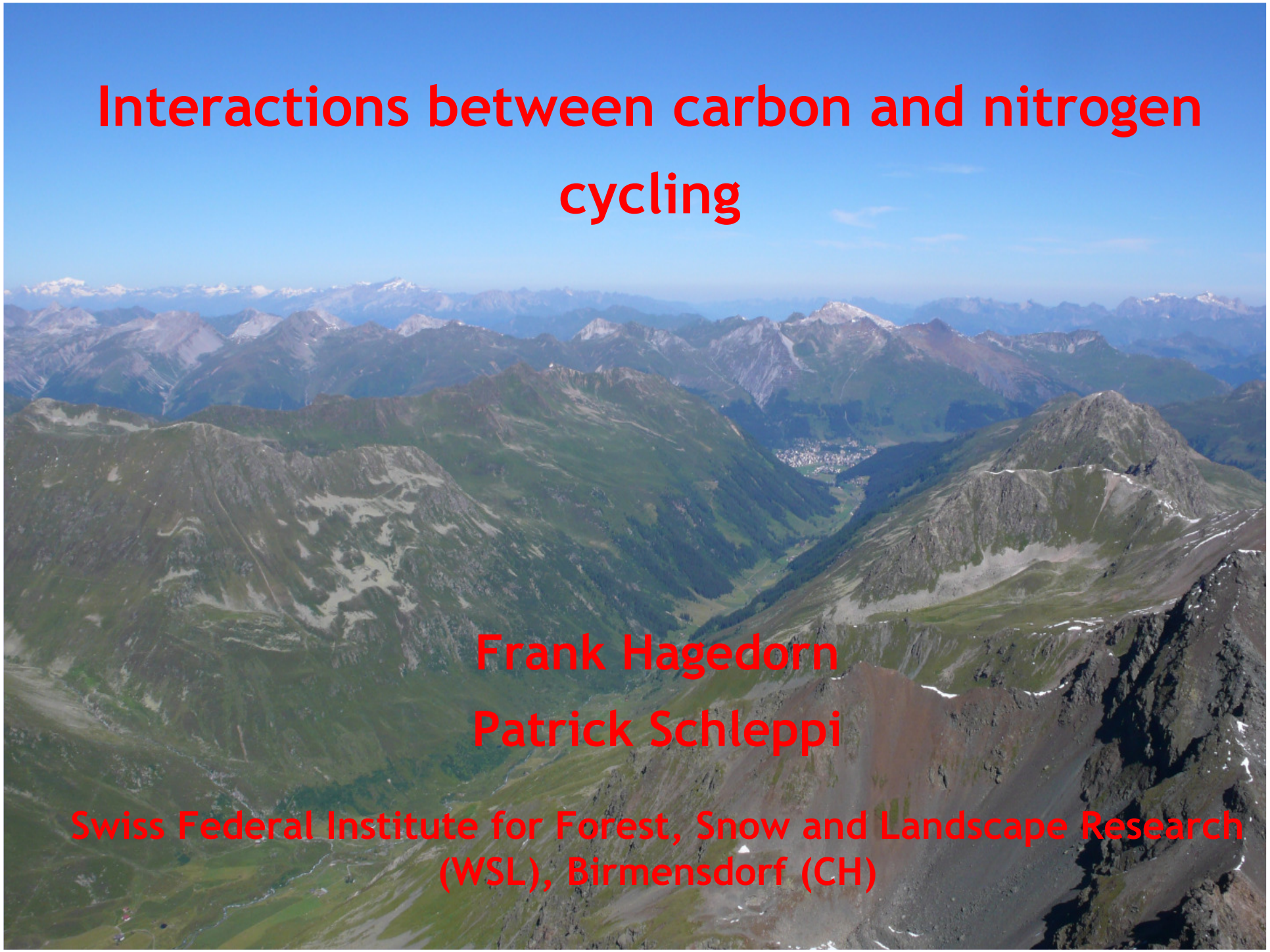
Interactions between carbon and nitrogen cycling



Frank Hagedorn

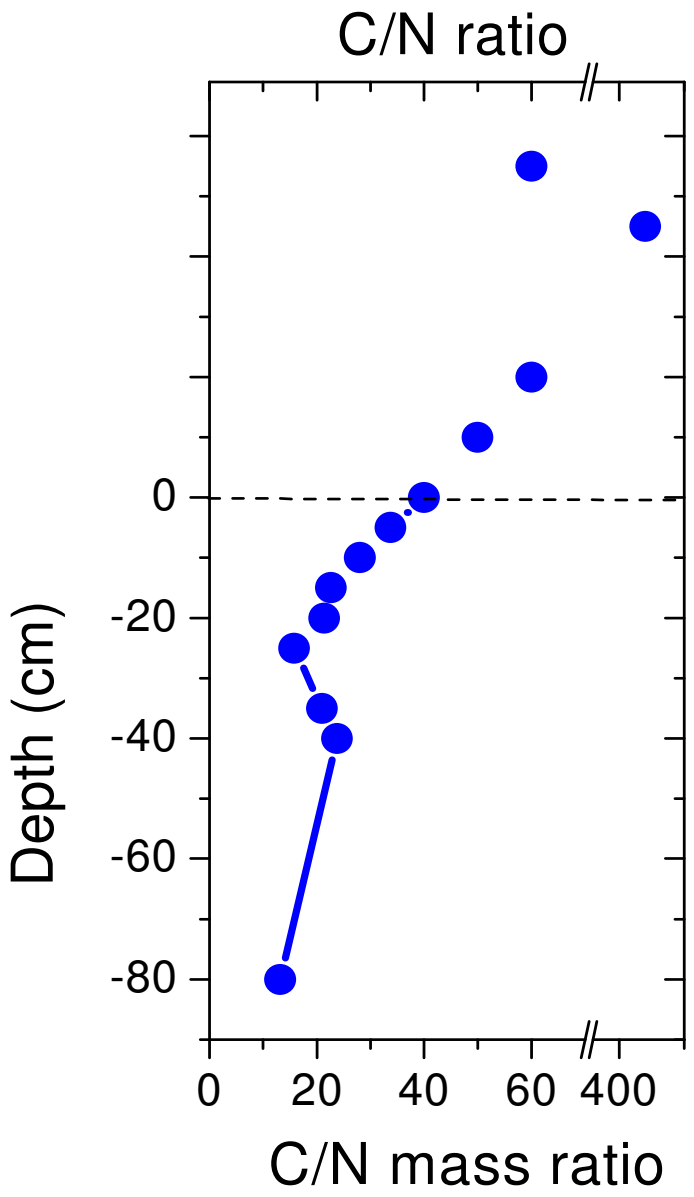
Patrick Schleppi

Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf (CH)

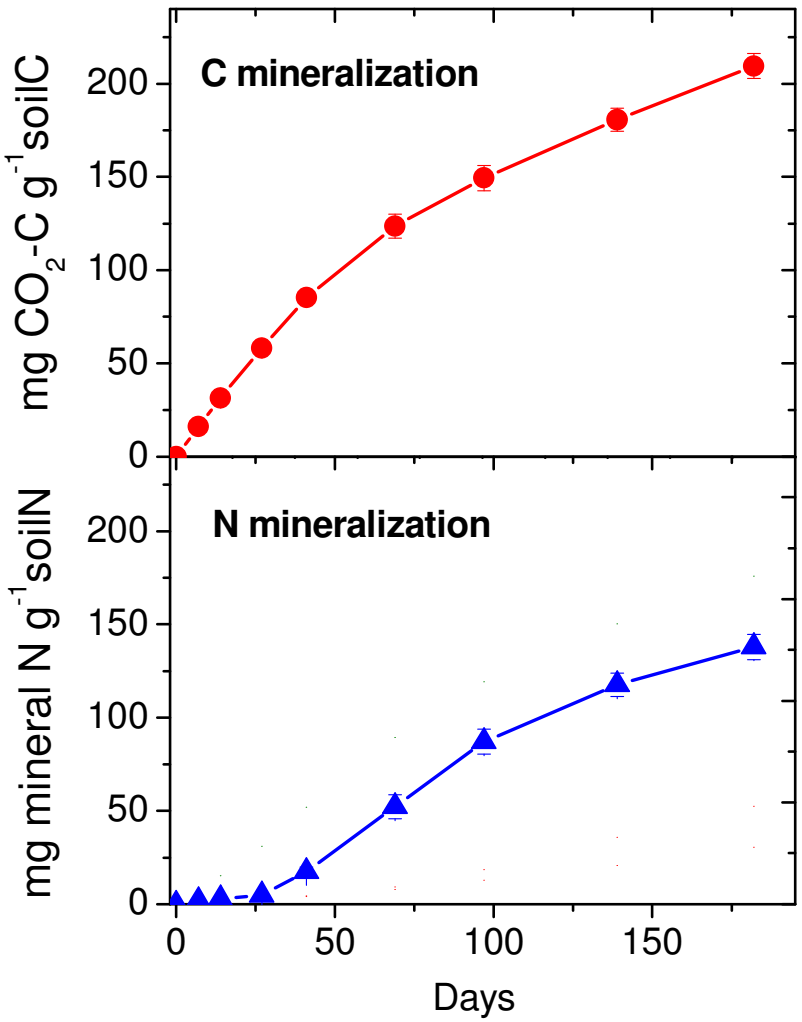
Outline

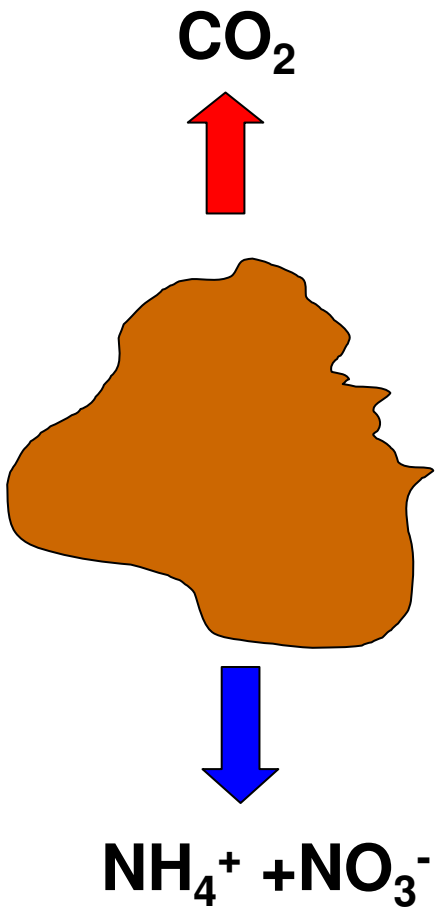
1. Coupling of C and N cycling
2. N deposition effects on C cycling
3. Feedbacks between increasing atmospheric CO_2 and N cycling

