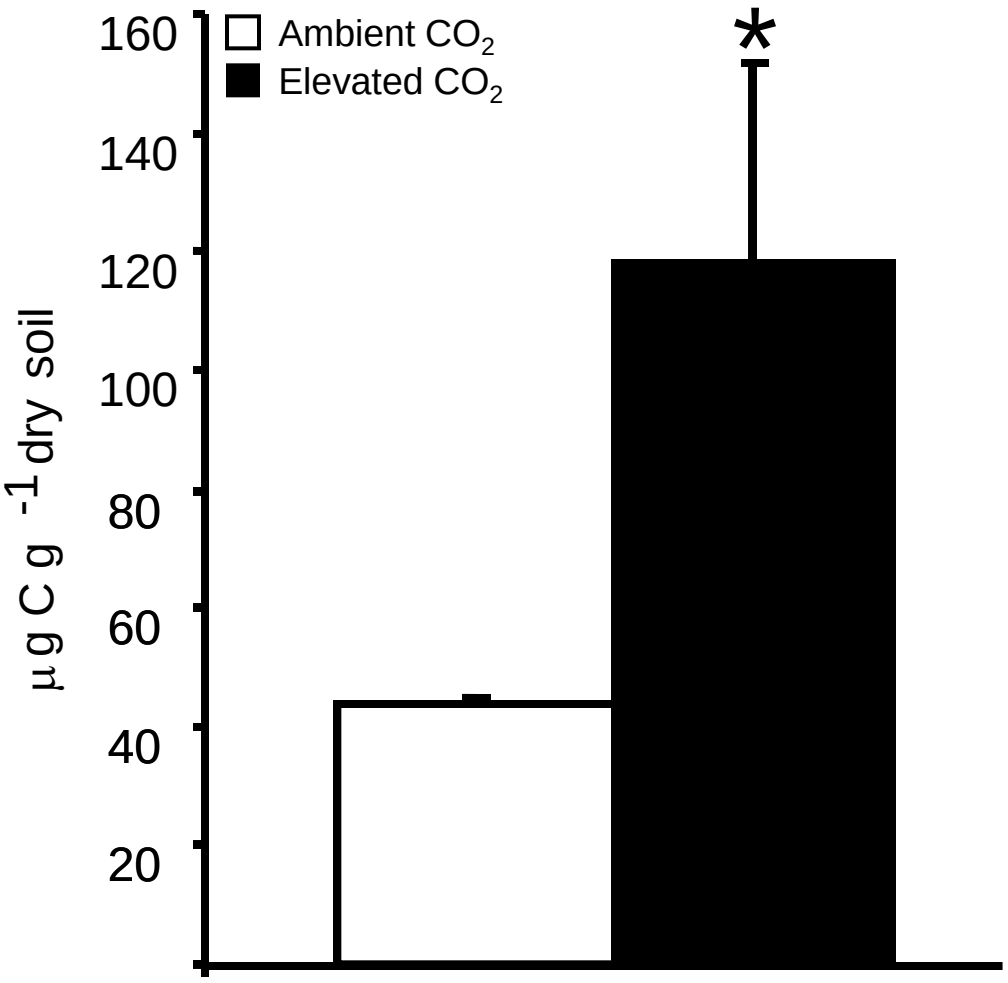
Elevated [CO_2] increases root-derived C in soil and microbial biomass





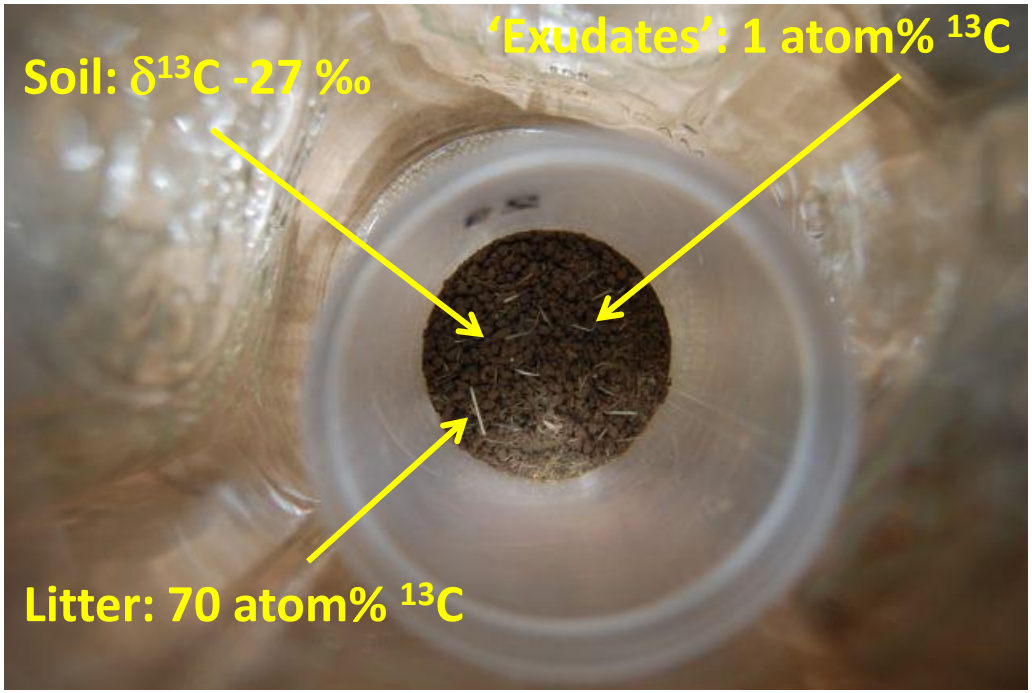
de Graaff *et al*., 2009 (*Soil Biology and Biochemistry*)

