HelmholtzZentrum münchen
German Research Center for Environmental Health

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

TECHNISCHE UNIVERSITÄT MÜNCHEN

Nitrogen turnover in early phases of ecosystem development

Michael Schloter, Stefanie Schulz, Robert Brankatschk, Alexander Dümig, Ingrid Kögel Knaber, Jean Charles Munch, Josef Zeyer and many many more ….

Cottbus, 12/12/12

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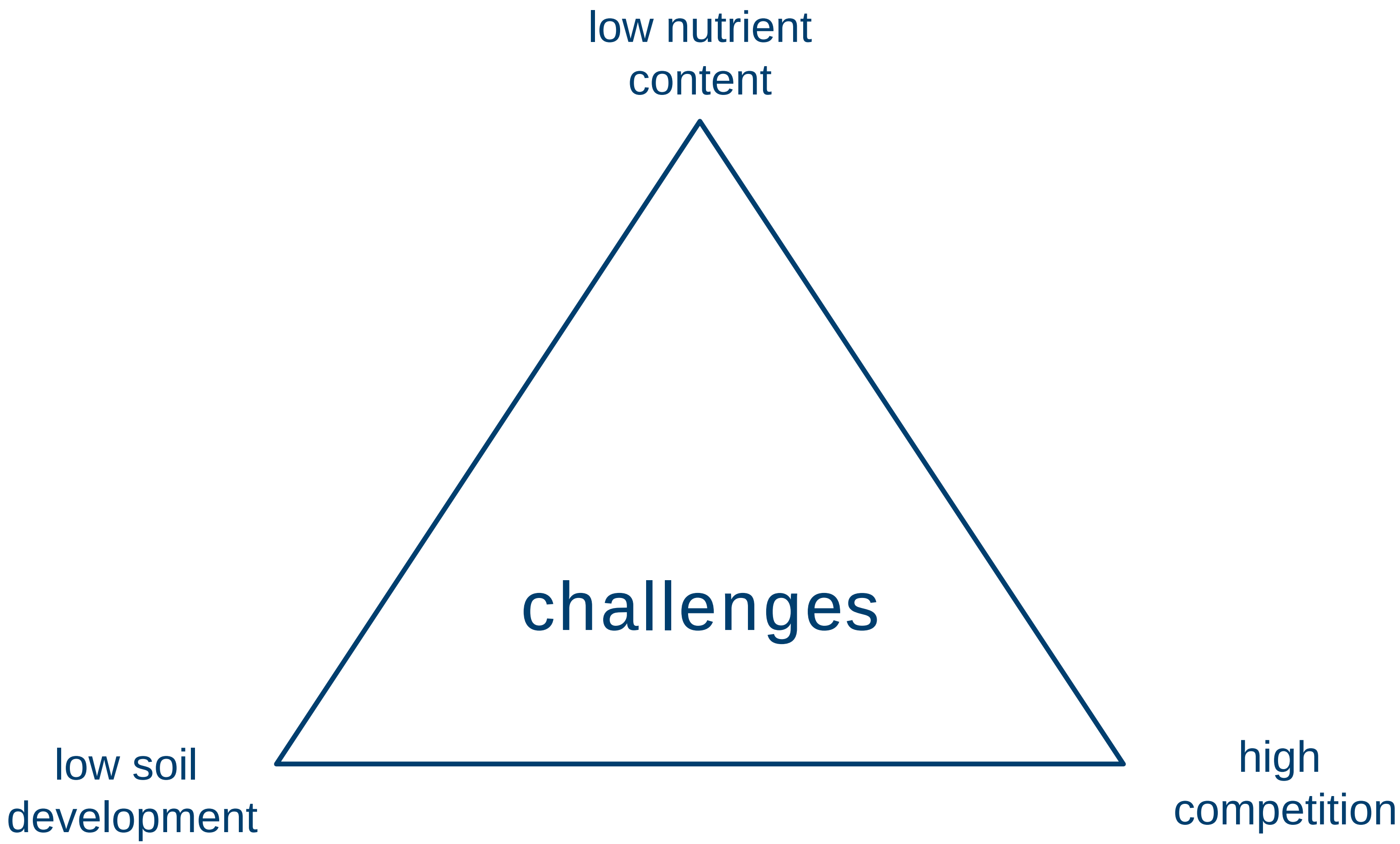
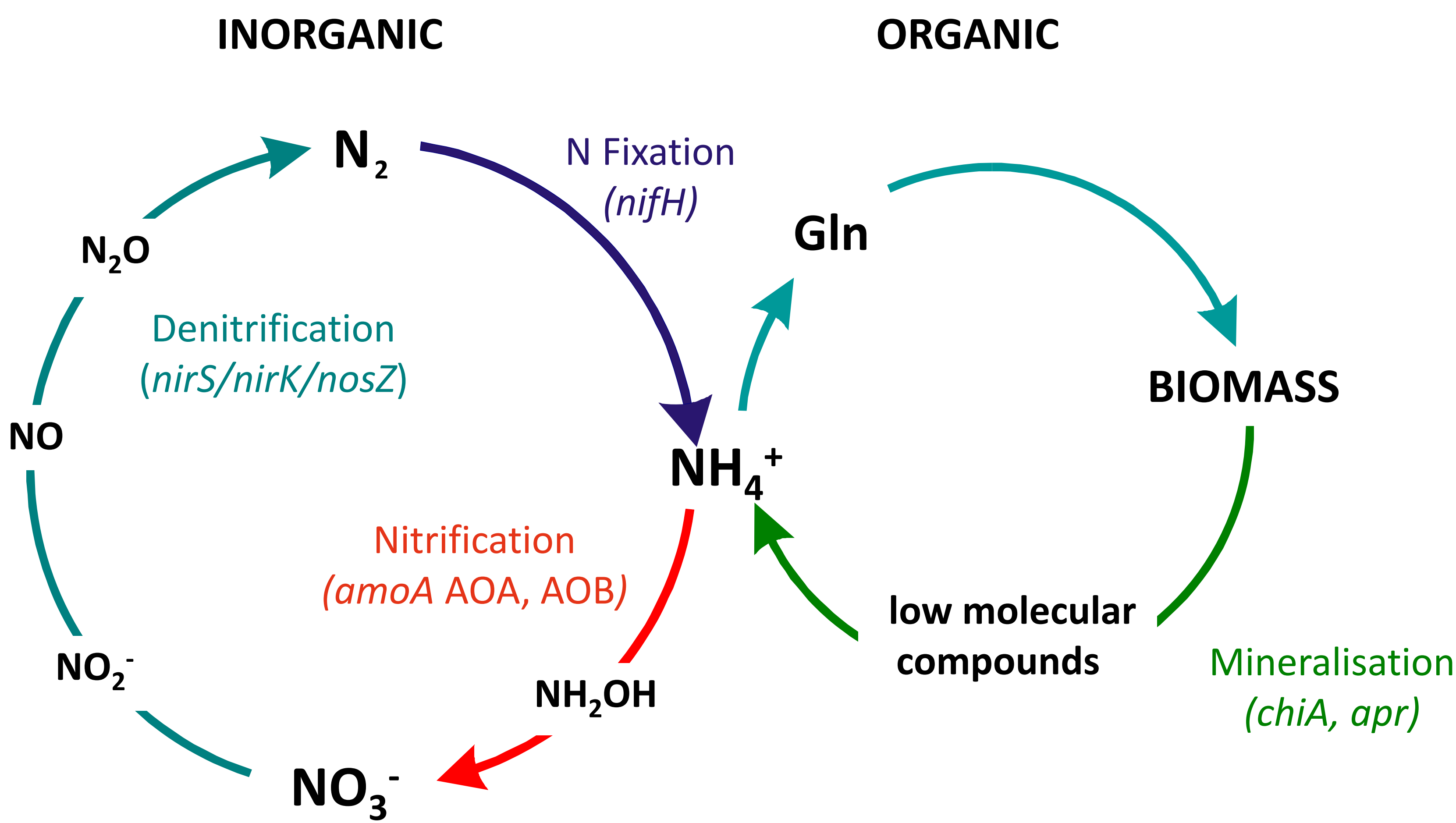
Initial ecosystems



Investigated N cycle processes



Outline

1. The Damma Glacier - A chronosequence approach

   Brankatschk & Töwe *et al.* (2011) ISME J

2. Biological Soil Crusts – A hotspot of nitrogen turnover

   Brankatschk *et al.* (2012) FEMS Microbiol Ecol

3. The role of plants

   → non-legumes (*Leucanthemopsis alpina*)

   Töwe *et al*. (2010) Microb Ecol

   → legumes (*Trifolium arvense*)

   Schulz *et al.* (2012) Biogeosci Discuss

1. The Damma Glacier - A chronosequence approach

Who dominates the N cycle in the initial phase?