Linkage of C and N cycling



C and N mineralization

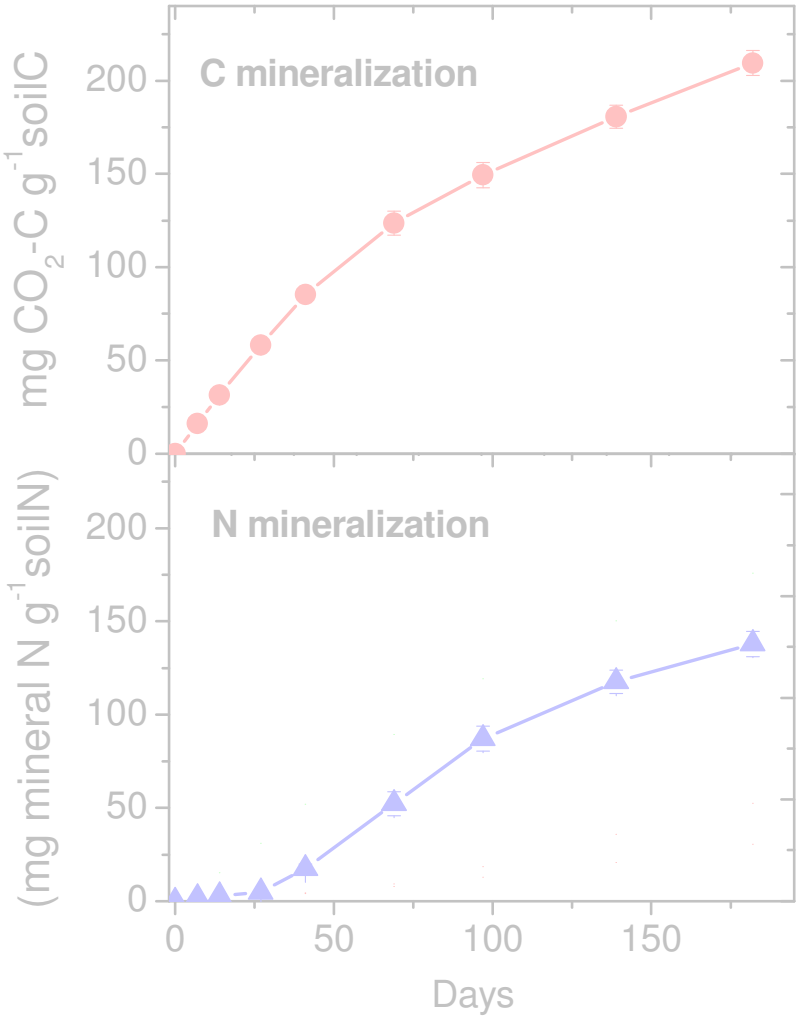


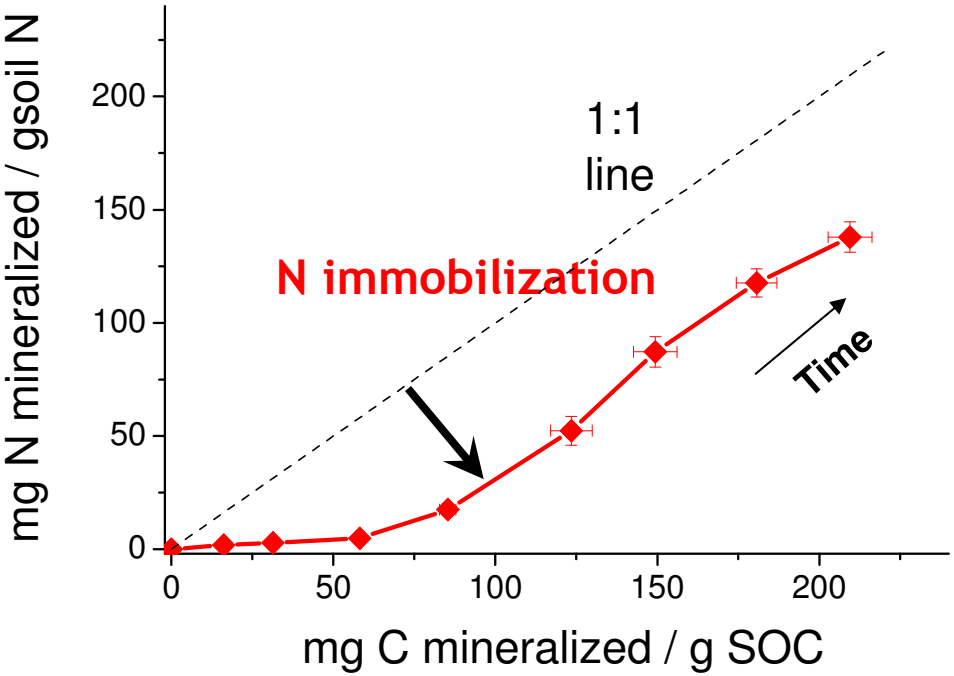


Organic layer - treeline

Kammer et al. (2009): GCB 15

C and N mineralization



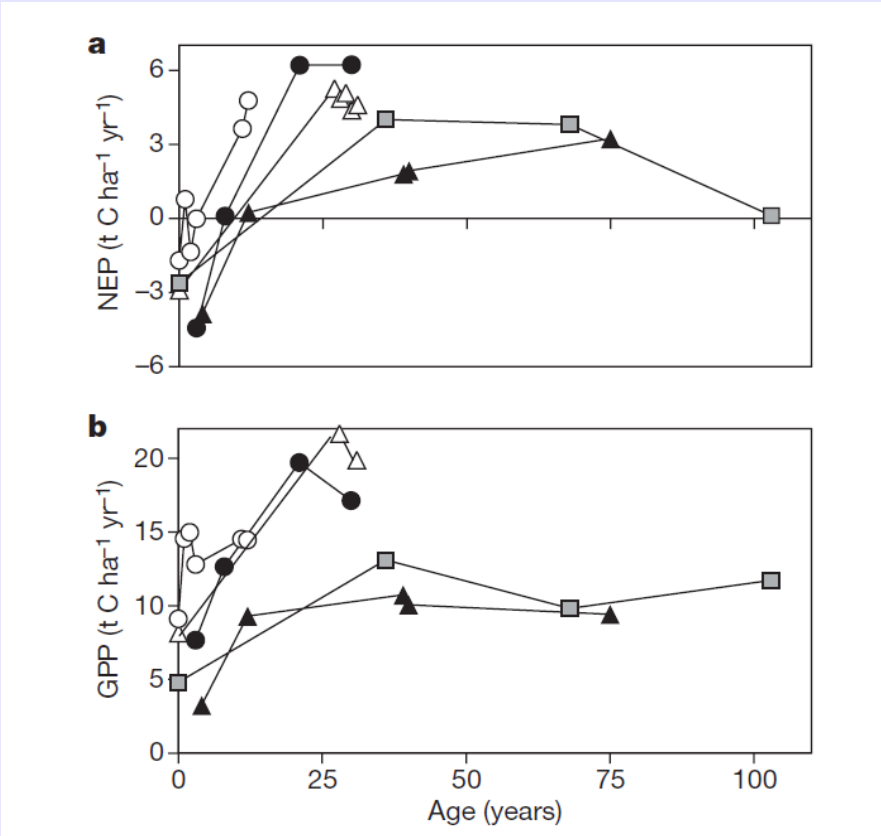


Organic layer - treeline

Kammer et al. (2009): GCB

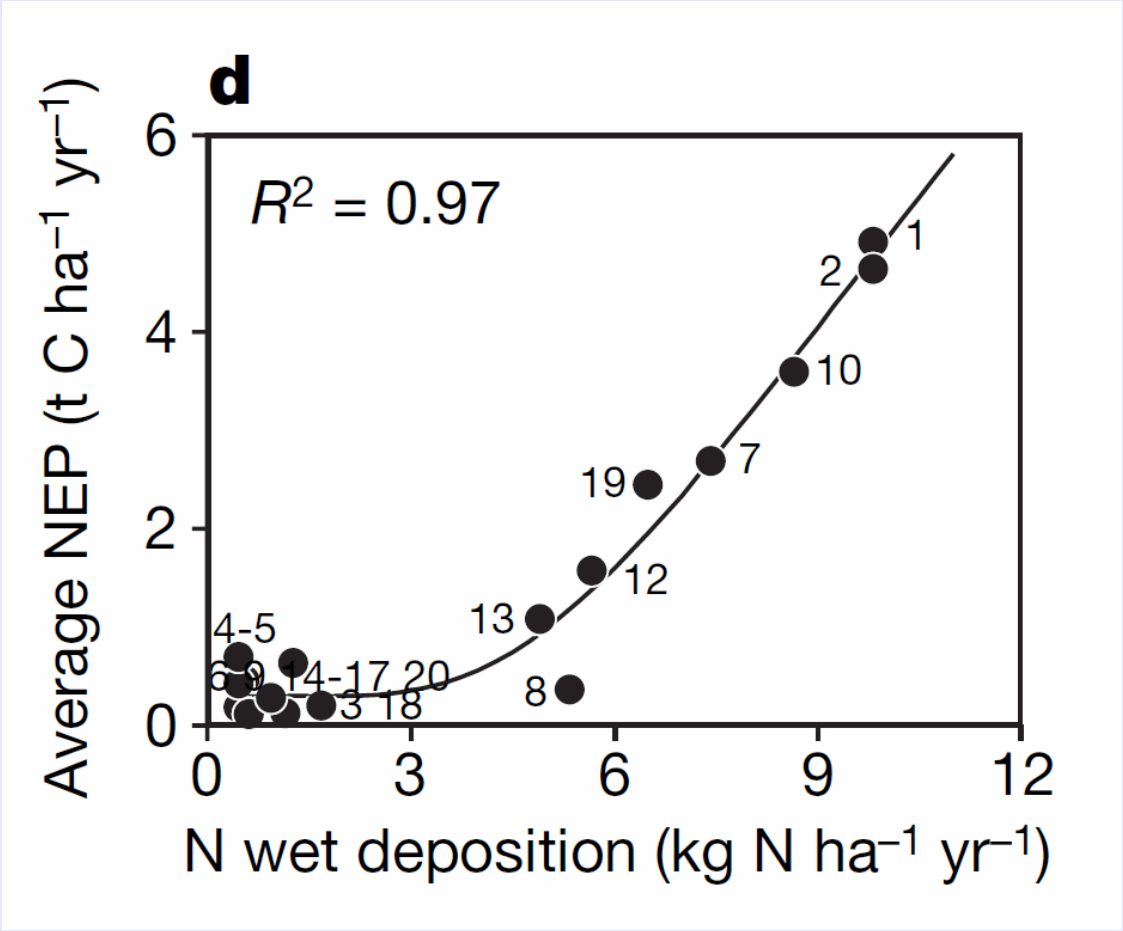
N Deposition effects on C sequestration

Magnani et al. (2007): Net C uptake (eddy covariance) along N deposition gradient across Europe