Elevated [CO_2] increases soil C decomposition



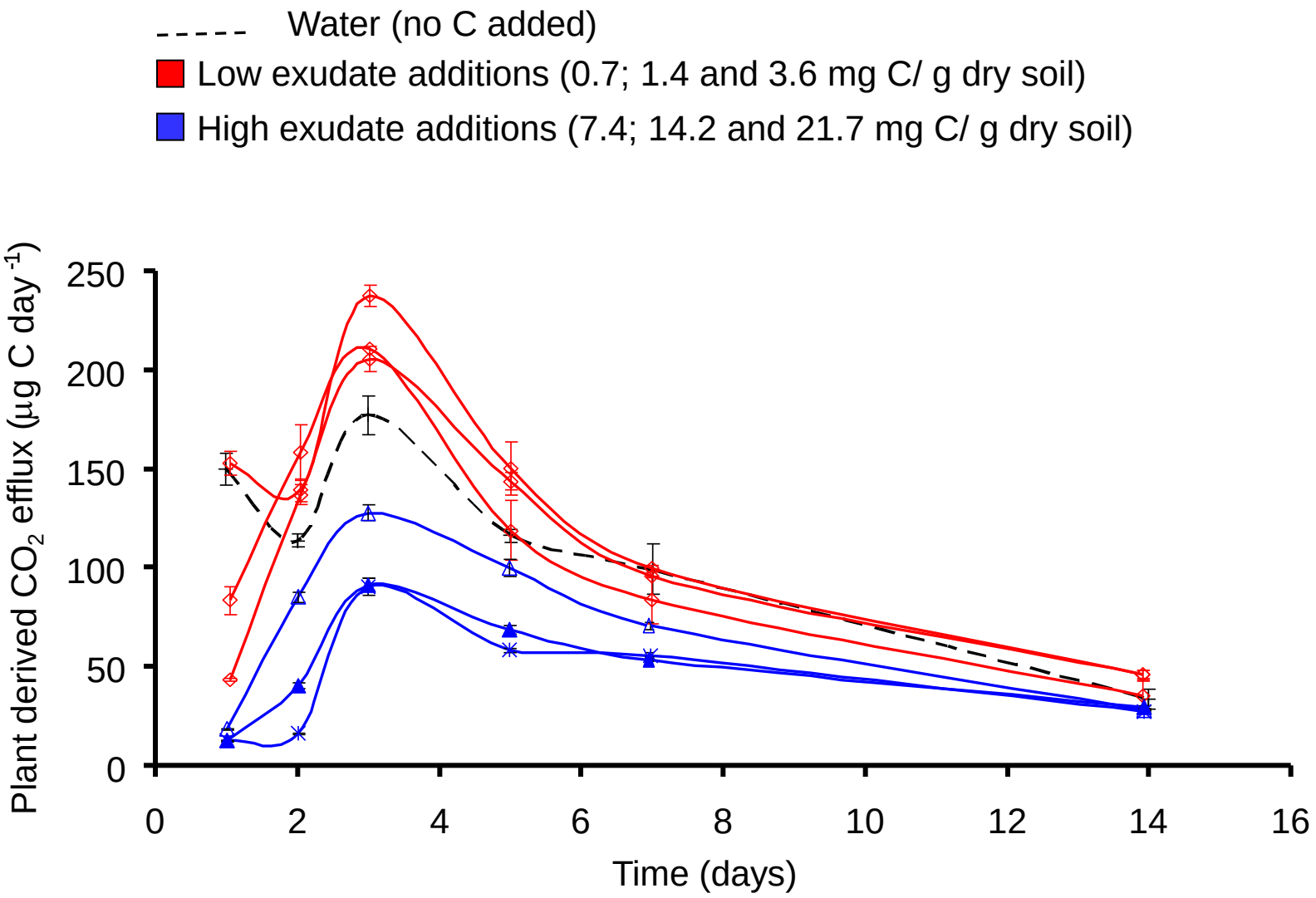
de Graaff *et al*., 2009 (*Soil Biology and Biochemistry*)

How does a change in exudate inputs affect soil organic matter decomposition?