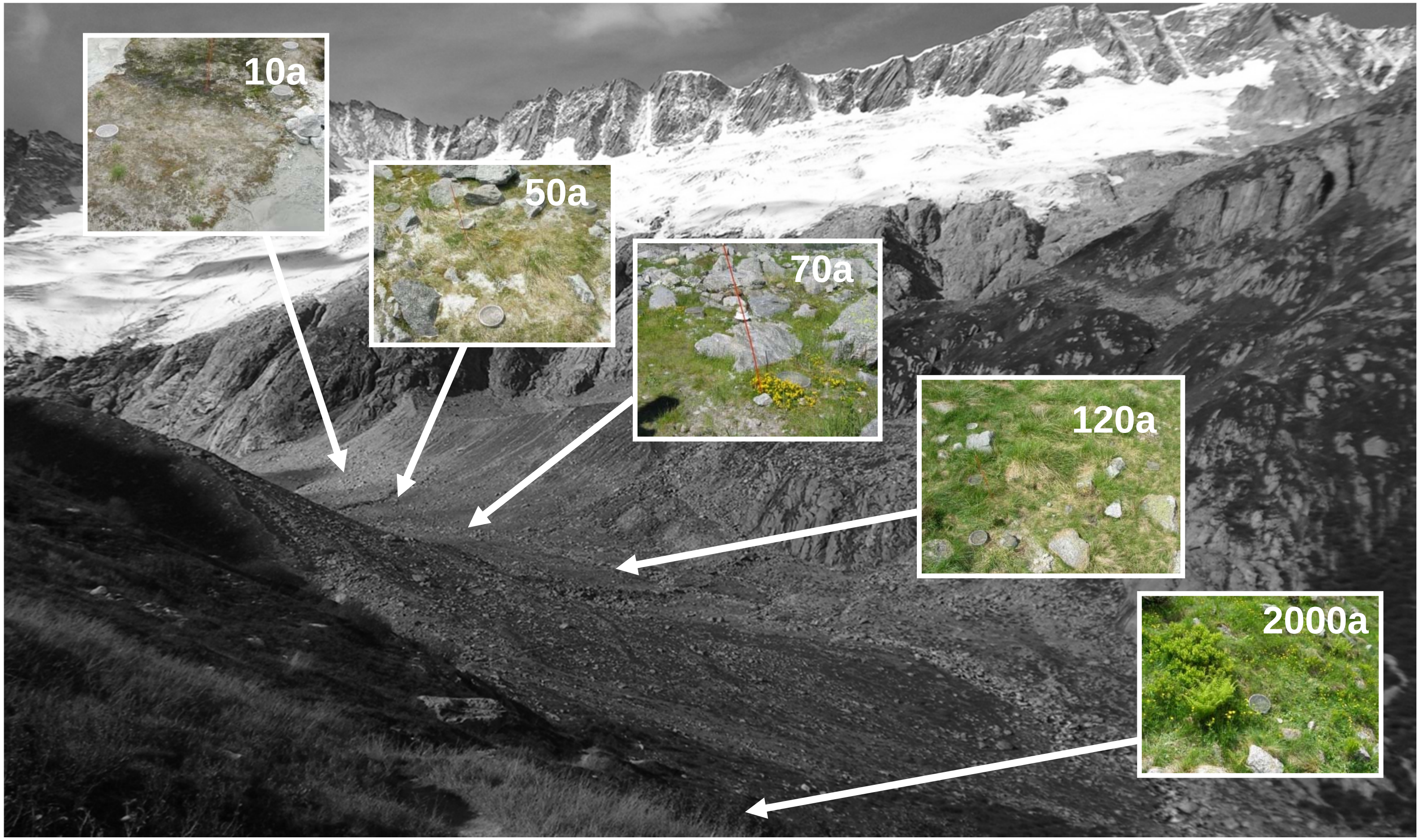
1. The Damma Glacier - A chronosequence approach

- glacier retreat since 1850, Damma glacier around 10 m a^{-1}

→ chronosequence of differently developed soils

1. The Damma Glacier - A chronosequence approach

- increasing plant coverage, microbial biomass



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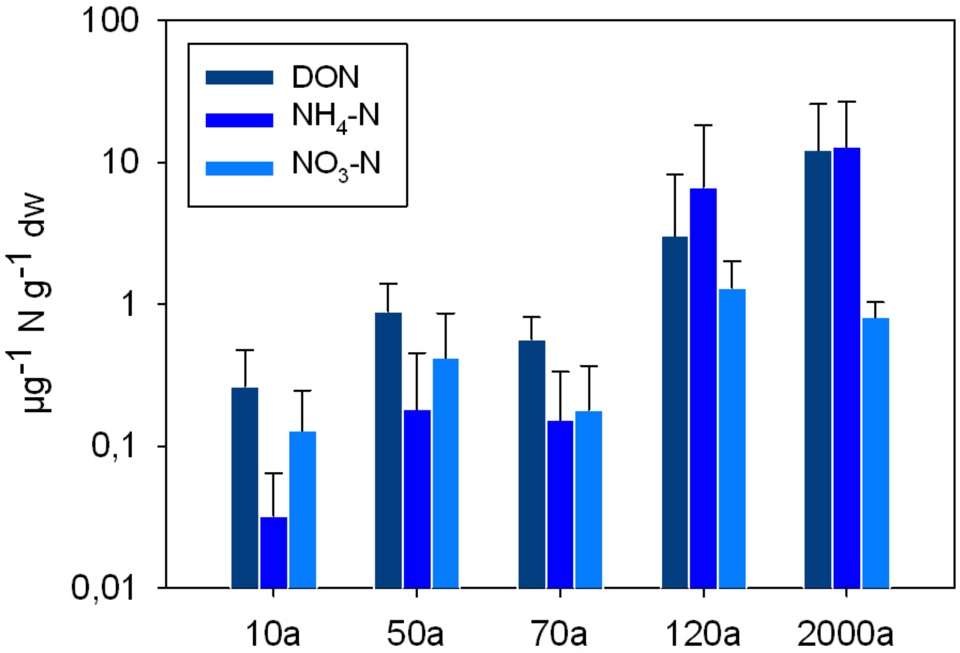
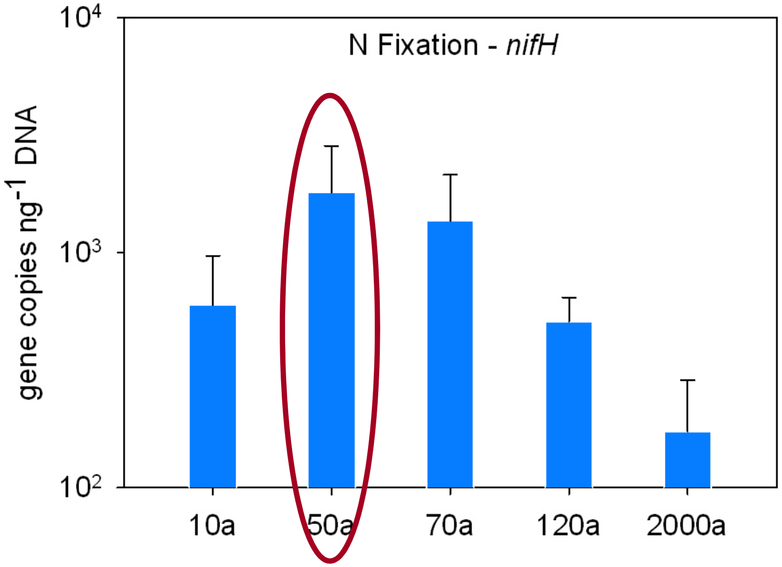


- N is lowest/rare at initial sites
- especially NH_4-N revealed 400-fold increase

→ N Fixation as an advantage?

