Differential effects of reduced versus oxidized N in species-rich grasslands and heathlands

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OUTLINE OF PRESENTATION

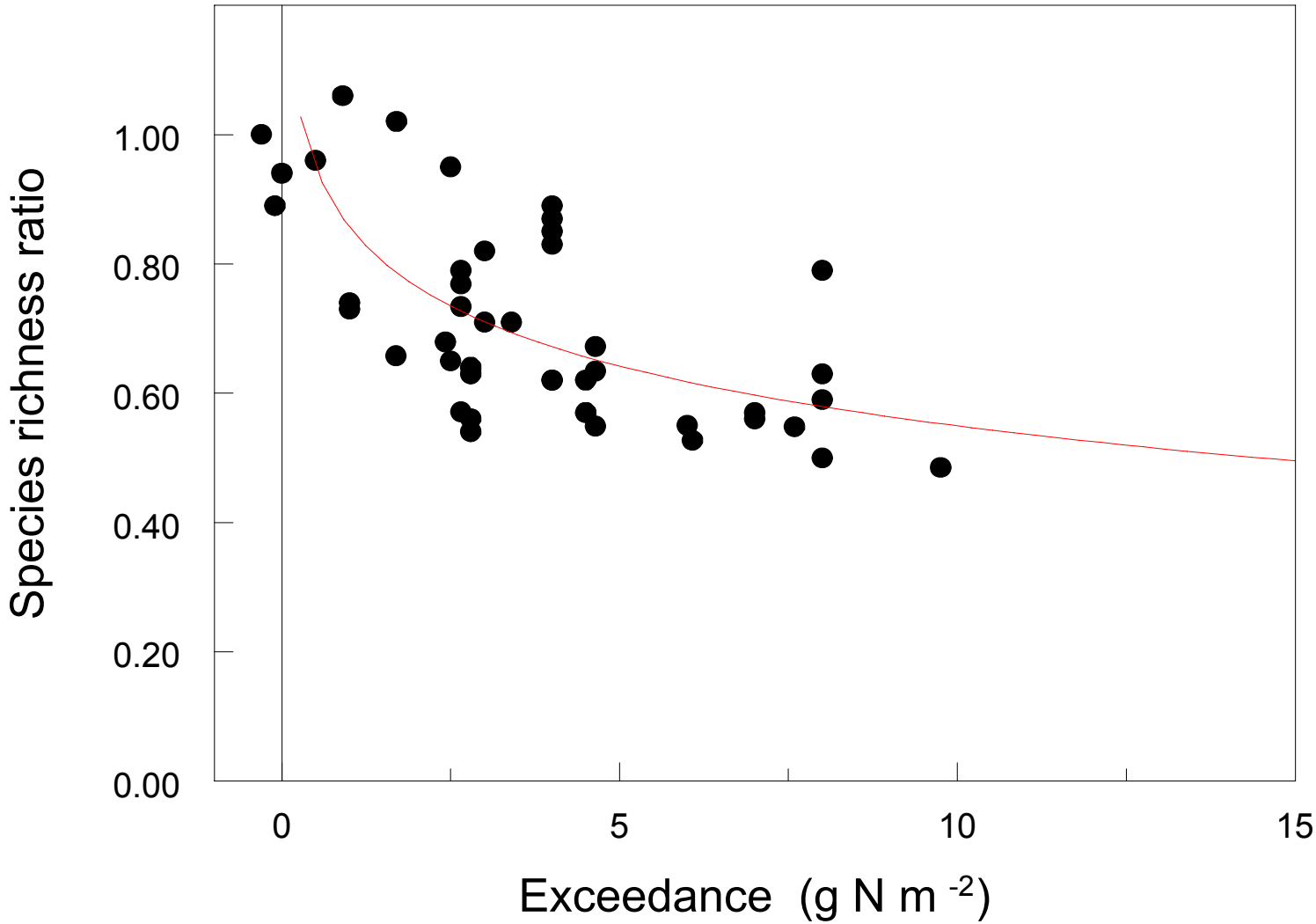
- **Introduction**
  - impacts of N deposition
  - reduced versus oxidized N
  - species-rich grassland & heaths
- **Effect studies**
  - correlative field studies
  - waterculture & pot experiments
  - mesocosm experiments
  - field addition studies (very rare)
- **Concluding remarks**