NATURE | Vol 447 | 14 June 2007

N Deposition effects on C sequestration



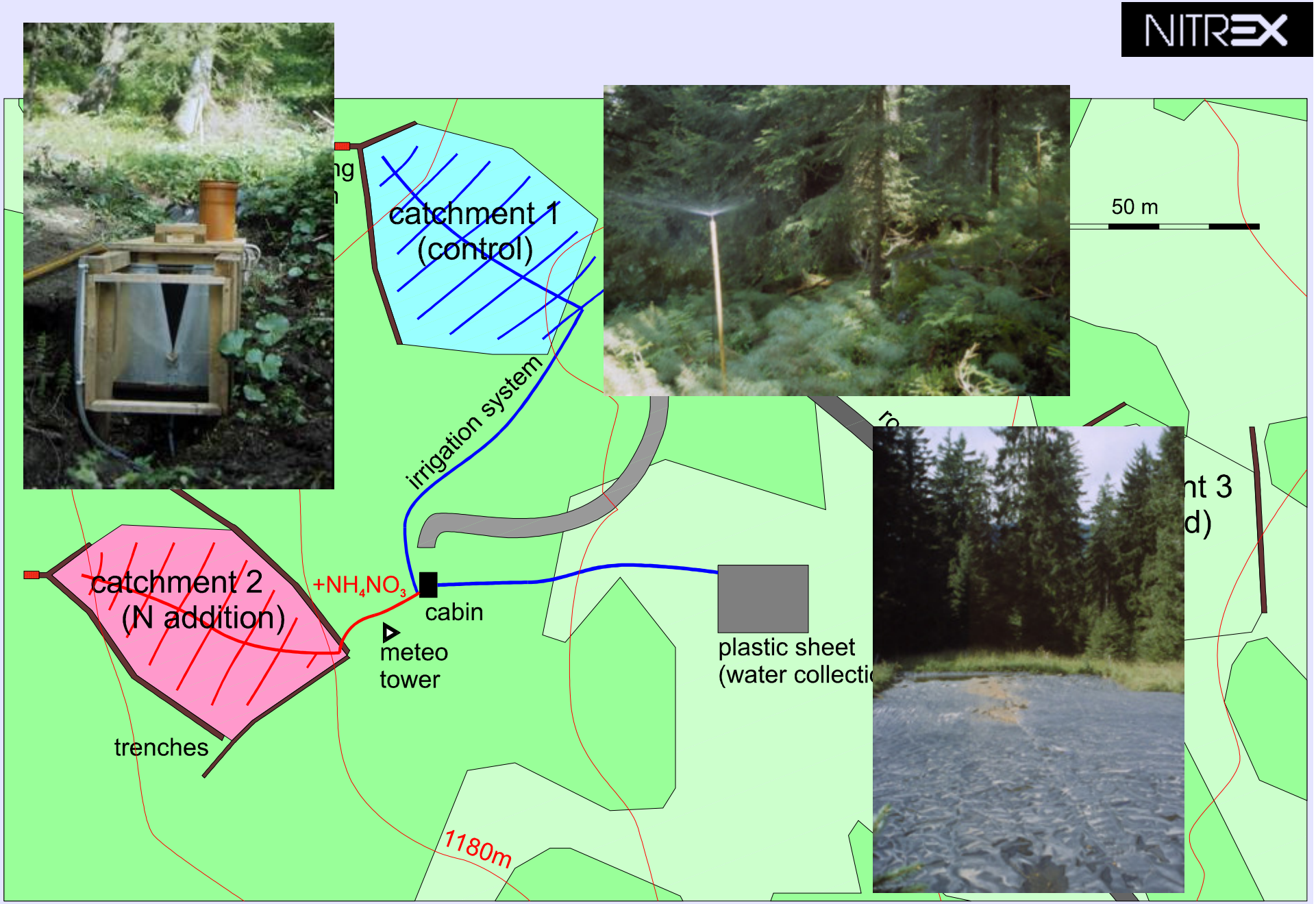
NATURE|Vol 447|14 June 2007

→450 kg C per kg N wet deposition

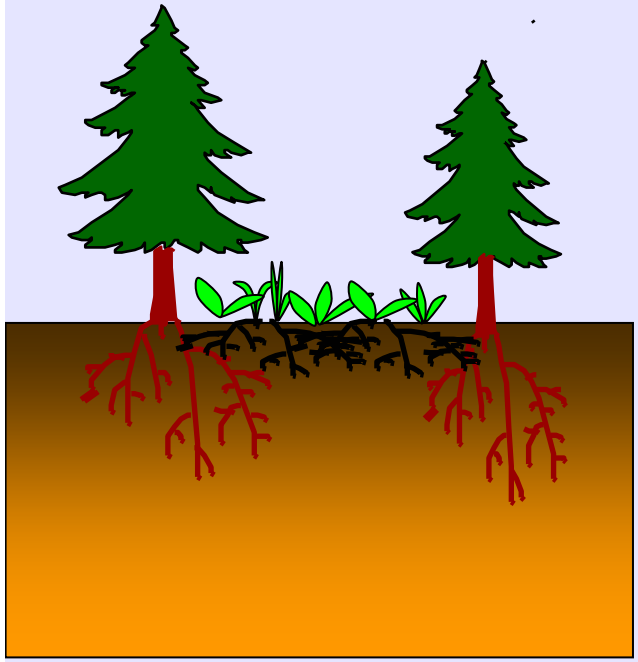
→ 200-400 kg C per kg N total deposition

→ 20 € per kg N

Tracing ^{15}N into C-pools of a subalpine forest


NITREX
catchment 1
(control)
irrigation system
50 m
catchment 2
(N addition)
+NH4NO3
cabin
meteo
tower
plastic sheet
trenches
1180m

Fate of ^{15}N in forest ecosytems

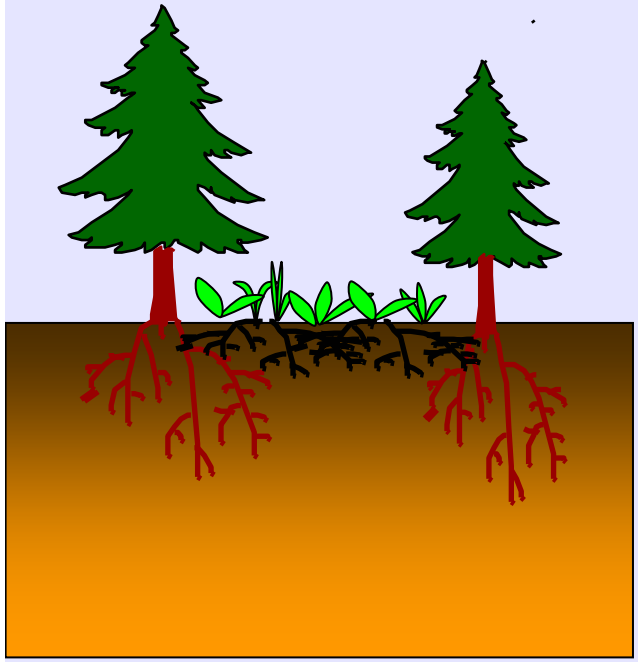


After 7 years		9 forest ^{15}N studies
Trees:	13%	5% wood, 15% non-woody
Ground vegetation:	5%	5%
Litter + Roots:	13%	13%
Soil:	60%	70%
Leaching:	10%	10%

Schleppi et al. (2004): WASP

Nadelhoffer et al. (1999): Nature

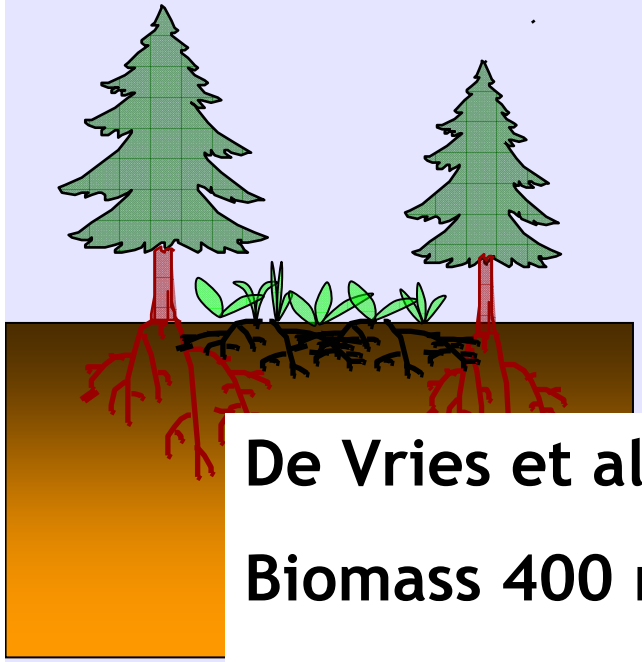
Sequestration of C per unit N



		C/N
Trees:	13%	200
Ground vegetation:	5%	50
Litter + Roots:	13%	50
Soil:	60%	18
Leaching:	10%	0