1. The Damma Glacier - A chronosequence approach



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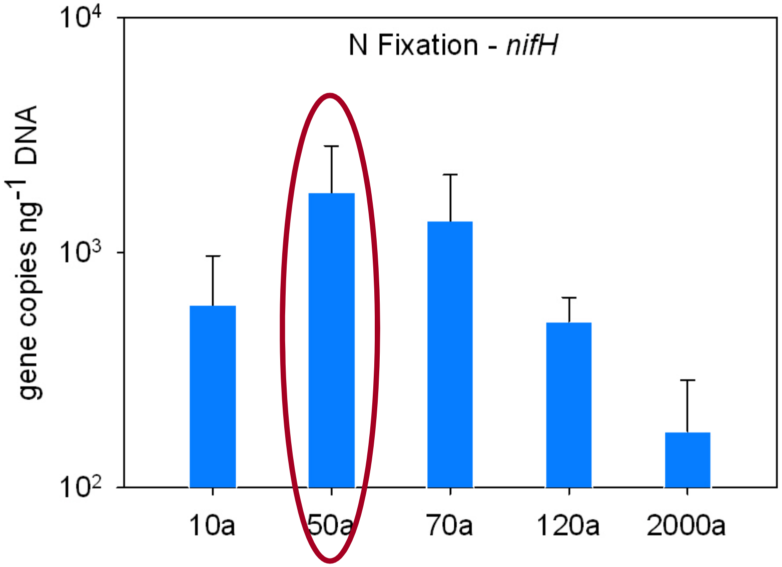
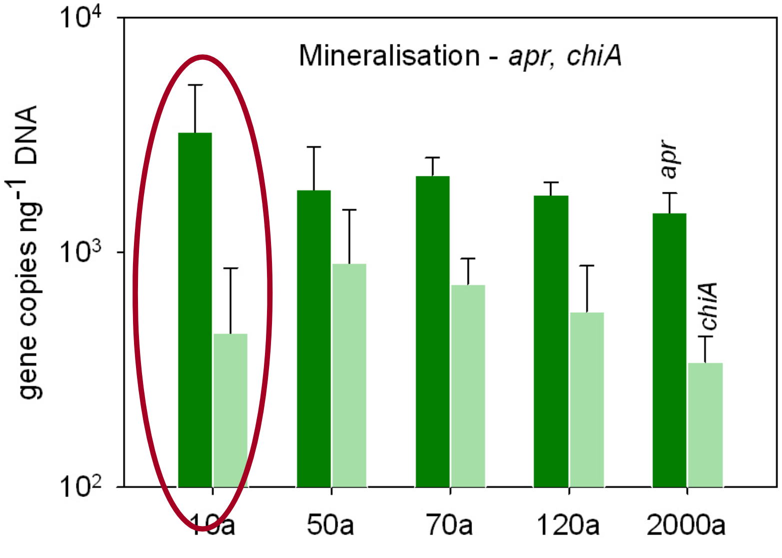


versus



1. The Damma Glacier - A chronosequence approach

Why do N fixers not dominate the initial phase?

1. N deposition:

- total : 10 - 15 kg N ha^{-1} a^{-1}
- organic : 0.63 kg N ha^{-1} a^{-1}

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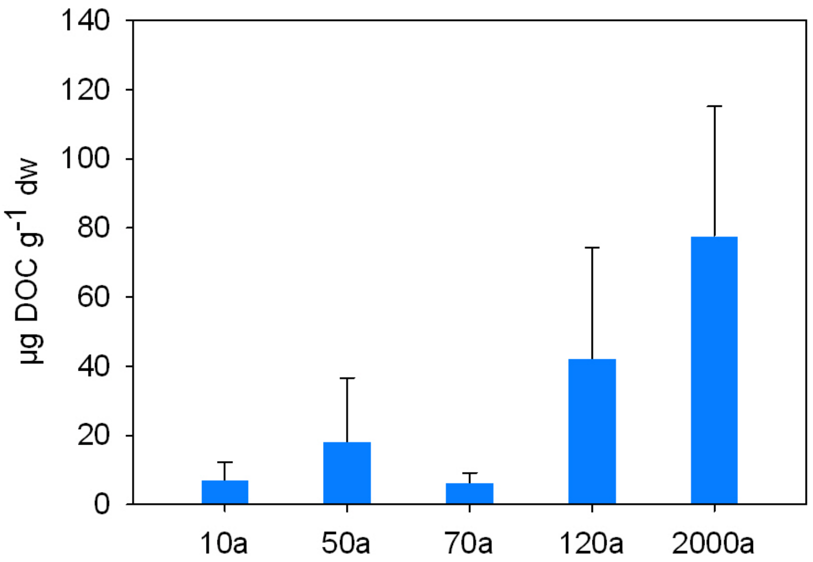
3. low amounts of DOC



2. Biological Soil Crusts – A hotspot of nitrogen turnover

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- gradient of different BSC development stages

→ soil stabilization, enhanced microbial activity…

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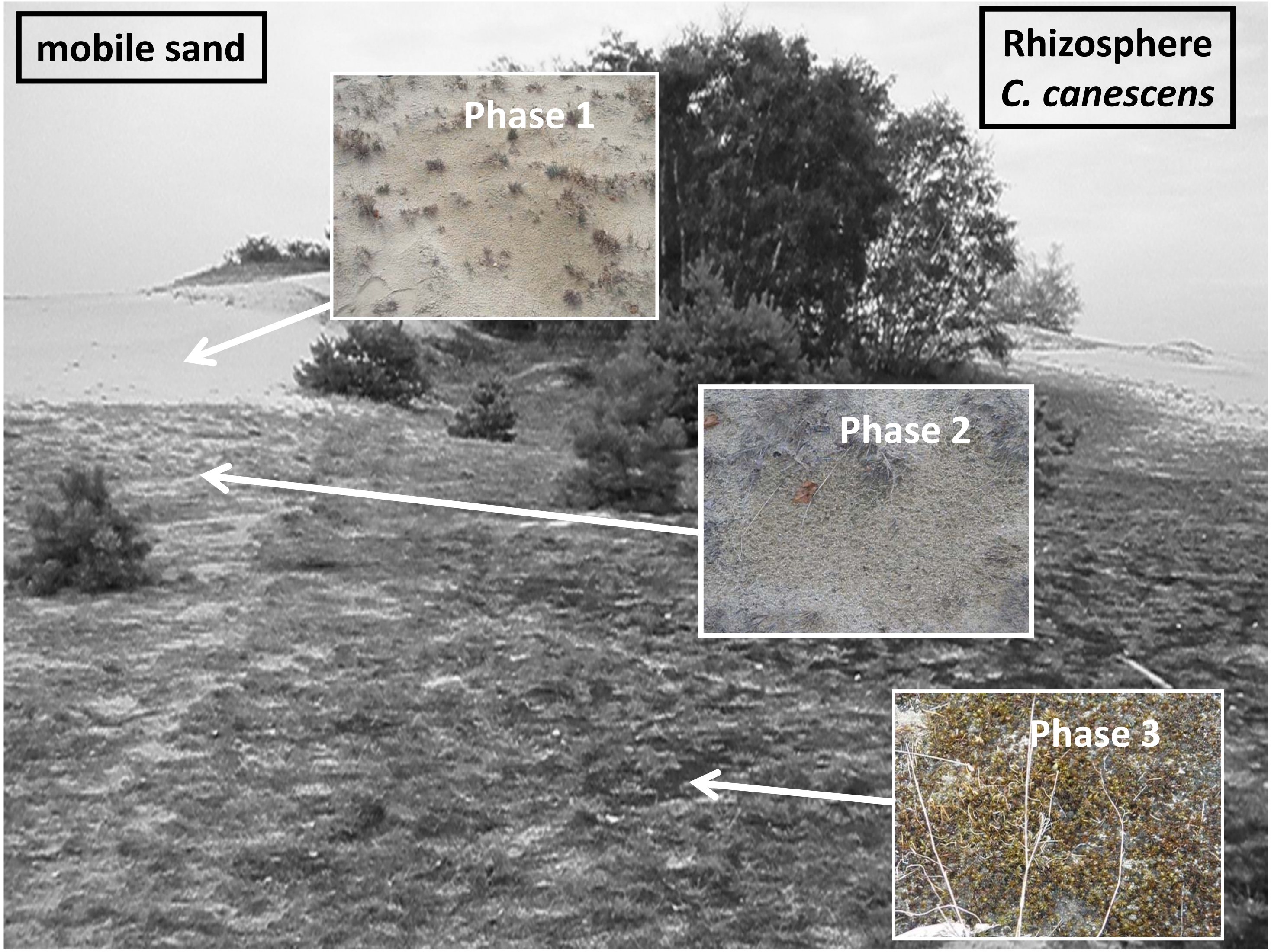