Overview impacts of N deposition

- **direct toxicity** of gases & aerosols;
- **accumulation** of nitrogen, resulting in changes in productivity and **species composition** in the long term;
- soil-mediated effects of **acidification**
- increased **sensitivity** to stresses and disturbances (drought, frost, pathogens, herbivores)

- **THUS: Very complex, many interactions, different timescales**

Plant species richness and N deposition (Sn/Sc)



(n=44; mostly grasslands & heaths; P<0.01) (Bobbink 2004)

Overview impacts of reduced N

- **membrane dysfunction** & **cell solute leakage**;
- **dysfunction of cell pH regulation** (internal cell acidification);
- **nutritional imbalance** (increased N%; lower cation % by reduced uptake and increased shoot leaching; accumulation N-rich amino-acids);

—►reduction in **plant growth (roots!!)** & **survival**

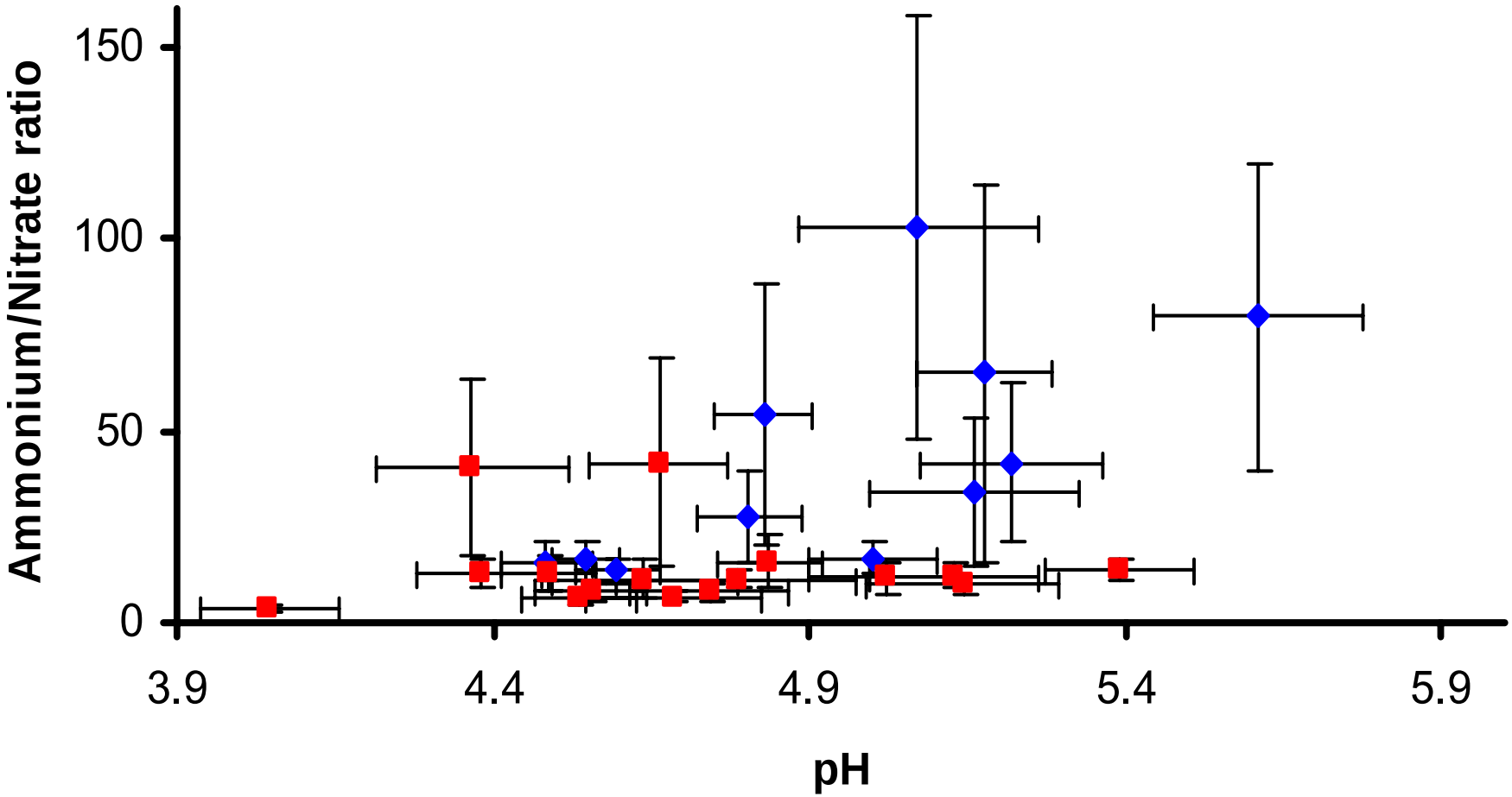

Species-rich grassland (pH 4.5 – 6.5)