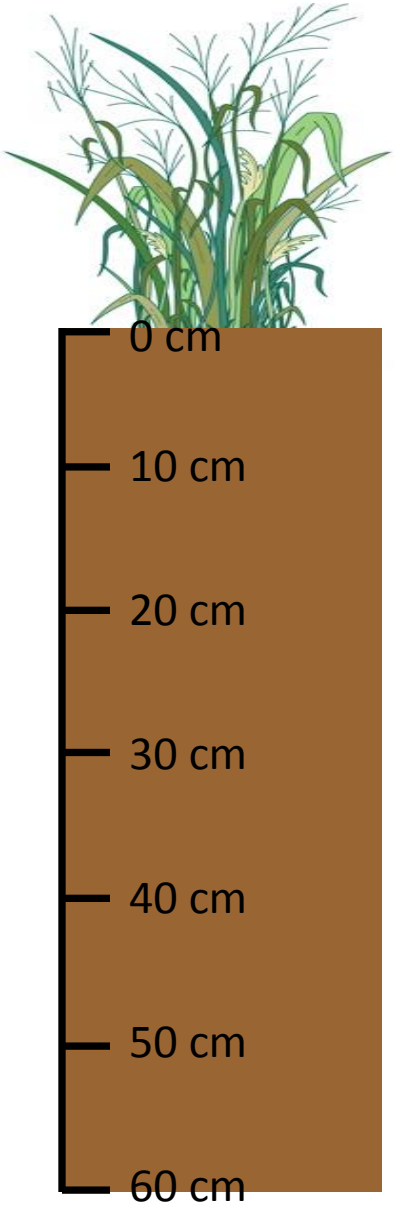
Controlled laboratory incubation experiments to assess how additions of synthetic root exudate solutions affects decomposition rates of litter and SOC

Exudate inputs regulate litter decomposition rates



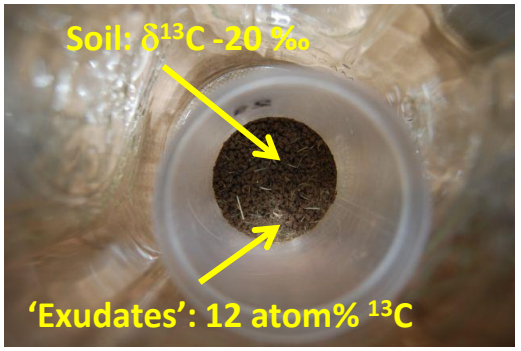
De Graaff *et al*., 2010 (*New Phytologist*)

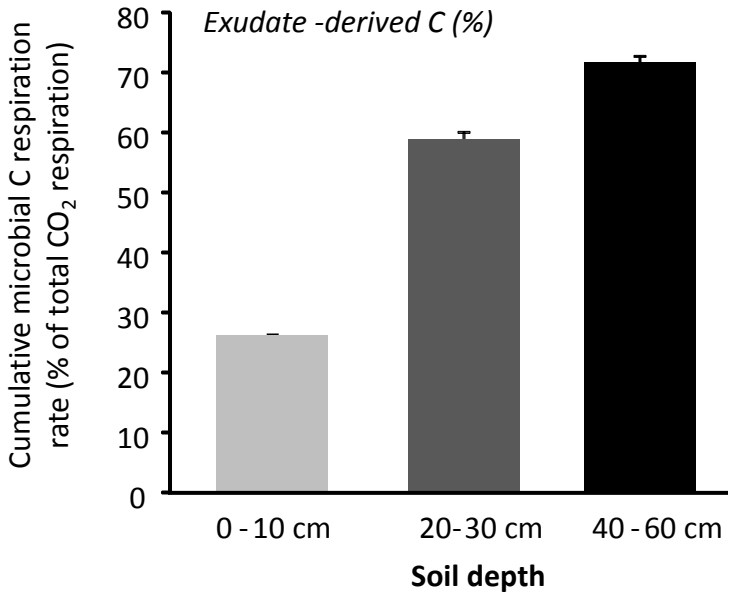
How does soil depth mediate the response of soil C decomposition to altered exudate inputs?

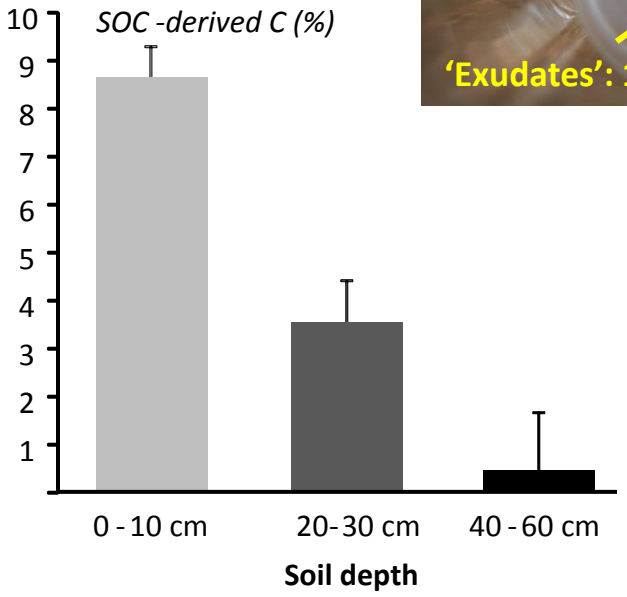


Controlled laboratory incubation experiments to assess how additions of synthetic root exudate solutions affects decomposition rates of litter and SOC at different depths

Soil depth controls microbial processing of exudates and priming of soil organic carbon







De Graaff *et al.*, 2014

Conclusions

(1) Changes in atmospheric [CO_2] and climate affect soil C input via roots.