< 70 g C/g N

Sequestration of C per unit N



< 70 g C/g N

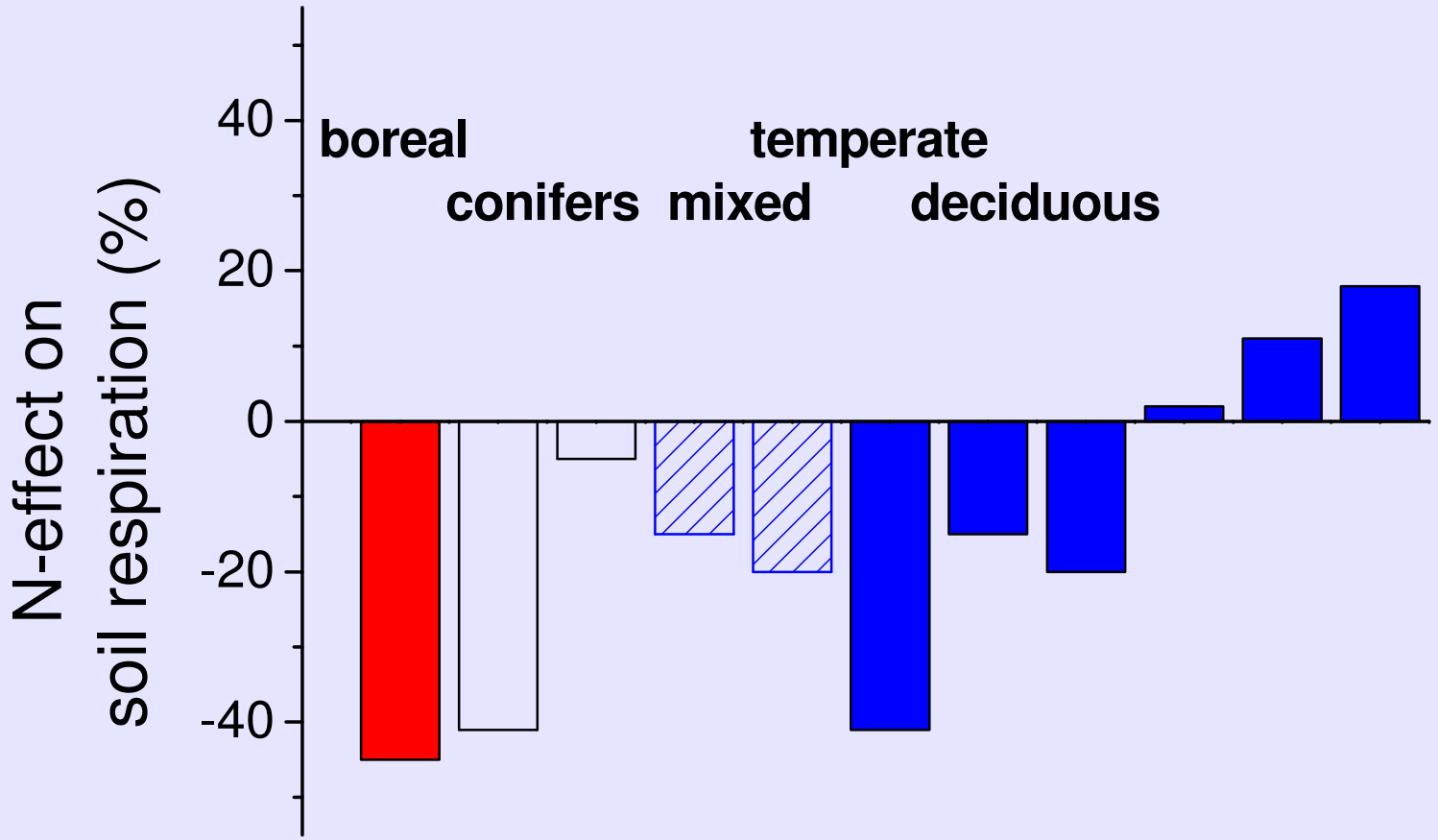
De Vries et al. (2008), Nature:

Biomass 400 monitoring forest plots: 20-40 g C/gN

Hyvönen et al (2008). BIOG:

Long-term N fertilization 15 sites: 20-50 g C/g N

N Deposition decreases soil respiration



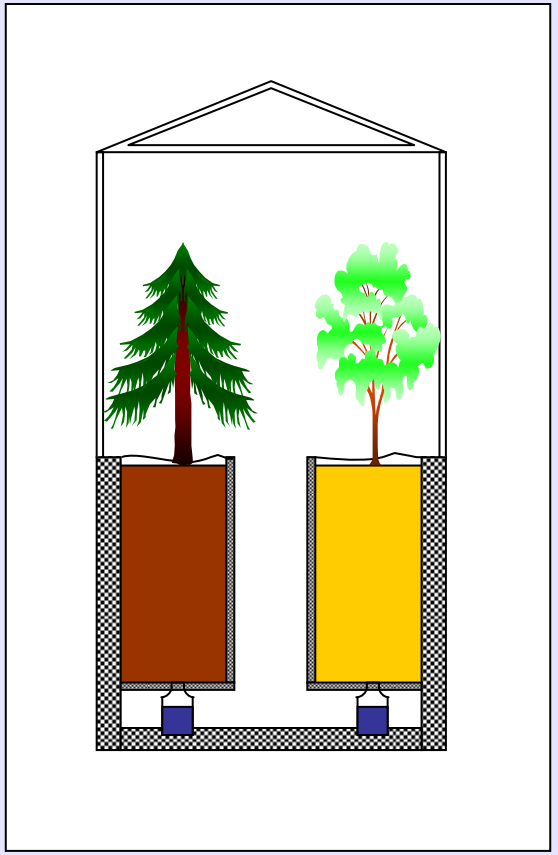
Brumme & Beese (1992; Gallardo & Schlesinger (1994); Spinnler et al. (2002): Trees; Bowden et al.(2004): FEM; Burton et al. (2004) GCB; Olsson et al. (2005): GCB; Swanston et al. (2004): BIOG; Kammer (unpubl.); Hutzler (unpubl.)

N Deposition decreases soil respiration

Potential reasons

- Reduced root respiration
- Decreased litter decomposition
- Suppressed mineralization of old SOM

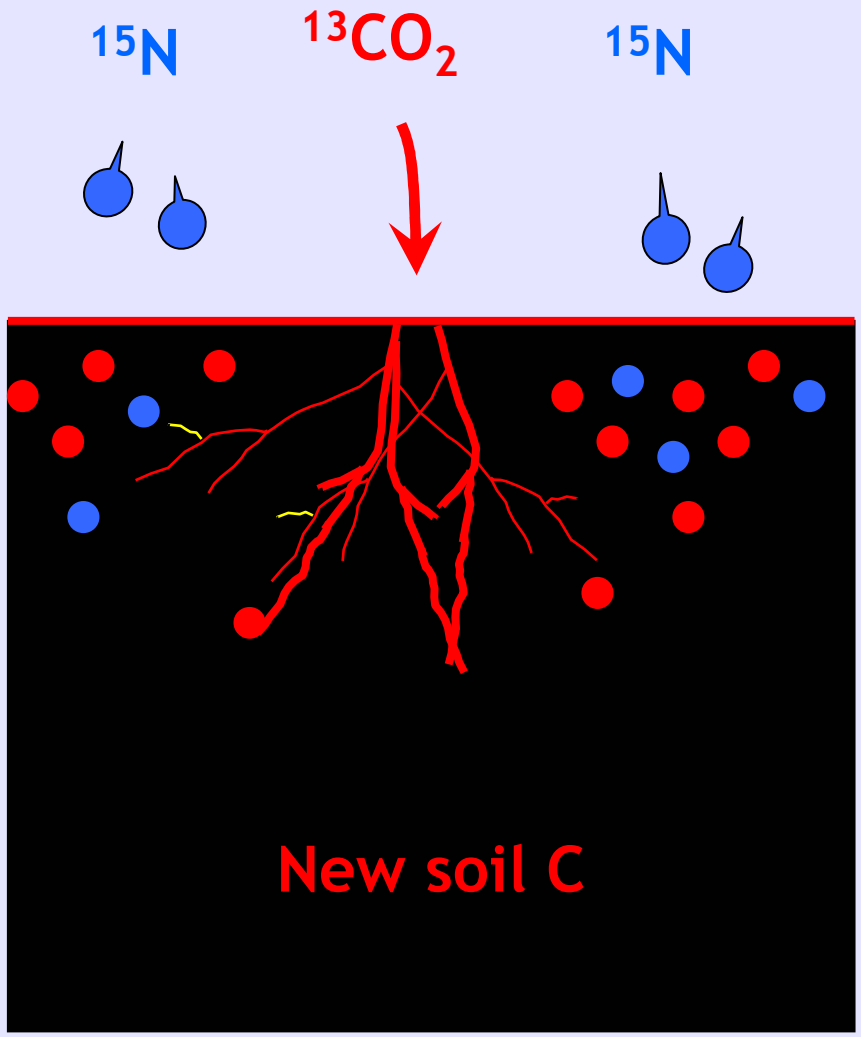
N deposition and $^{13}CO_2$ enrichment experiment