Species-rich heaths
(pH 4.5 - 6.0)

Correlative field studies on plant species and soil conditions

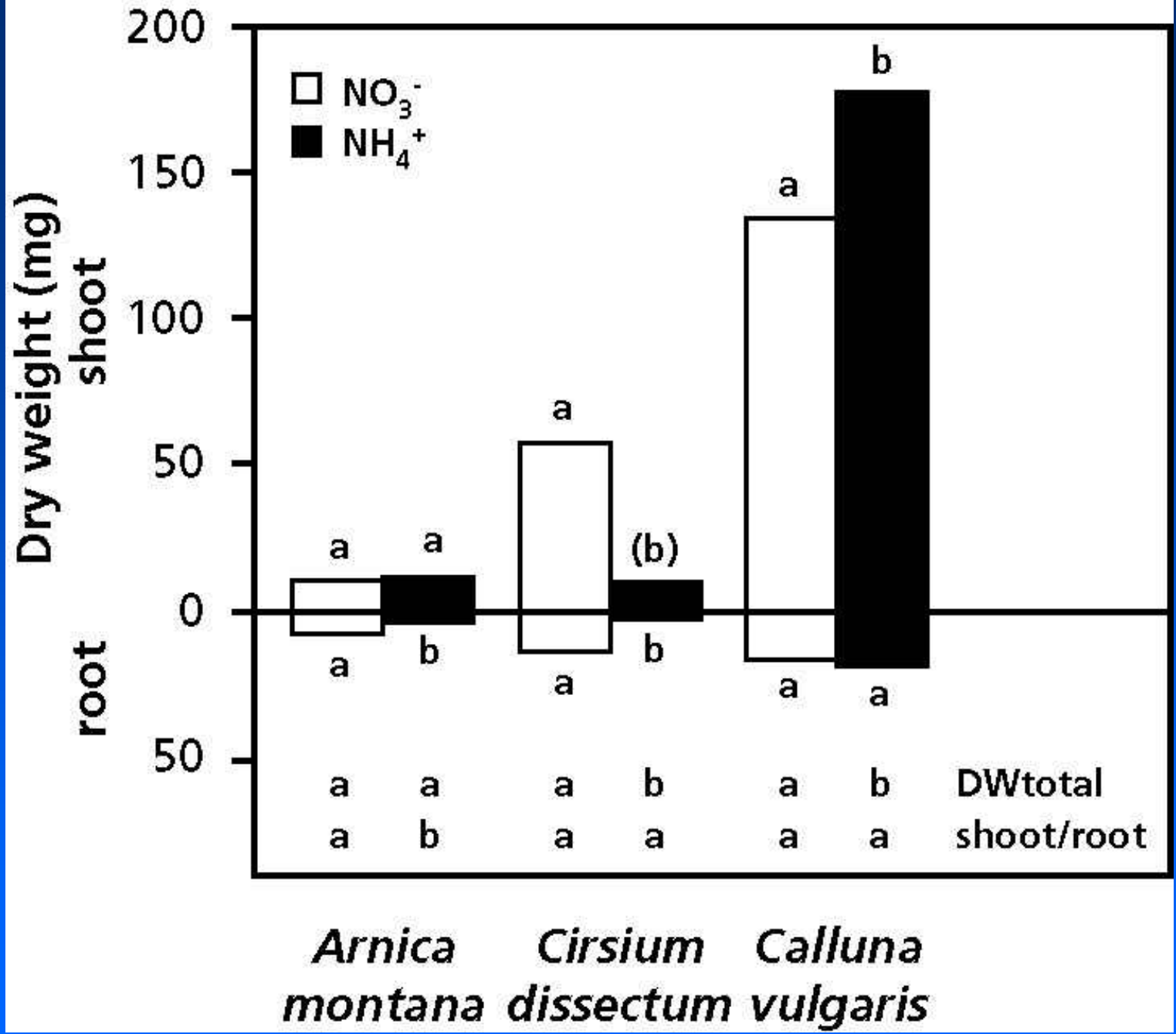
- 300 vegetation samples with full soil chemistry
- acidic grasslands and heaths in the Netherlands (sandy parts);
- Almost 90 areas (nature reserves!!)
- To avoid pseudo-replication: never more than 2 randomly selected samples per area;
- Kleijn et al. (submitted)