(2) A small atmospheric [CO_2] or climate induced change in soil C input via roots can increase decomposition rates of litter and soil organic carbon.

(3) The magnitude and direction of priming is mediated by the quantity of exudate inputs and by soil depth.

Acknowledgements:

Funding: ORNL-DOE, USDA-NIFA, NSF-EPSCoR

Collaborators: Aimee Classen, Julie Jastrow, Chris Schadt, Johan Six, Chris van Kessel, Stan Wullschleger

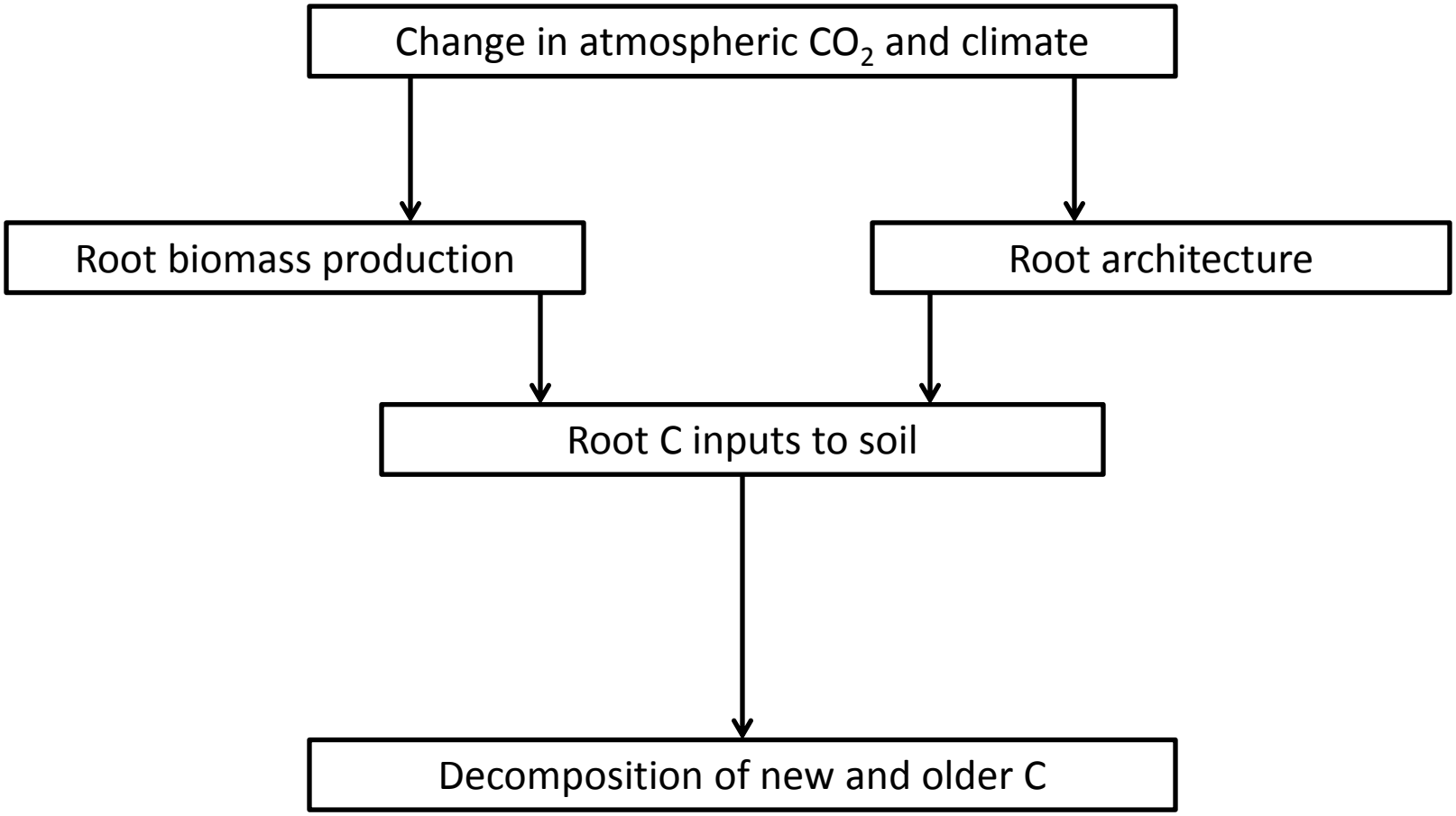
Students/ lab-techs:, Aislinn Johns, Xochi Campos, Ian DuVall, Jamie Hicks, Tim Vughteveen, Jaron Adkins, Shay Gillette