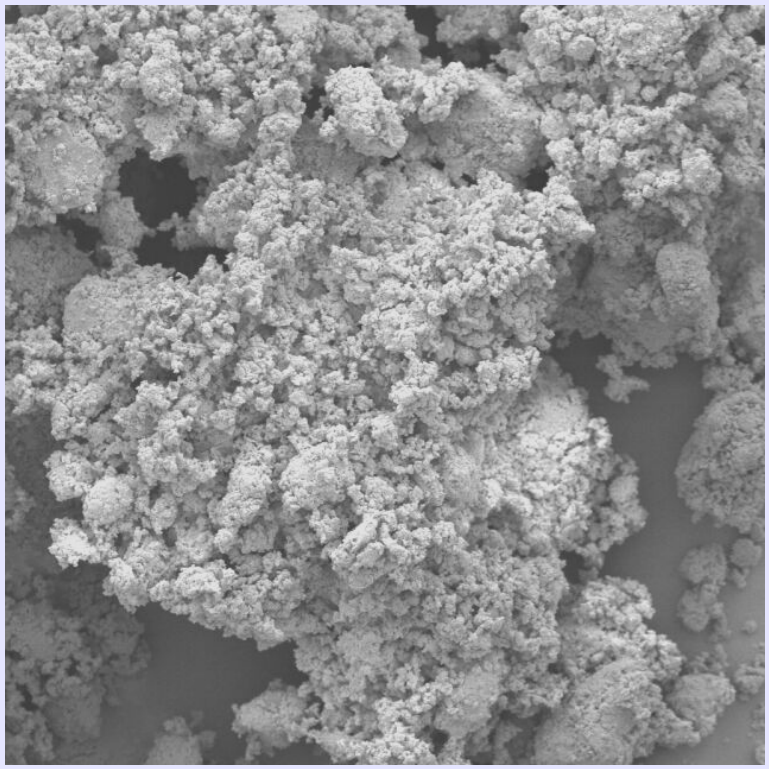
Beech-spruce systems on two soils
+ 70 kg N $ha^{-1}y^{-1}$
+ 200 ppm_v CO_2