Growth site characteristics of common (blue) and rare (red) species of heaths and acidic grasslands



Kleijn et al (submitted)

Water culture & pot experiments



pH =4

(De Graaf et al. 1998)


ARNICA MONTANA
NO_3^- = 100 µmol/L
NH_4^+ = 0 µmol/L
pH = 4
1-10-1991

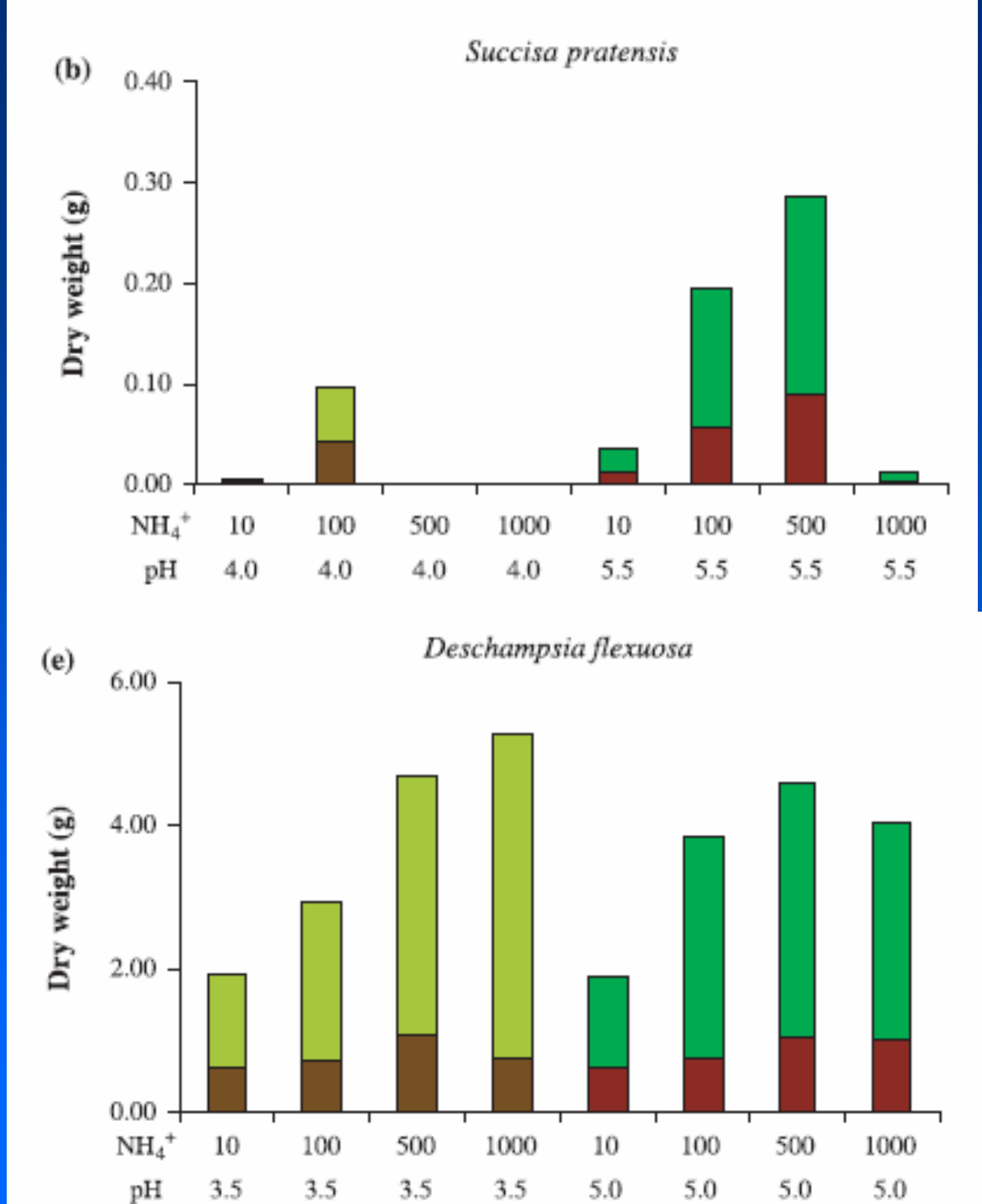

ARNICA MONTANA
NO_3^- = 100 µMOL/L
NH_4^+ = 500 µMOL/L
pH = 4
1-10-1991

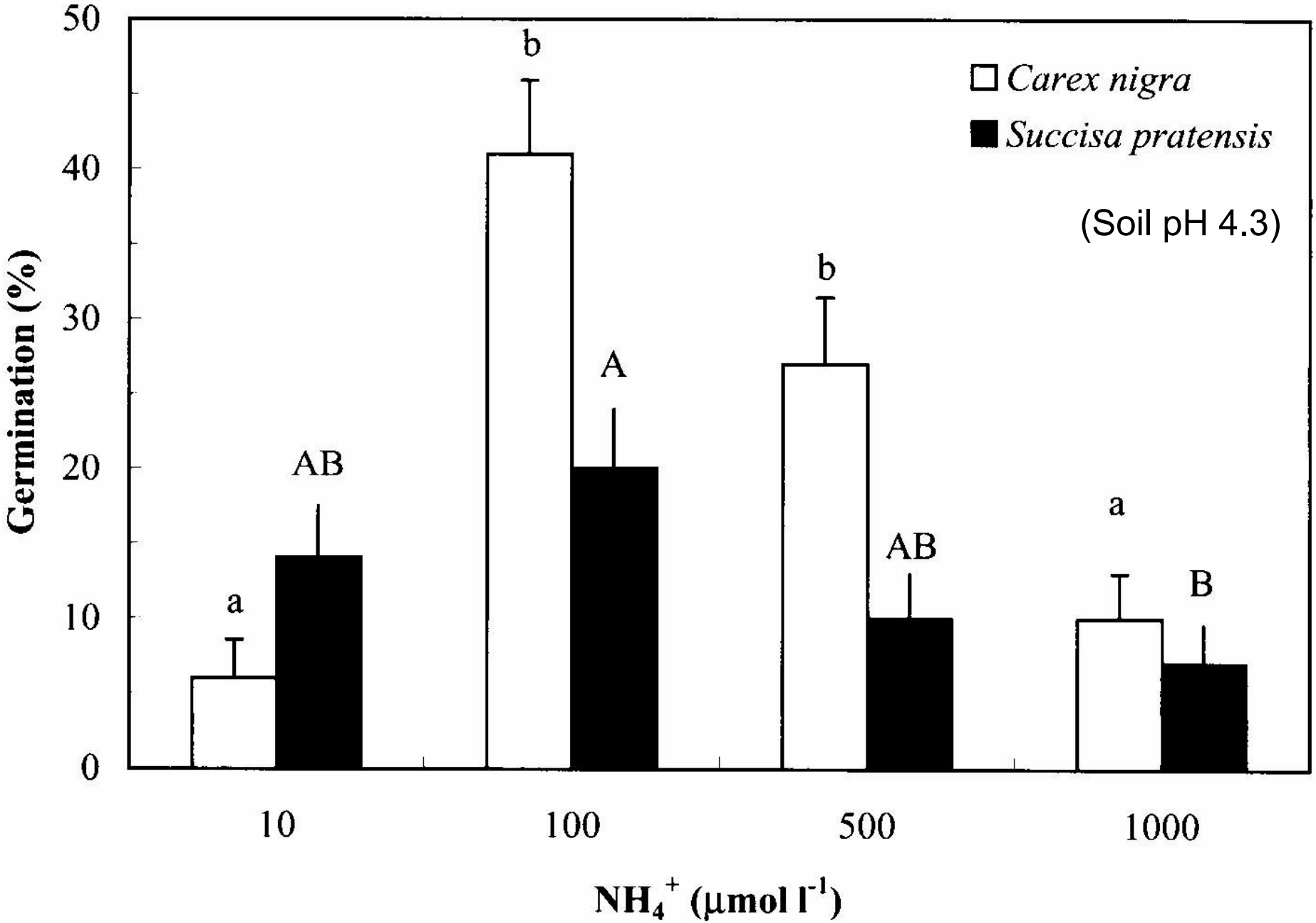