Argonne NATIONAL LABORATORY

BOISE STATE UNIVERSITY

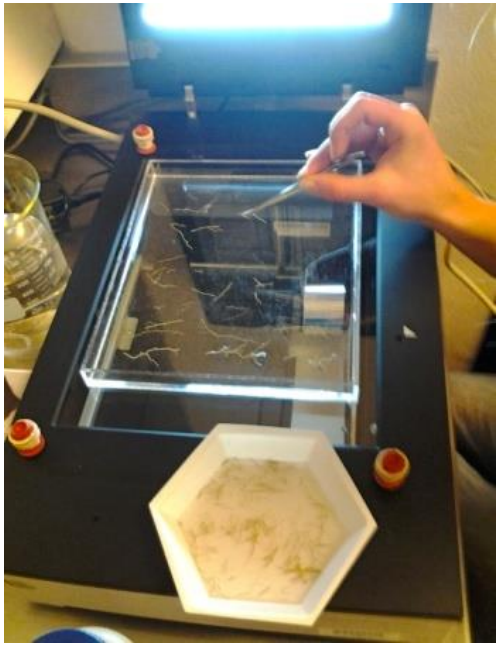
IDAHO EPSCoR

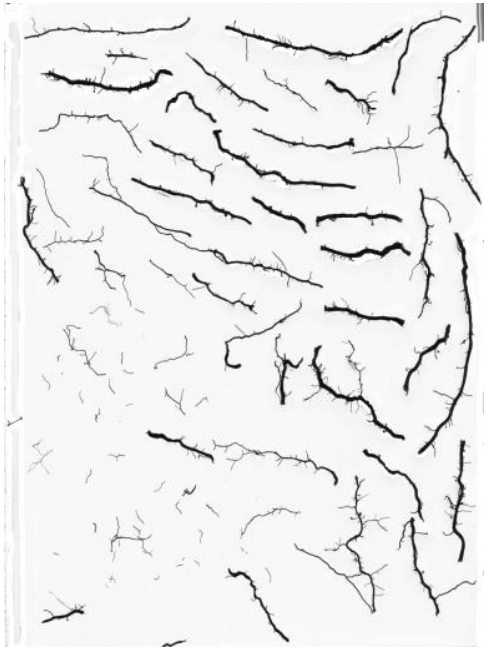
OAK RIDGE National Laboratory


Change in atmospheric CO_2 and climate
Root biomass production
Root architecture
Root C inputs to soil
Decomposition of new and older C

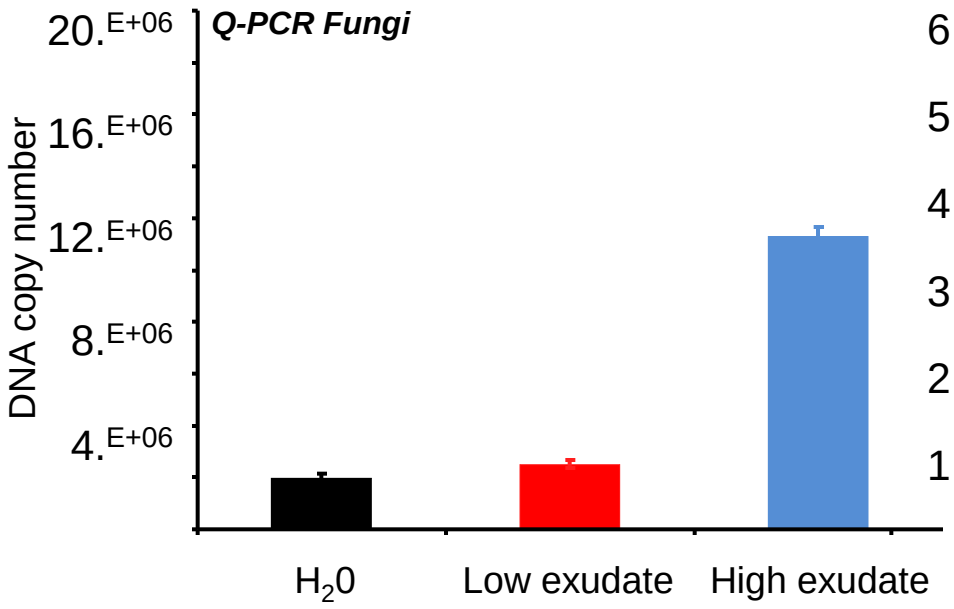
Analyses:

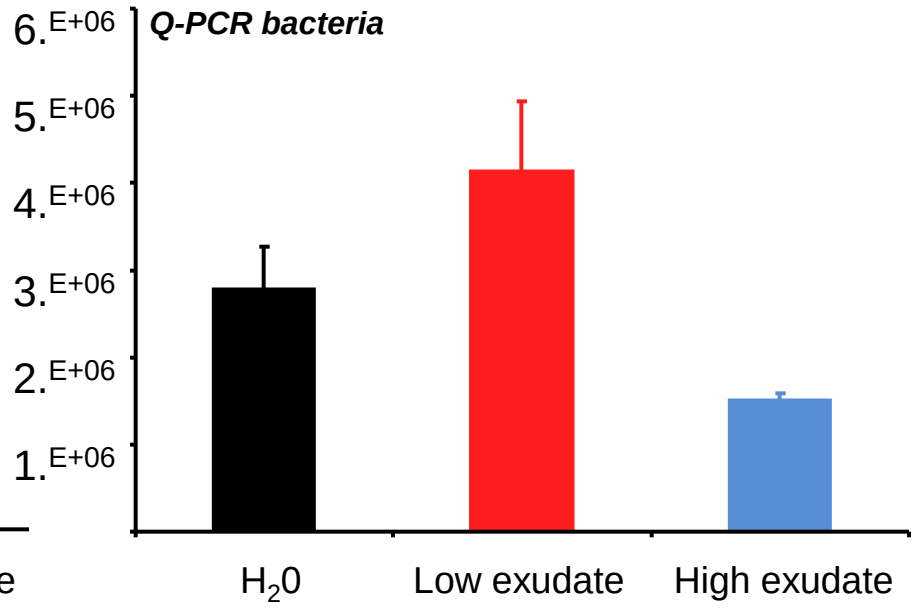
- Specific root length (60 cm depth)
- CO_2 respiration on days: 1, 3, 7, 15, 30 and 60
  - CO_2 was partitioned into root-derived C, SOC derived C and exudate derived C