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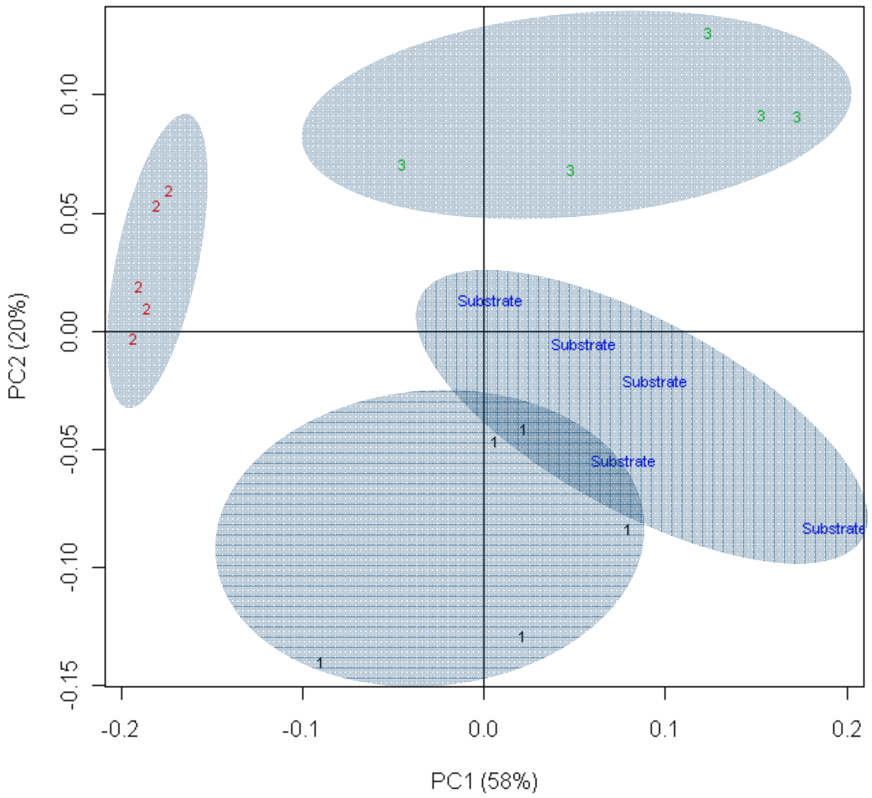

tRFLP of the 16S rRNA gene

Shift in the microbial community composition during BSC development

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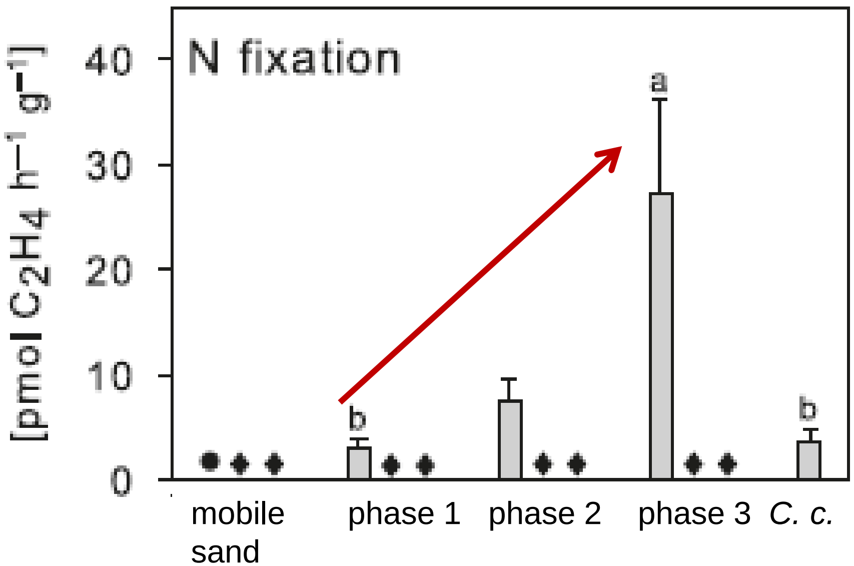
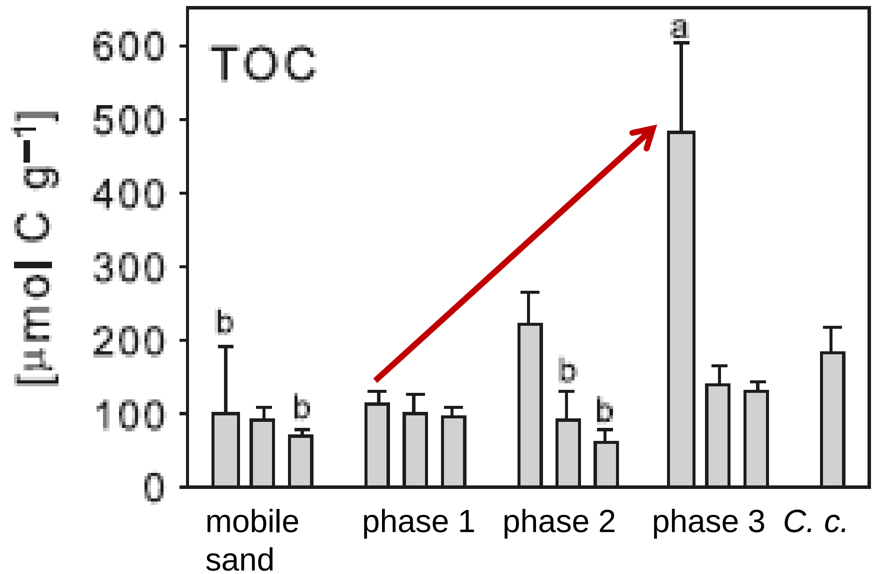
Functional or only structural?

2. Biological Soil Crusts – A hotspot of nitrogen turnover

? N fixing microbes?

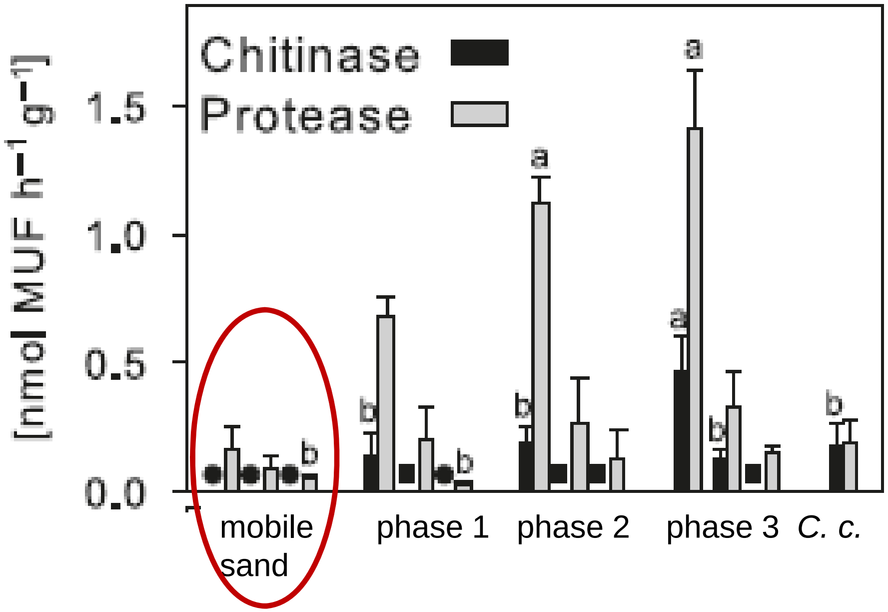




nitrogen fixation increases with carbon content, moss coverage and is absent in the mobile sand