Interaction of pH and ammonium

Green = shoot

Brown = root

Van den Berg et al. 2005

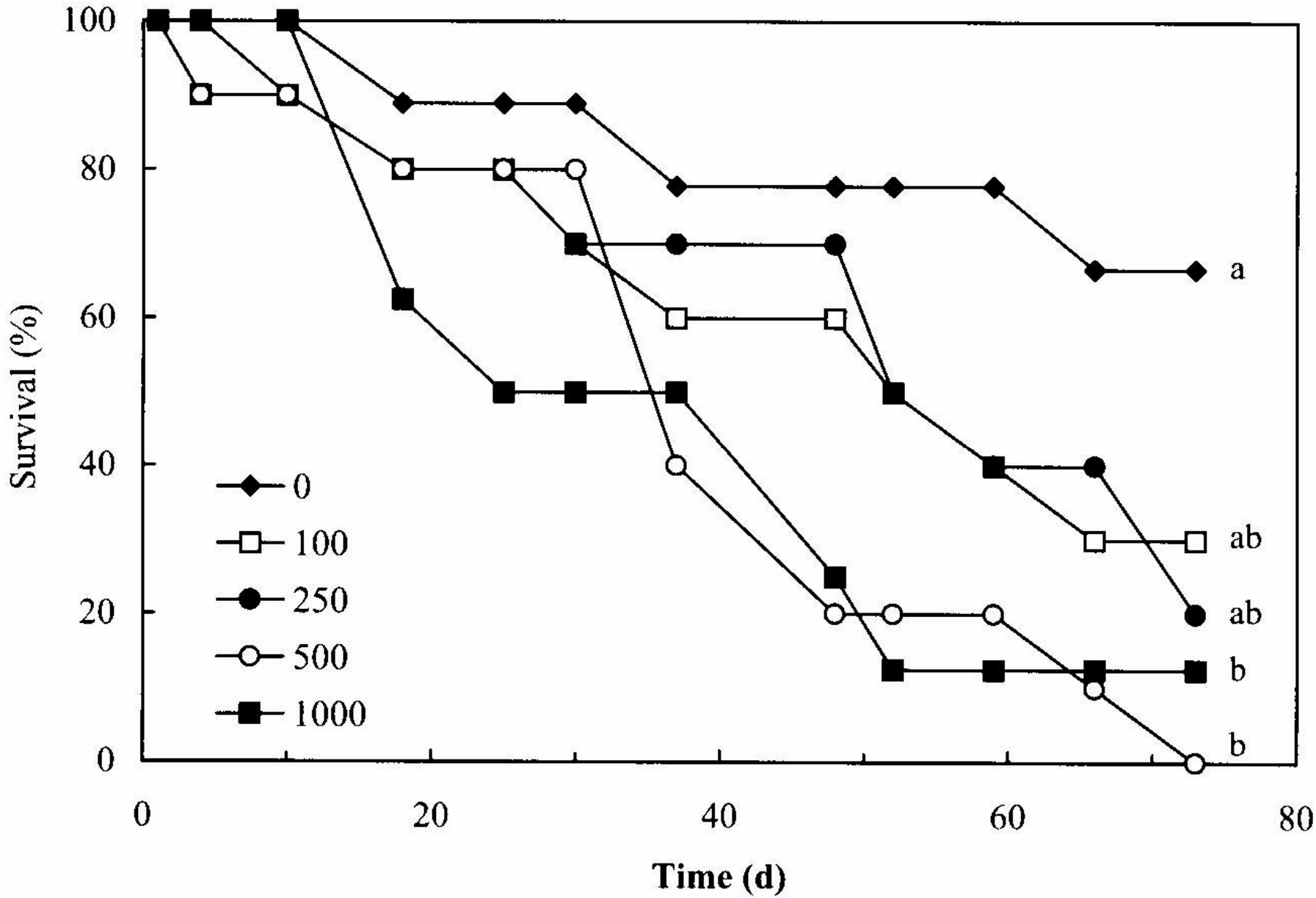




Dorland 2004

Survival of Succisa with increasing ammonium (Dorland et al. 2003)