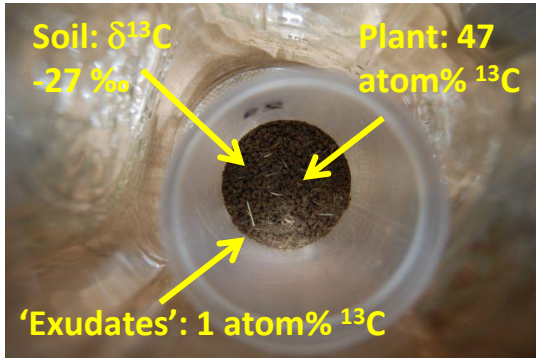
Root derived C mediates the microbial community structure

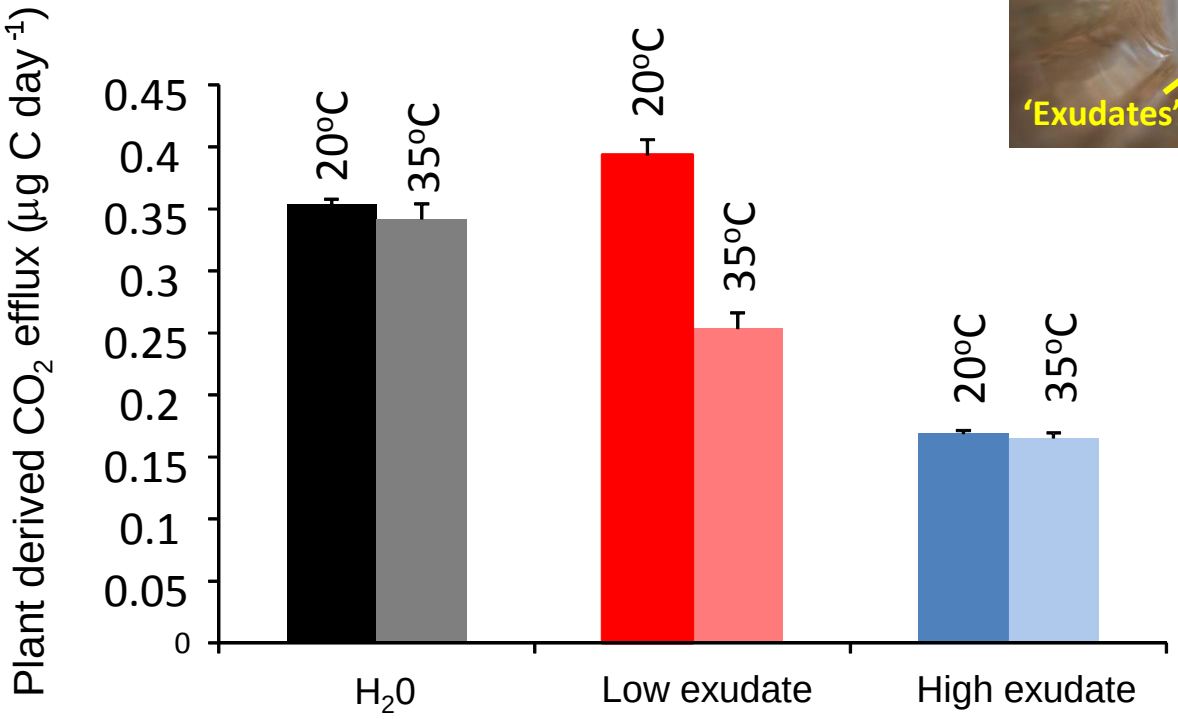




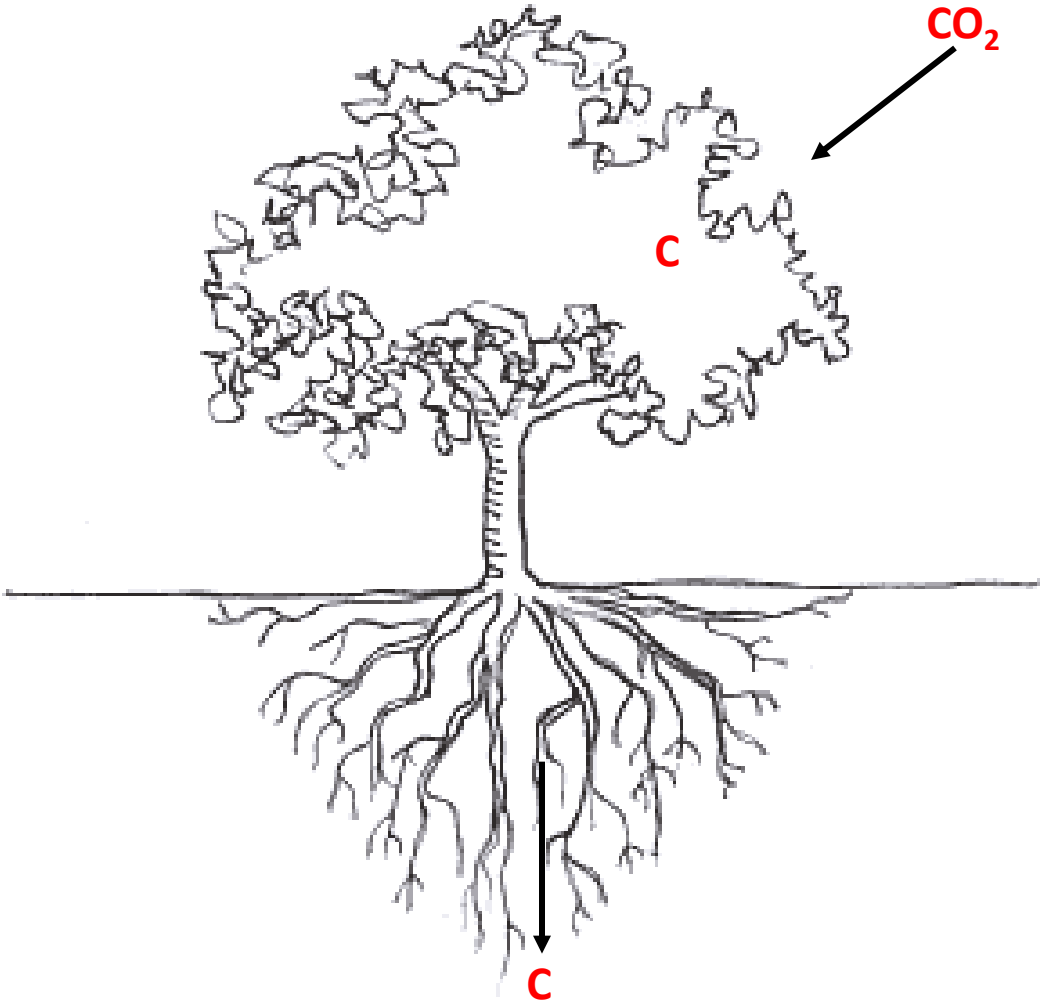
De Graaff *et al*., 2010 (*New Phytologist*)