total n = 32

Tracing new C and N into SOM



Tracing ^{15}N into soil fractions



Sand fraction

C/N: 55

Turnover: high

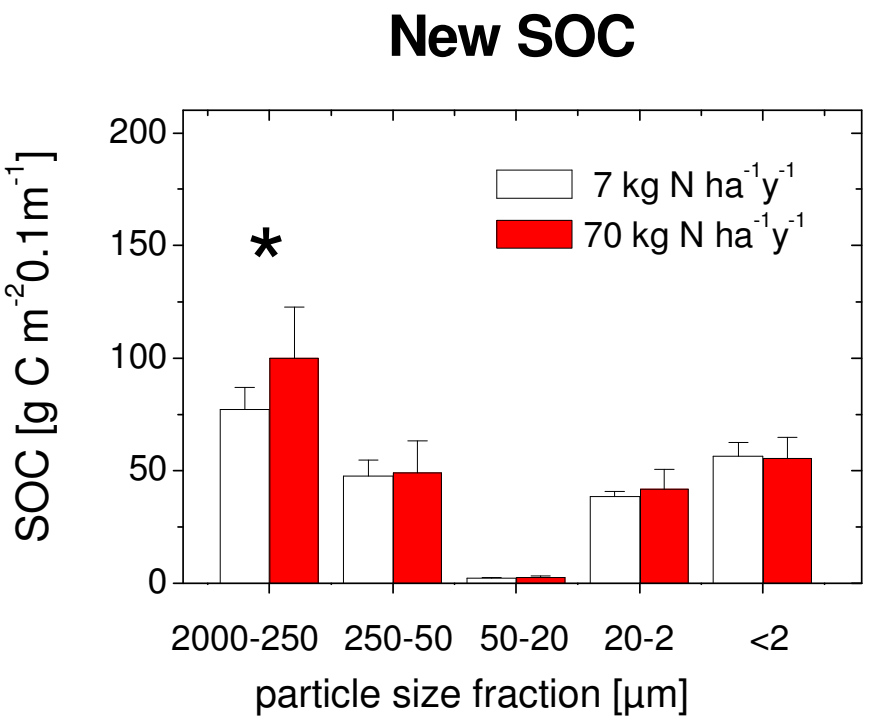
Clay fraction

13

low

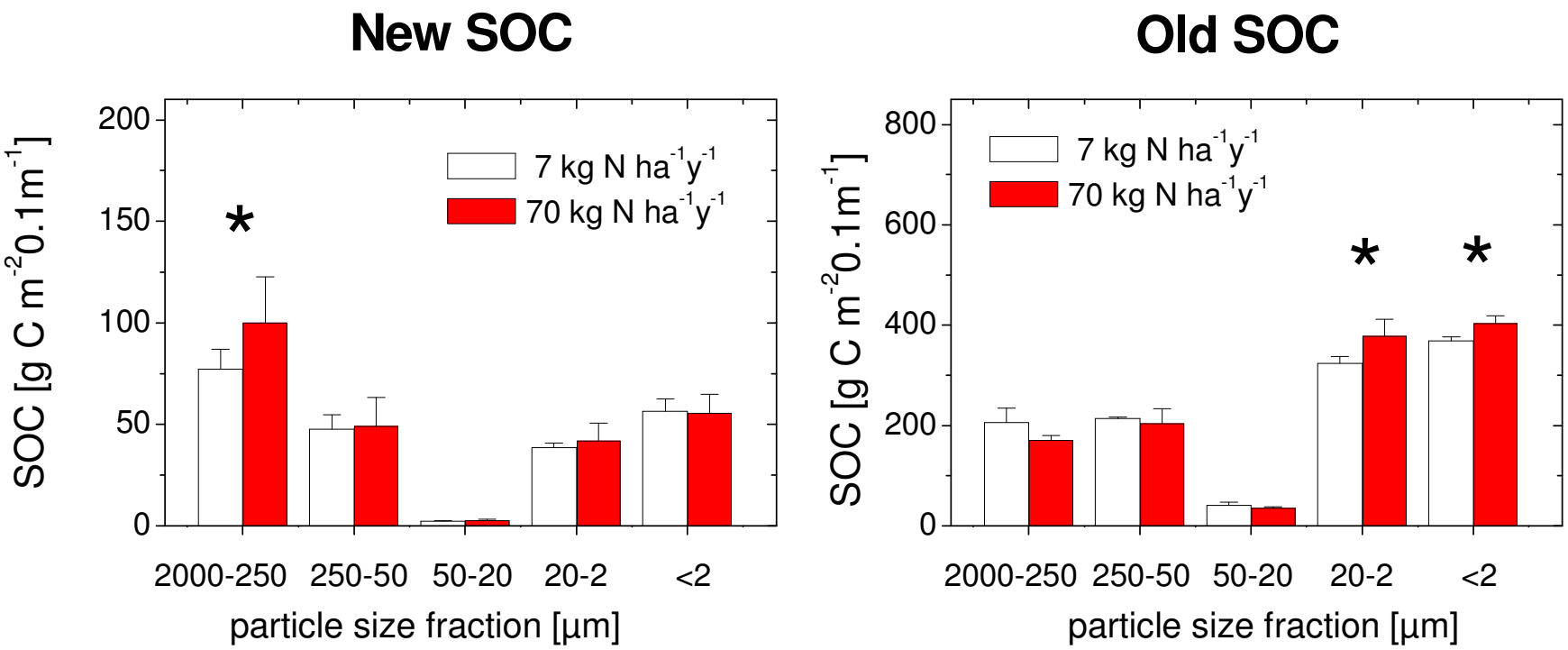
Hagedorn et al. (2005): GCB

Increased new C inputs



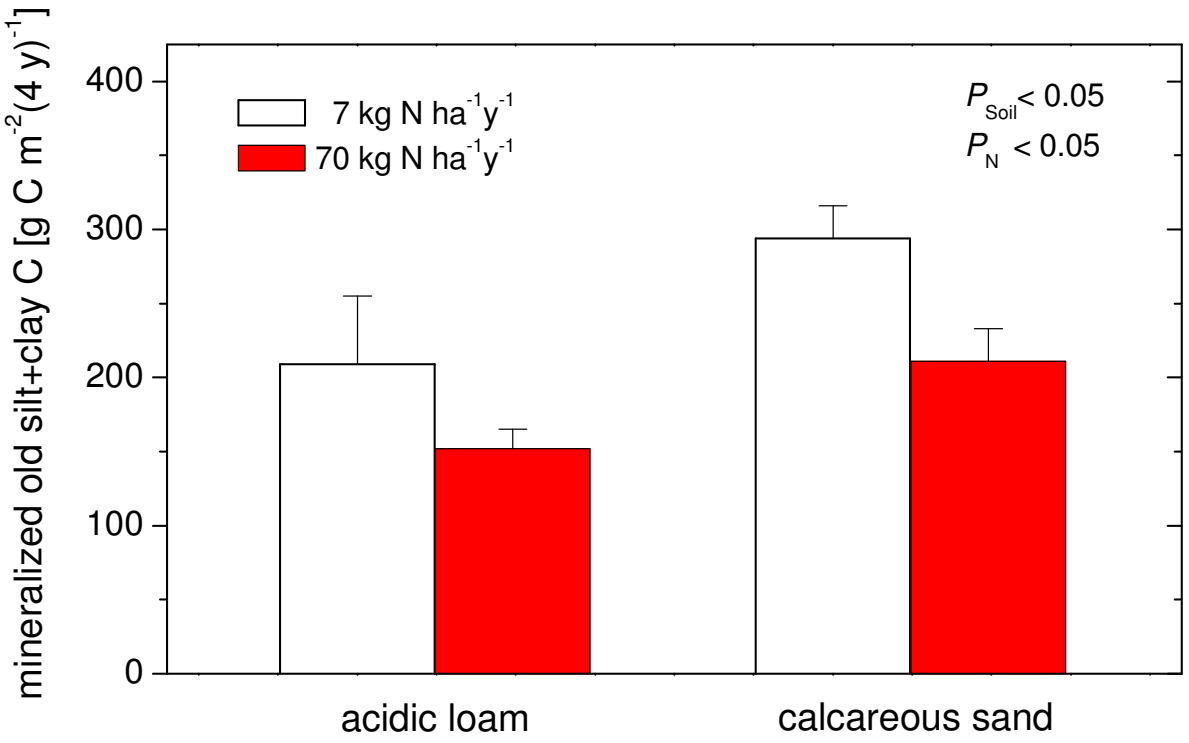
Hagedorn et al. (2003): SBB

Increased new C inputs and accumulation of old SOC



Hagedorn et al. (2003): SBB

Suppressed mineralization of old SOC



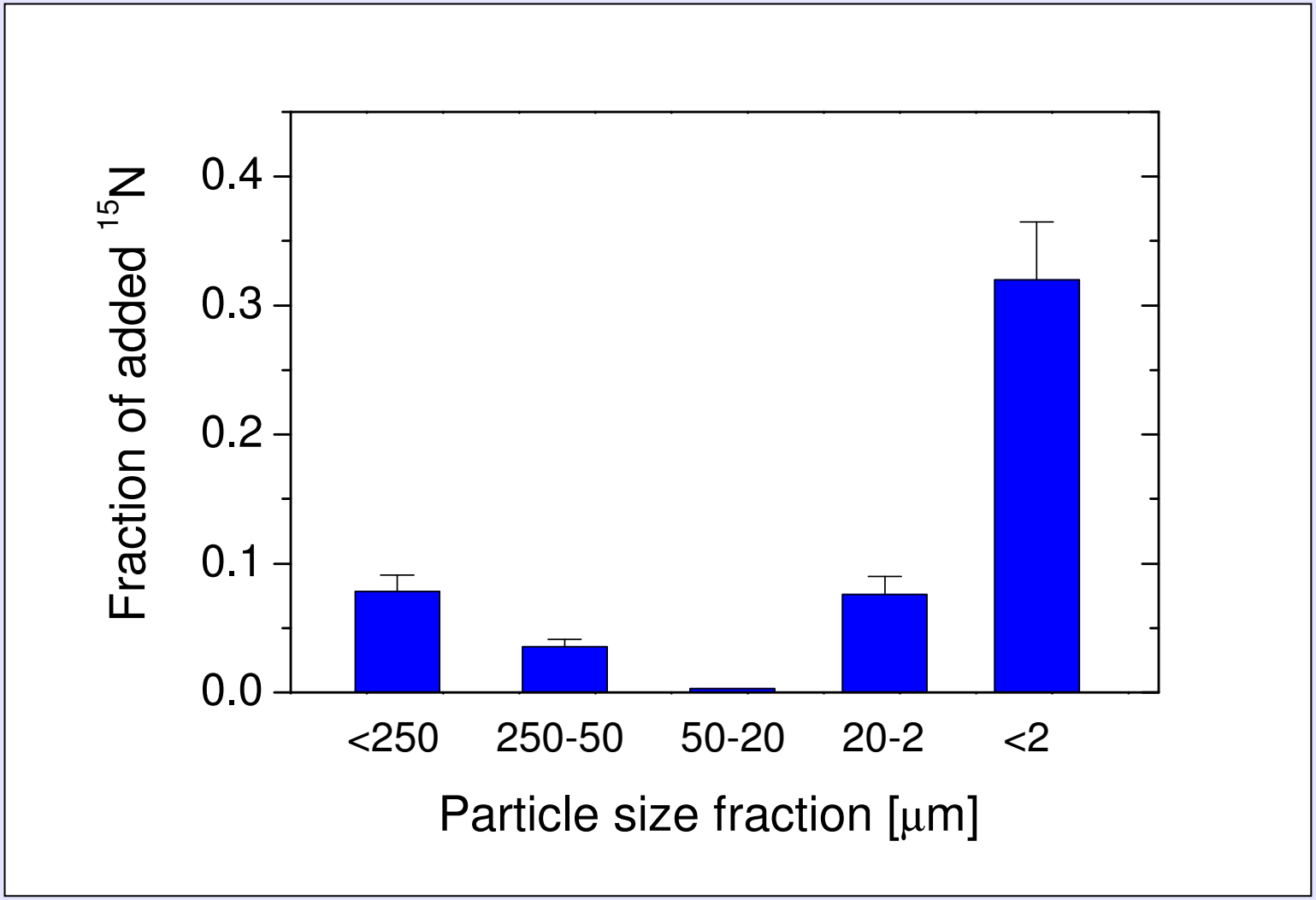
Hagedorn et al. (2003): SBB

Suppressed mineralization of old SOC

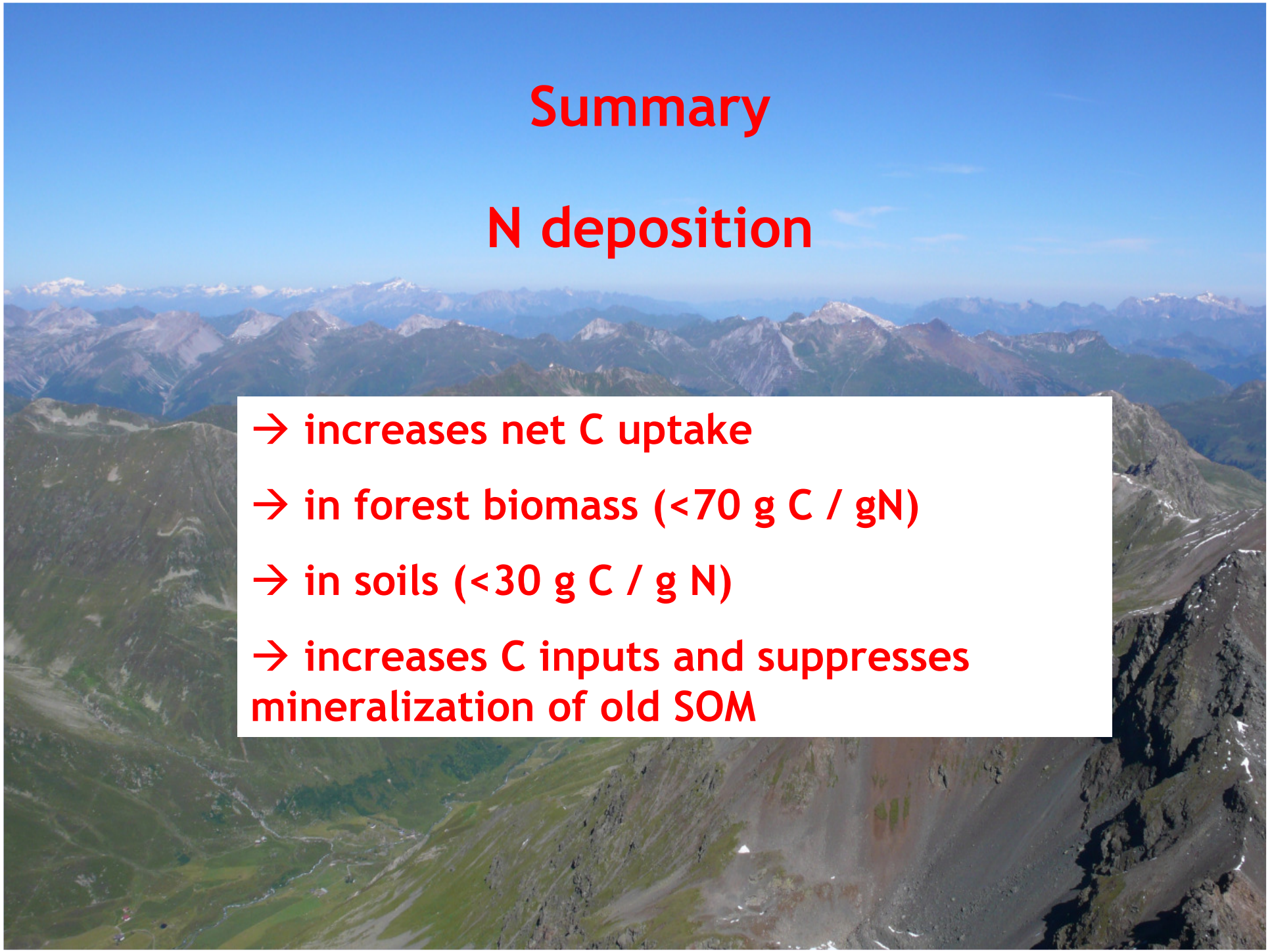
Potential reasons

- Change in decomposer community
- Suppression of oxidative enzyme activity
- No need to decompose recalcitrant compounds with high N contents

Tracing ^{15}N into soil fractions



Hagedorn et al. (2005): GCB



Summary

N deposition

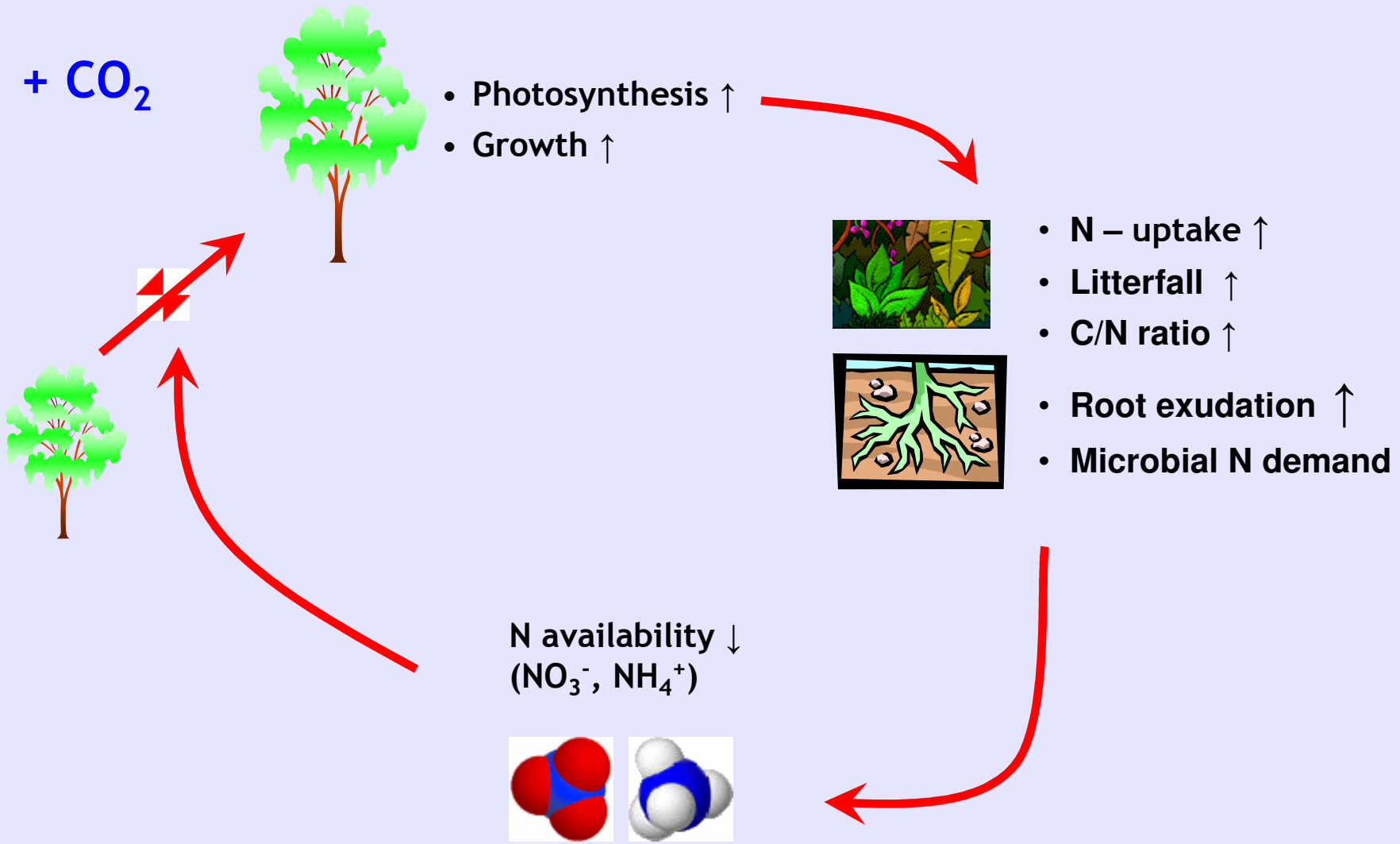
→ increases net C uptake

→ in forest biomass (<70 g C / gN)