3. Biological Soil Crusts – A hotspot of nitrogen turnover

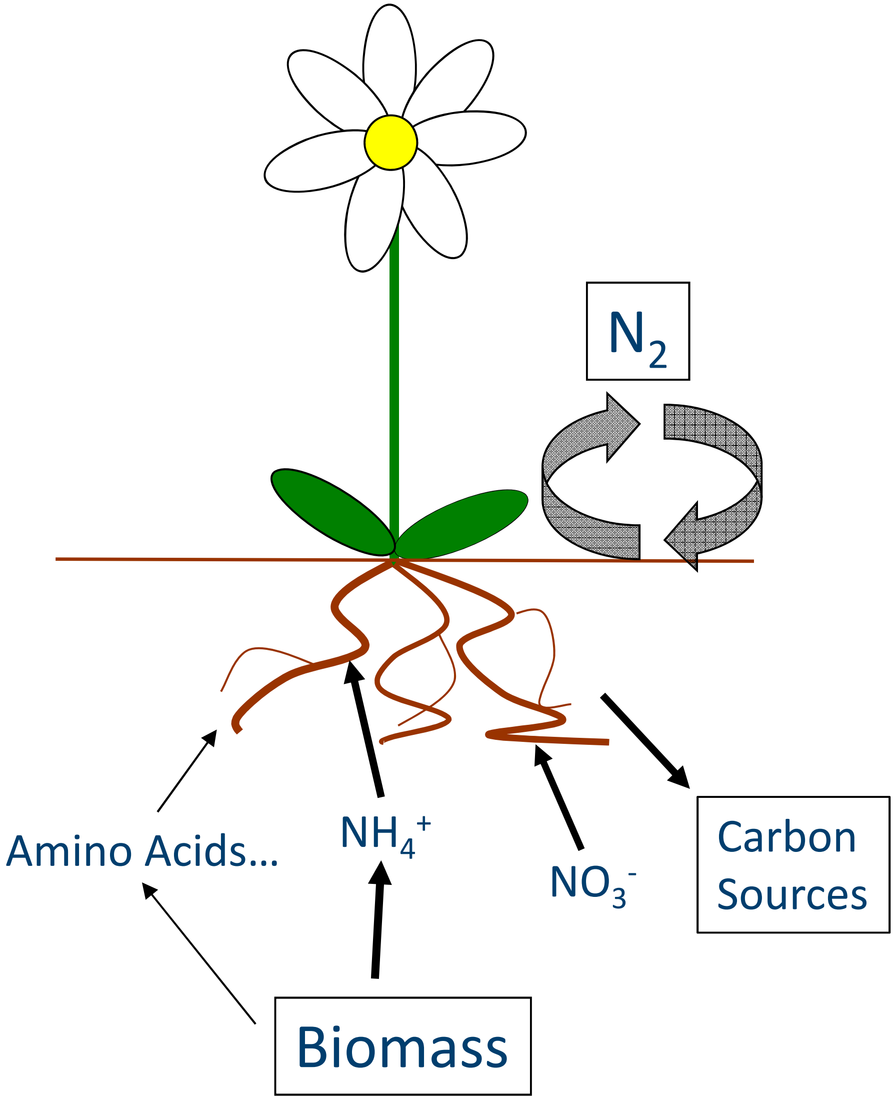
? mineralising microbes ?



- already detectable in the mobile sand

3. The role of plants for microbial N turnover

3. The role of plants



→ Plant delivers extra carbon

→ Microbes deliver N

→ but stronger competition about N for non-symbiotic microbes at initial sites

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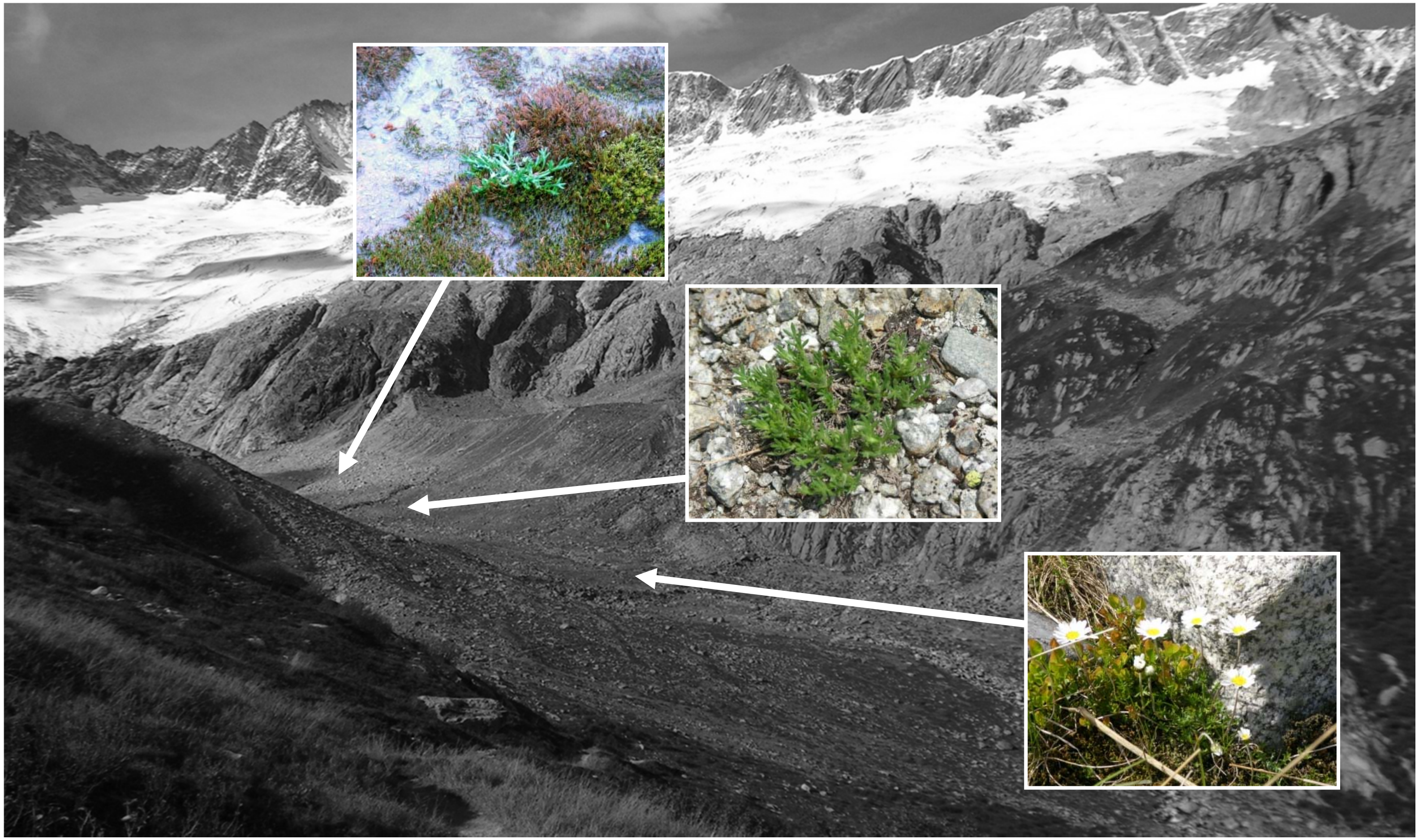
N fixing community increased with 1st plant patches

3. The role of plants – non legumes

- *Leucanthemopsis alpina* is distributed over the whole forefield



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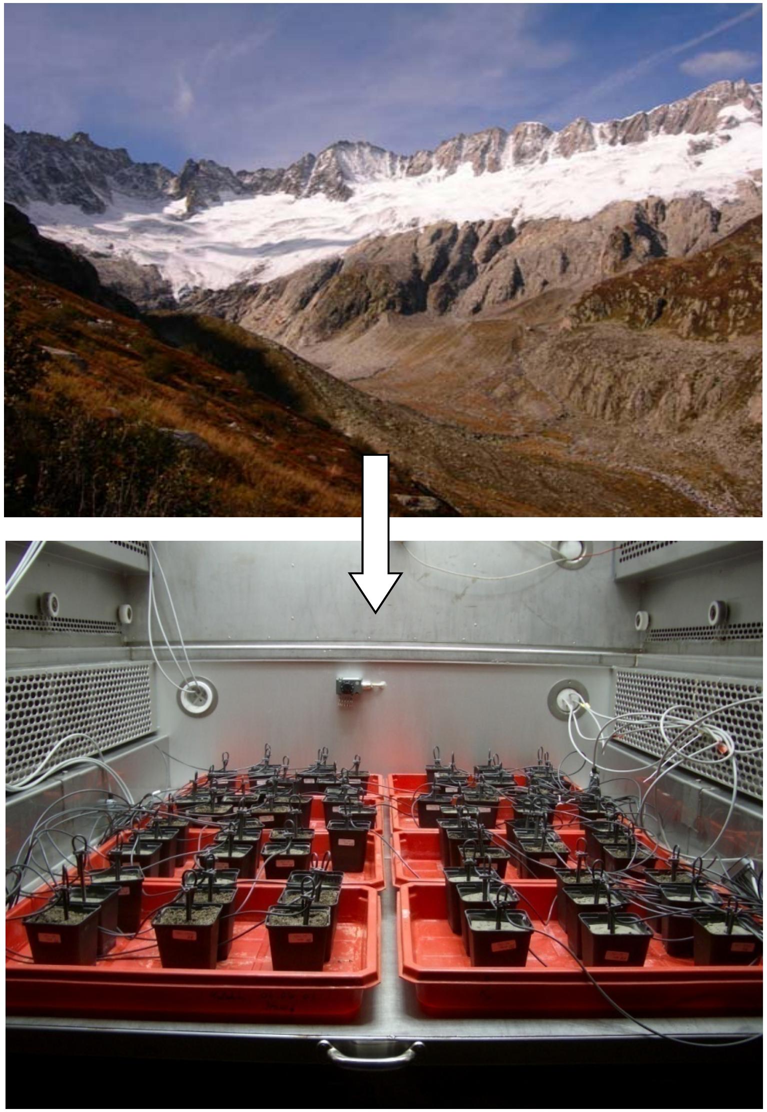


soil

10 years ice-free

120 years ice-free

incubation period

7 weeks (T1)