Temperature mediates exudate impacts on priming of litter decomposition





How do changes in root morphology affect root C inputs to soil and SOM decomposition?



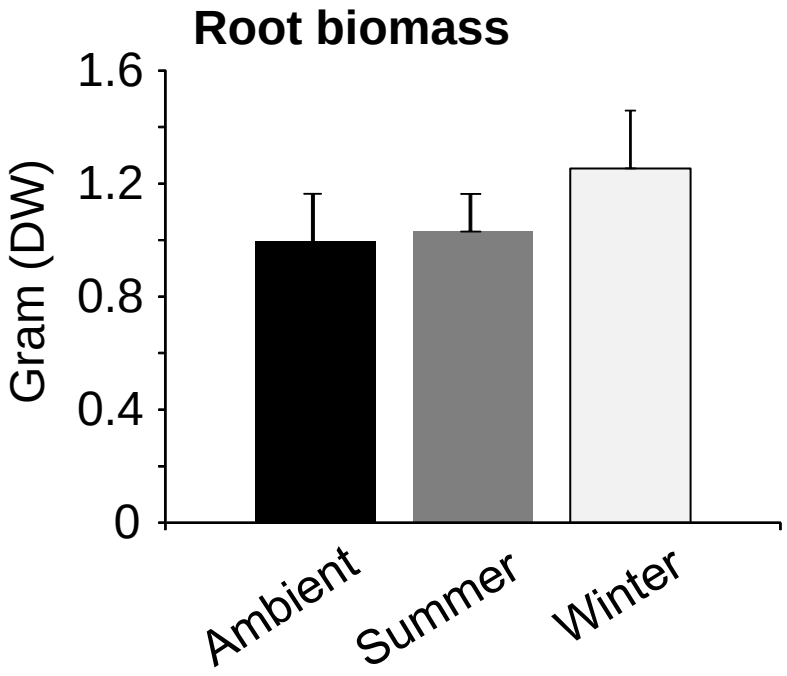
Root exudates
(sugars, organic acids, amino acids)