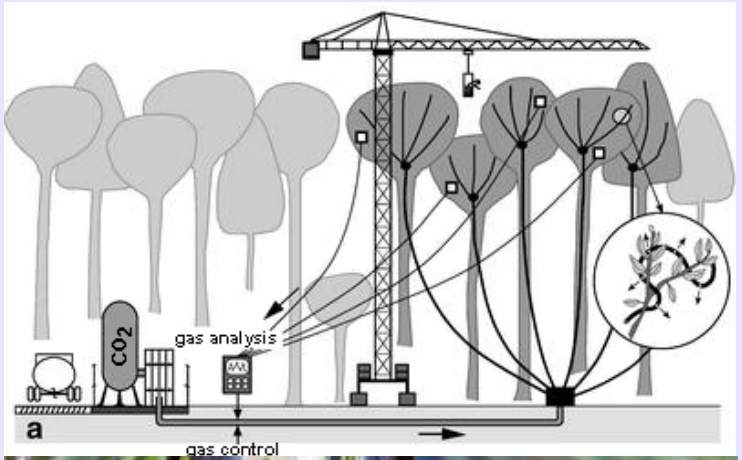
→ in soils (<30 g C / g N)

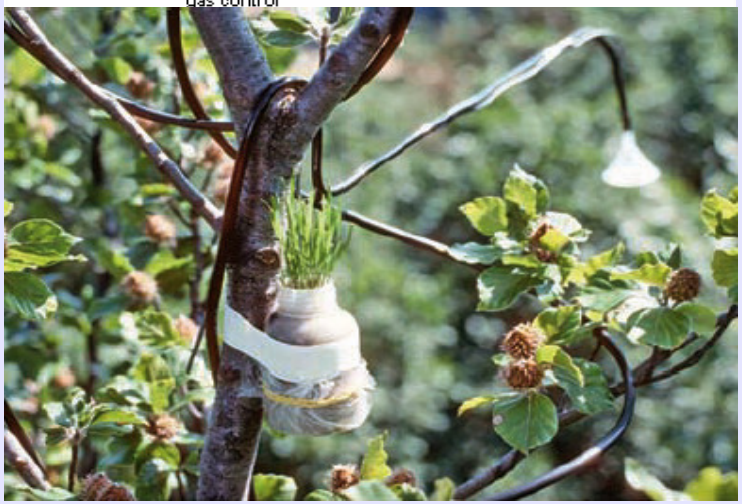
→ increases C inputs and suppresses mineralization of old SOM