13 weeks (T2)

samples

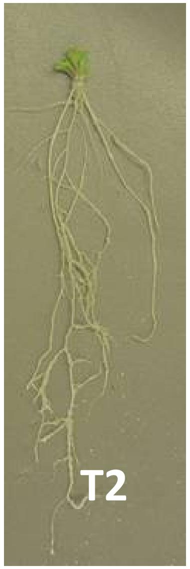
bulk soil

rhizosphere

3. The role of plants – non legumes

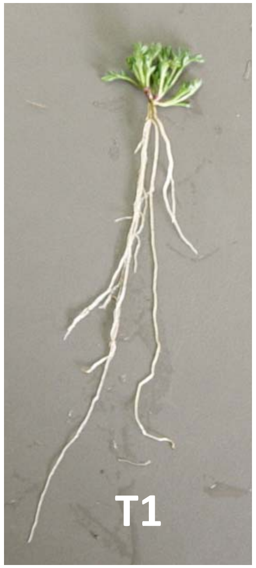
10a

x 2 →



- less changes in plant + root biomass at T1 and T2

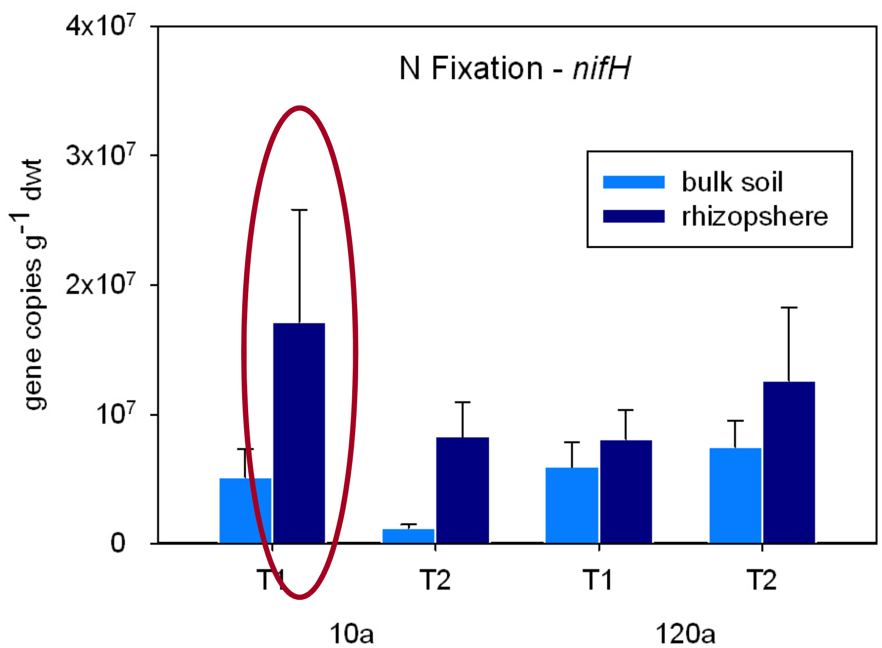
120a

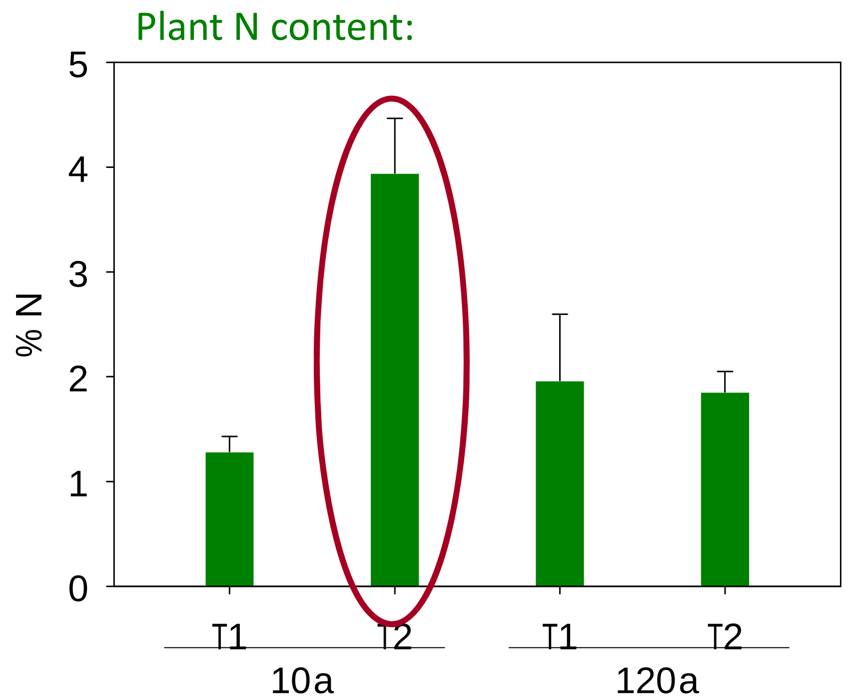


x 7 →

- strong increase of plant + root biomass

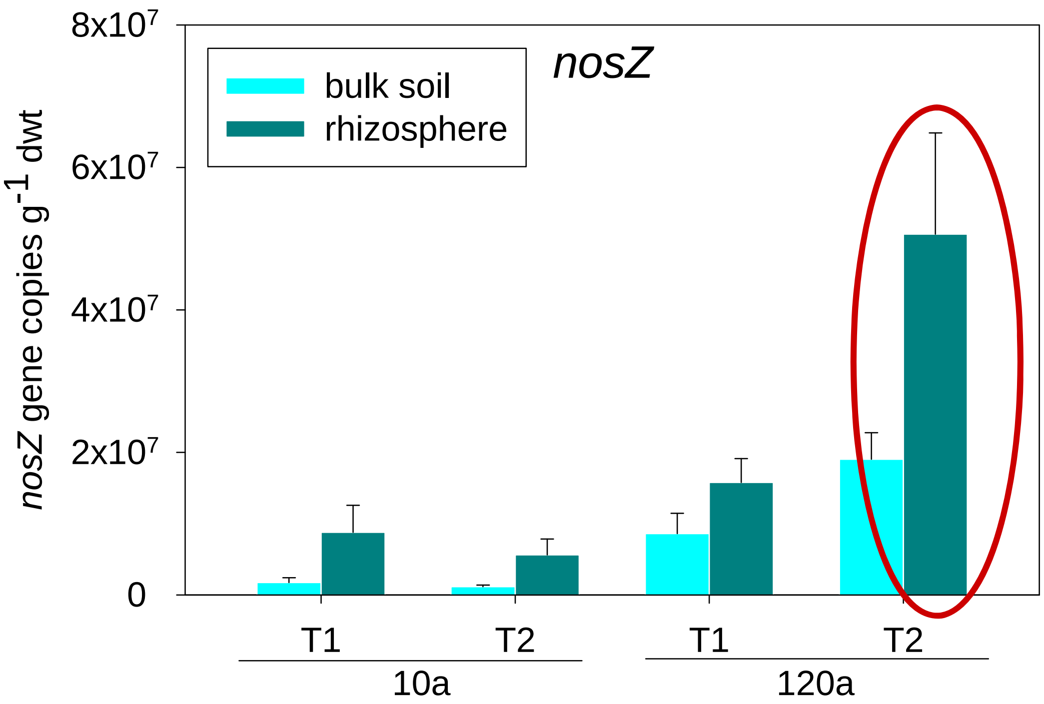
2. The role of plants – non legumes