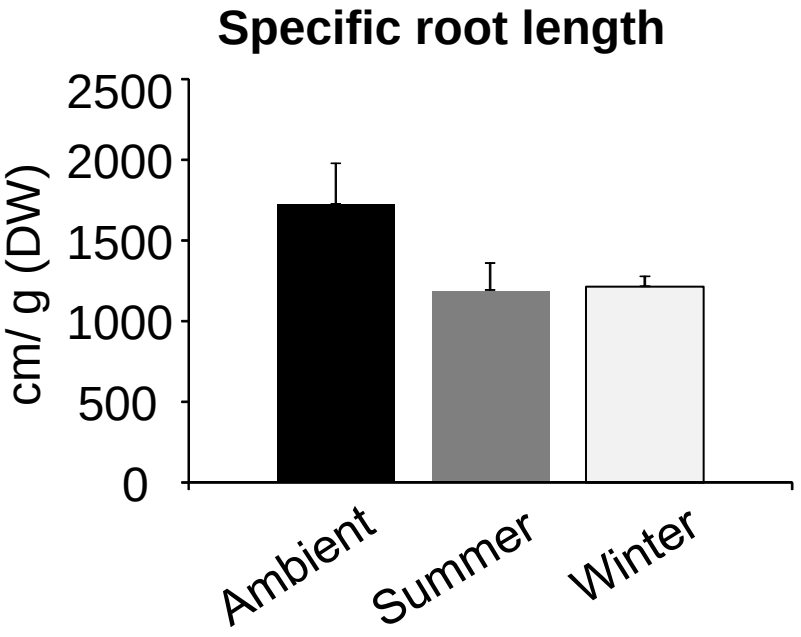
Does a change in atmospheric [CO_2] or climate affect root derived C inputs to soil?

^{13}C labeling experiment to assess changes in root C input under elevated [CO_2]

20 yr. precipitation manipulation experiment in ID, USA to assess altered precipitation impacts on root architecture

Changes in the timing and amount of precipitation (20 years) affect specific root length





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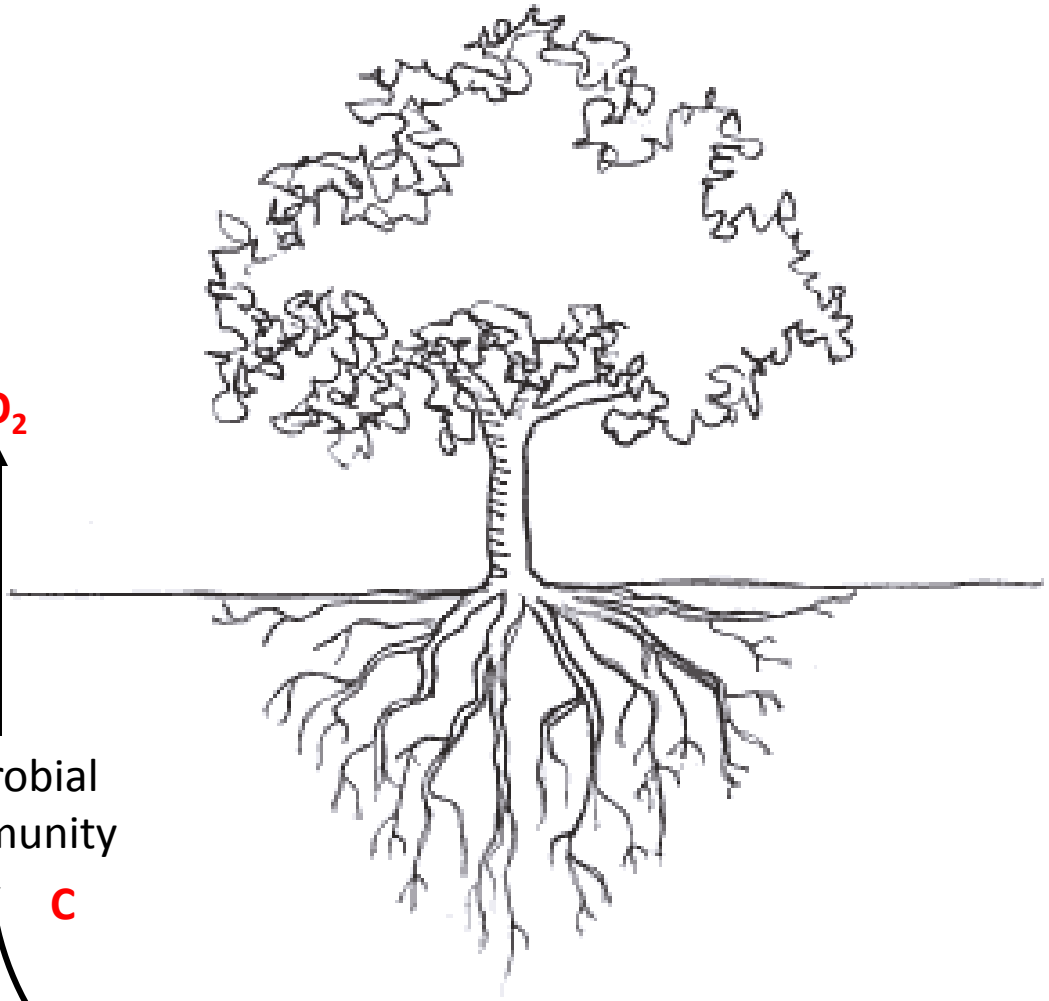

How do changes in root structure affect root-derived soil C inputs and SOM decomposition?

CO_2

C

CO_2

Microbial community

C

C

Stable soil C

Root exudates
(sugars, organic acids, amino acids)