Progressive N limitation hypothesis



Swiss Canopy Crane Project





100 y old deciduous forest; + 200 ppm CO_2

Körner et al. (2005): Science

CO_2 enrichment at the alpine treeline

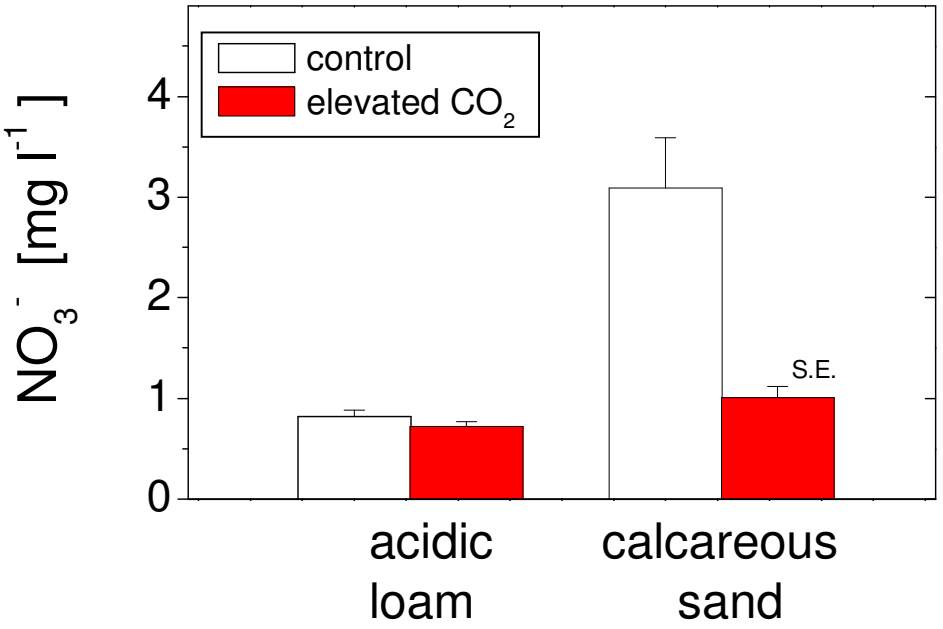
+ 200 ppm_v

Larix, *Pinus*

n=20

Elevated CO_2 decreases NO_3^-

Open-top chambers

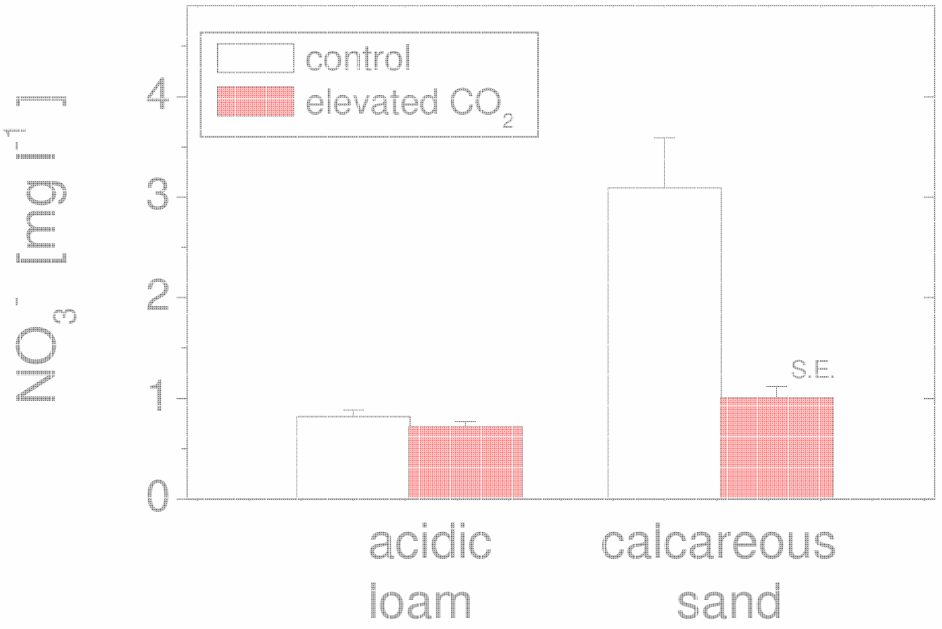


Soil solution 5 cm depth, n=4 per treatment

Hagedorn et al. (2005): GCB

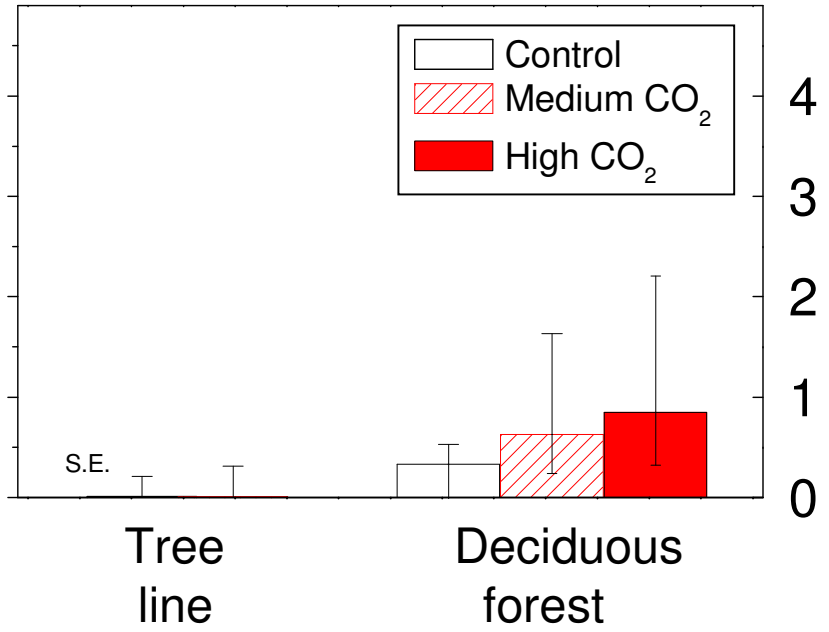
Elevated CO_2 decreases NO_3^-

Open-top chambers



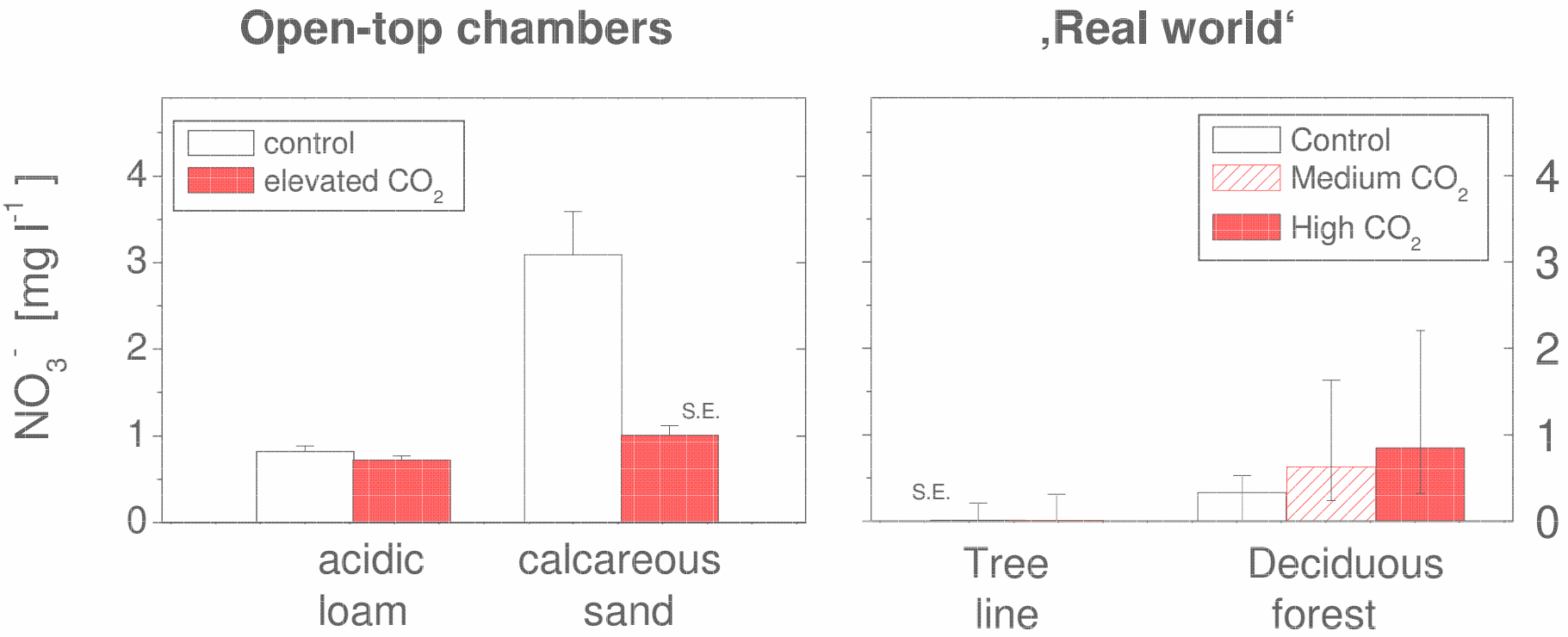
Hagedorn et al. (2005): GCB

‚Real world'



unpublished data

Elevated CO_2 decreases NO_3^-

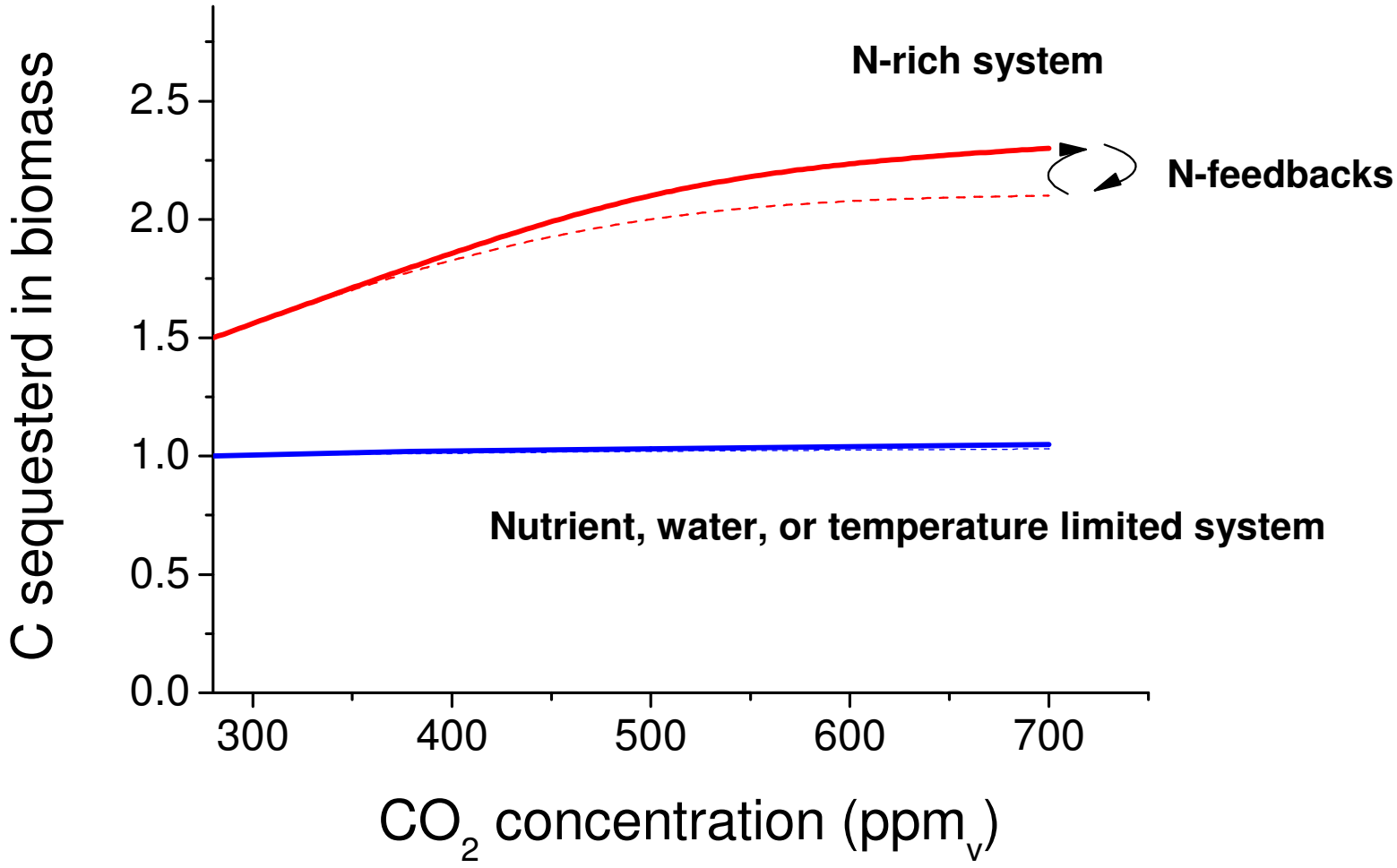


Growth response:	**+7%**	**+30%**	**+5%**	**0%**

Hagedorn et al. (2005): GCB

unpublished data

Feedbacks of increasing CO_2 with N



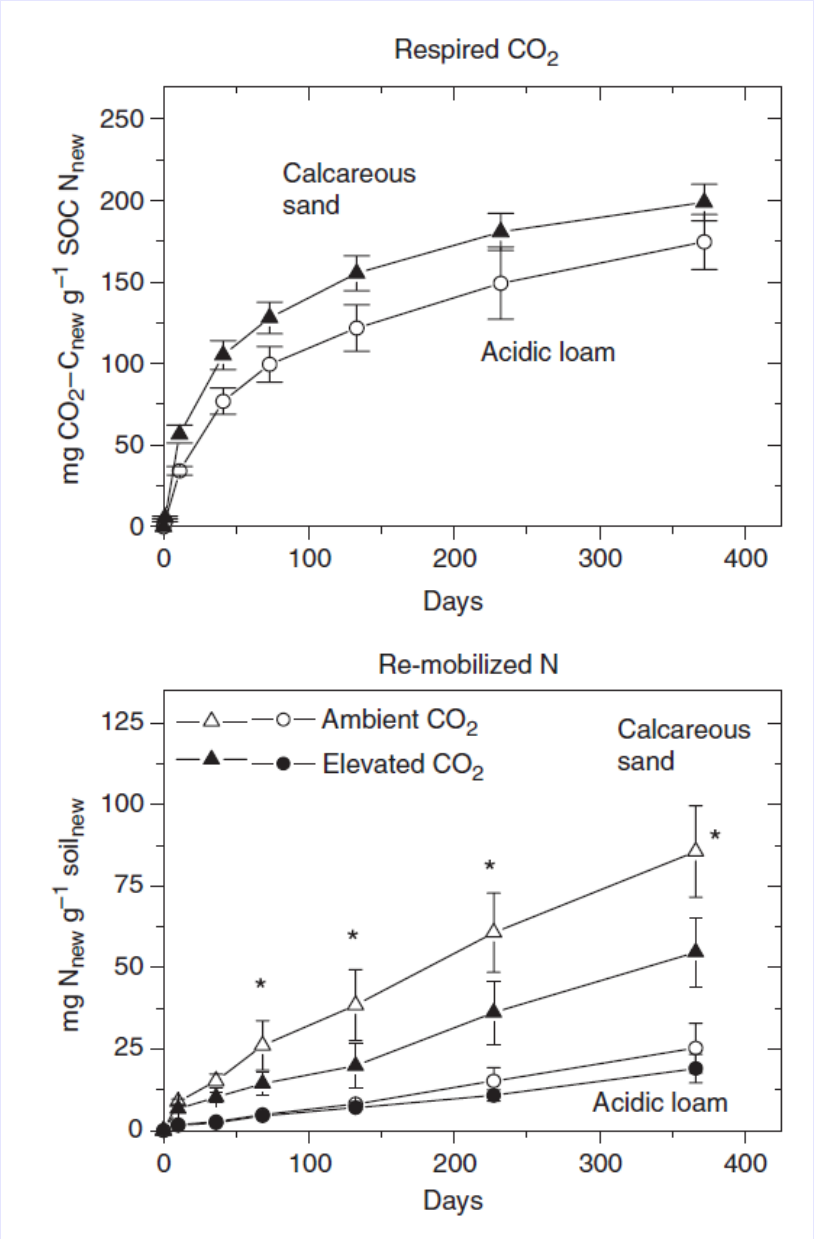
Summary

1.N is more effectively retained in ecosystem than C

2. N deposition increases C sequestered in biomass and soils
Realistic effects: < 100 gC/gN

3. N limitation of CO_2 effects (?)


Thanks!
M. Bauer, P. Bebi, T.I. Handa, S. Hättenschwiler, J. Hutzler, T. Hollmann, R. Köchli, K. Löffler, Ch. Rixen, S. Rusch, M. Saurer, A. Zürcher
Schweizer Nationalfonds, Velux-Stiftung
BAFU


Respired CO_2
mg CO_2–C_{new} g^{-1} SOC N_{new}
250
200
150
100
50
0
Calcareous sand
Acidic loam
0
100
200
300
400
Days
Re-mobilized N
mg N_{new} g^{-1} $soil_{new}$
125
100
75
50
25
0
Ambient CO_2
Elevated CO_2
Calcareous sand
Acidic loam
*
0
100
200
300
400
Days