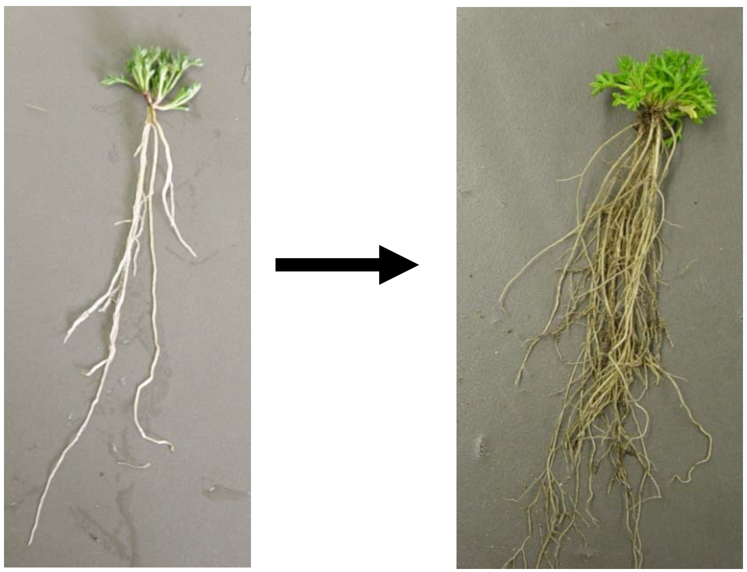


- strong rhizosphere effect in the 10a soil
- extra C boosted N fixing microbes

3. The role of plants – non legumes



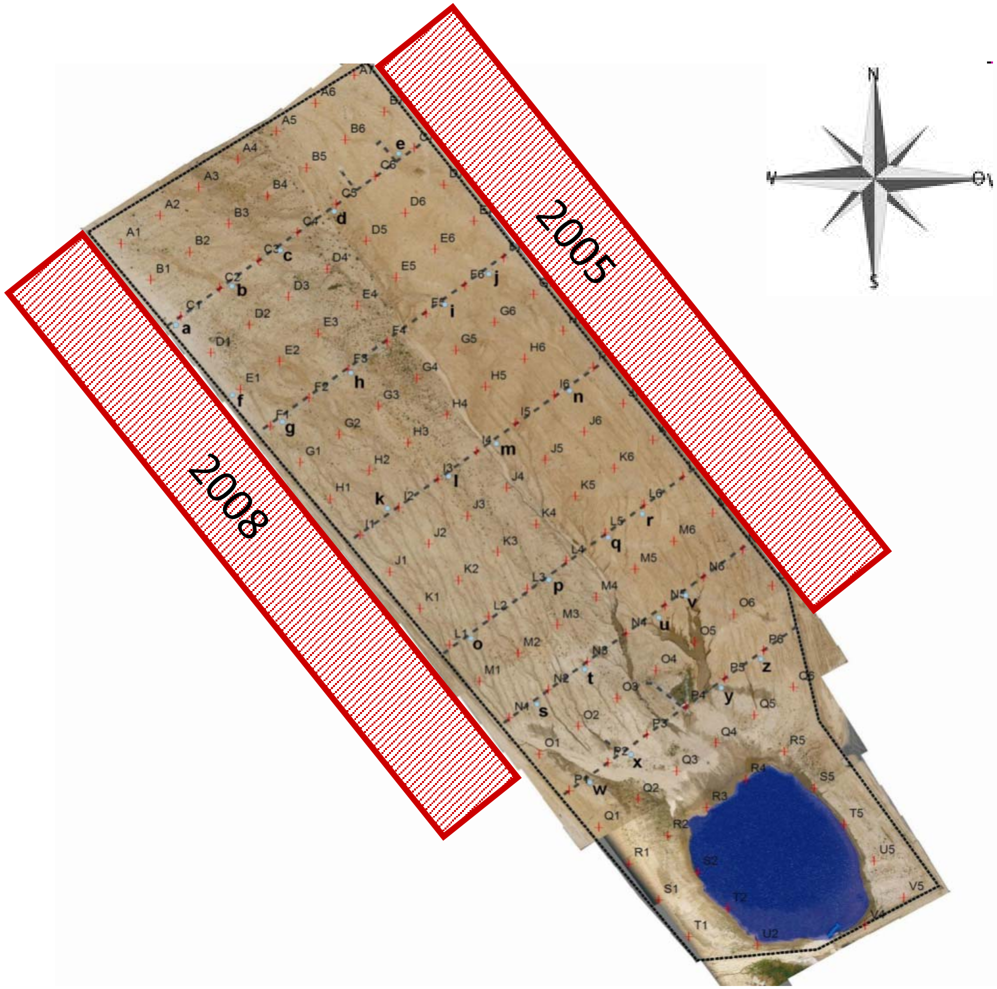
Denitrification



- lowest values in the 10a soil but strongest rhizosphere effect
- *nosZ* is boosted by: (i) decreasing partial oxygen pressure and
  (ii) higher C and NO_3^- availability in the pronounced root system

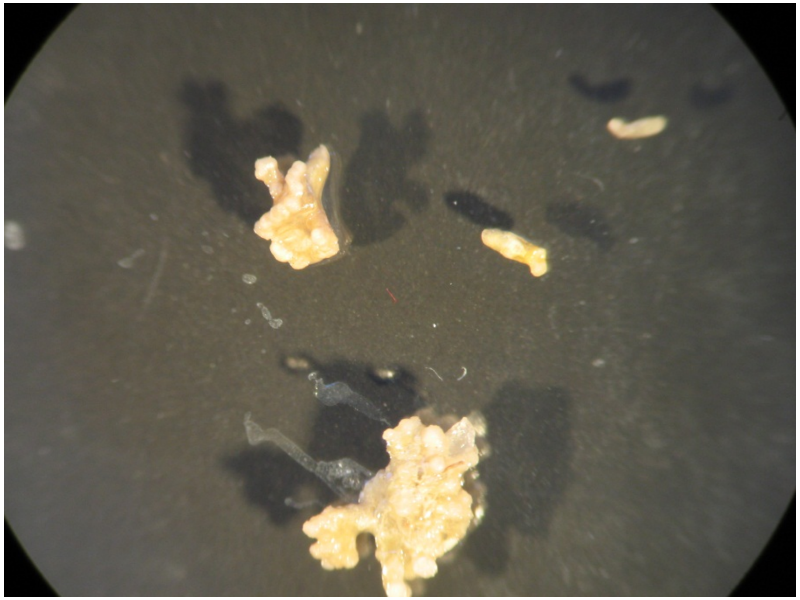
3. The role of plants - legumes

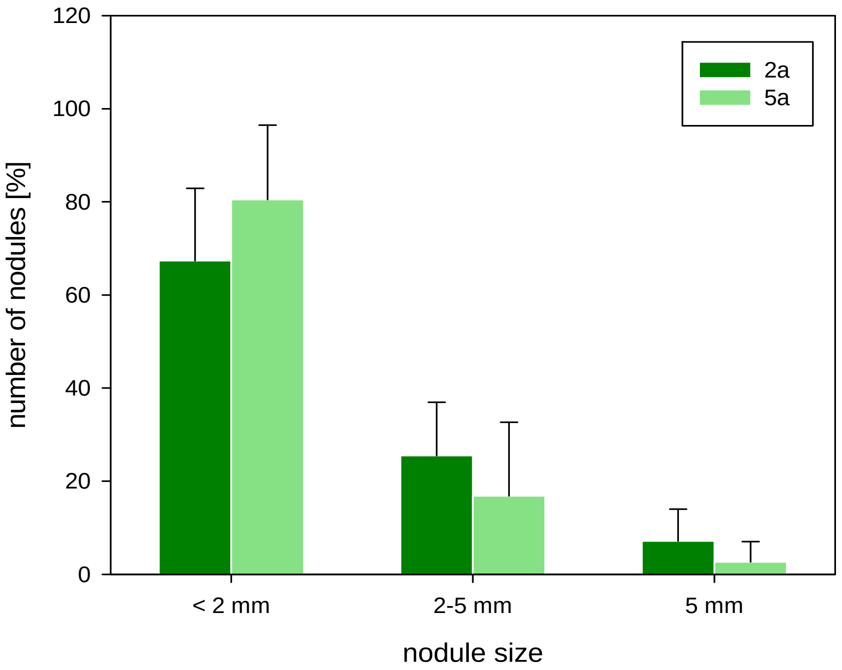
Chicken Creek



Trifolium arvense (L.) (Hasenklee)
+ *R. leguminosarum*

2. The role of plants - legumes





3 groups: < 2 mm

2-5 mm

> 5 mm

- small nodules are most abundant

2. The role of plants - legumes

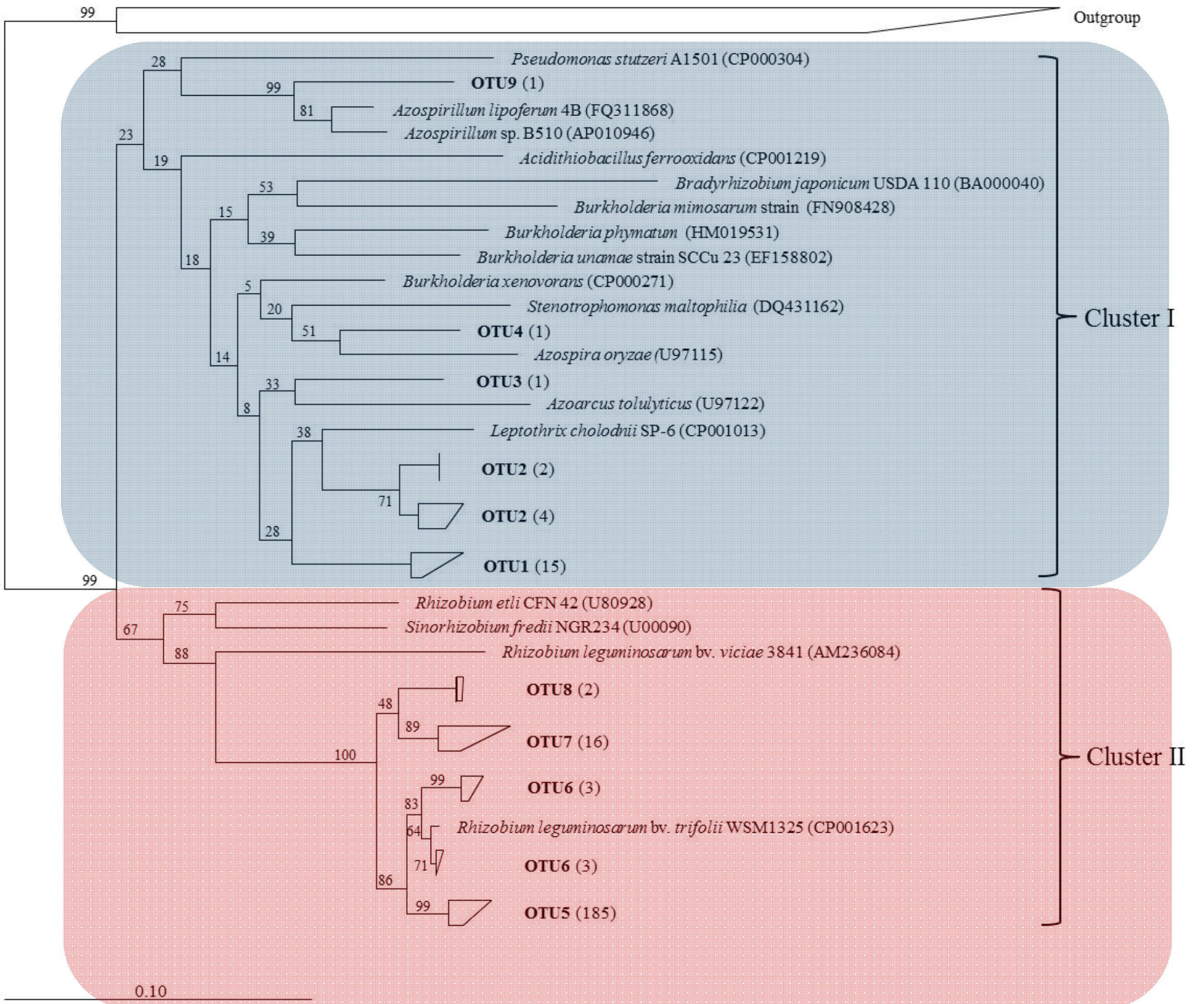
What's the difference between the different nodules?

Does nodule size matter?

↓

nifH gene clone libraries

3. The role of plants - legumes



- 24 clones
- 209 clones

2. The role of plants - legumes

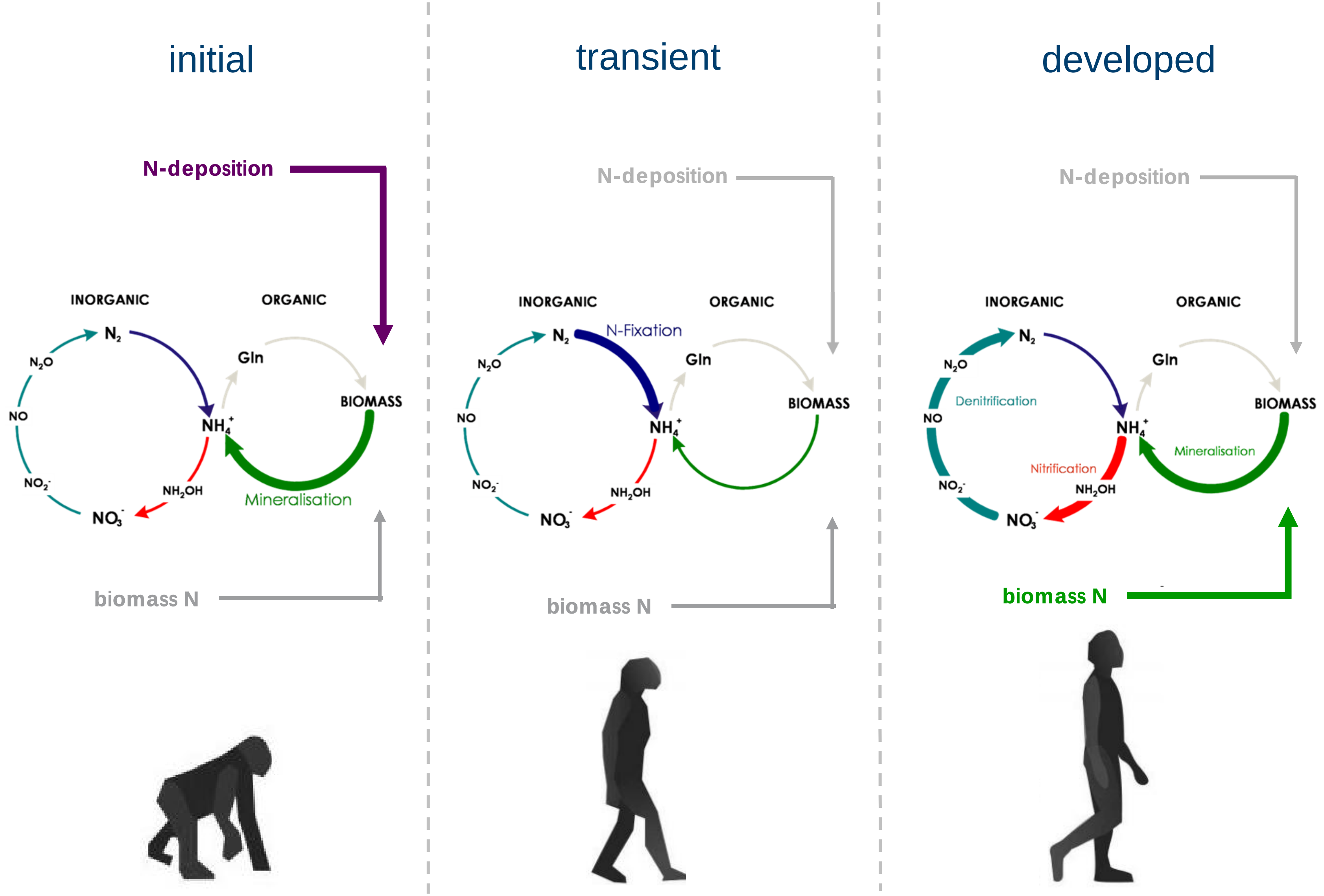
	number of sequences			
OTU (97% similarity)	**2a small**	**2a medium**	**5a small**	**5a medium**
1	13	2		
2			6	
3			1	
4				1
5	15	74	19	77
6			6	
7	9	1	6	
8			2	
9				1

- medium nodules are mainly composed of *R. leguminosarum*

- small nodules from 5a site higher proportion of *R. leguminosarum* clones (24 vs. 33)

→ significant impact of soil age ($p = 0.048$)

Final Conclusion



Many thanks to…