pH soil 4.3



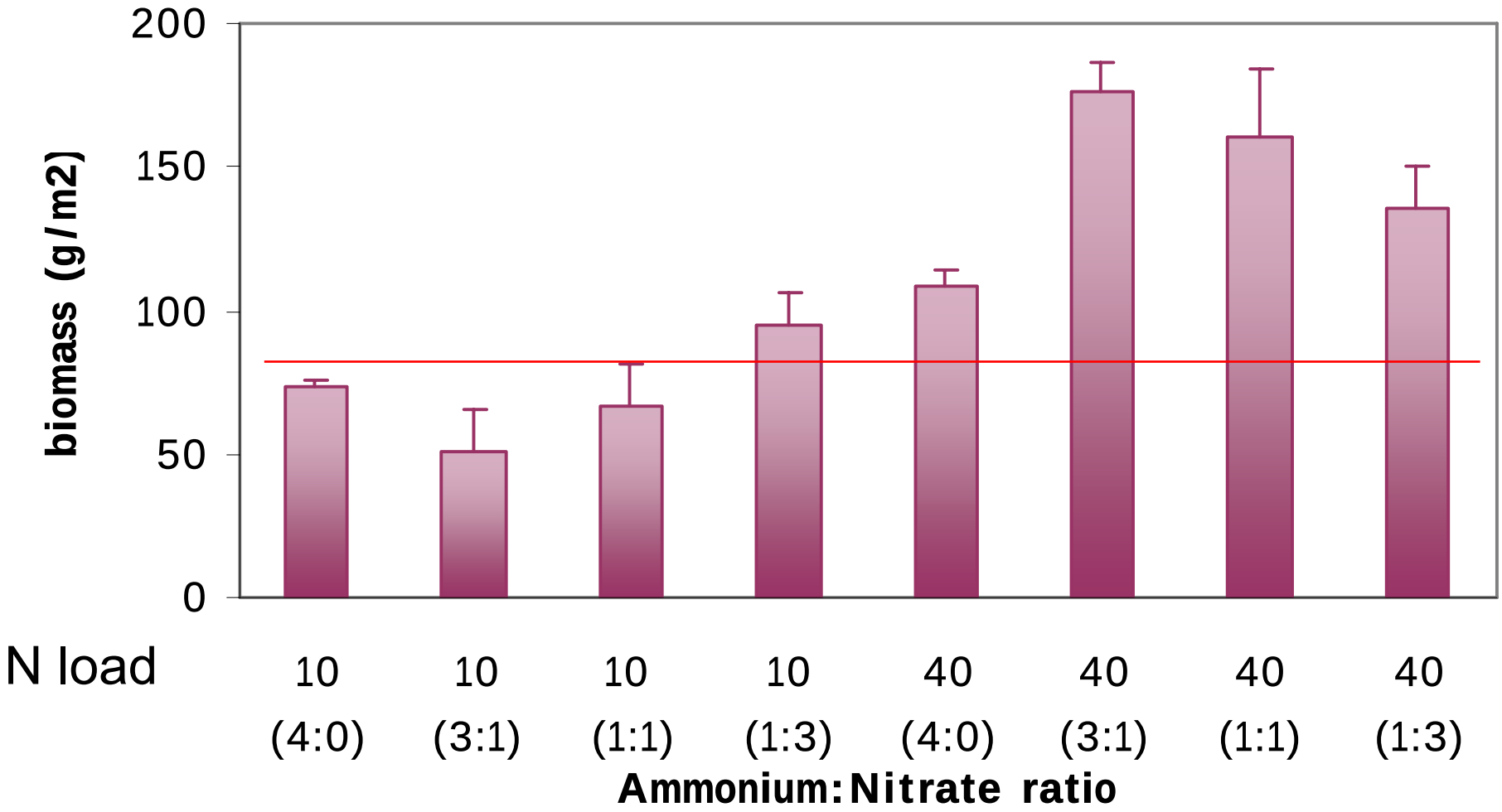
Mesocosm experiments

- **Plant – plant interactions included;**
- **Plant – (natural) soil interactions;**
- **Also more "long-term" processes in plants and soil incorporated;**
- **Best experimental alternative for field addition in high N regions.**

Influence of ammonium:nitrate ratio

(2 experiments; 3 grasses; 6 endangered species)

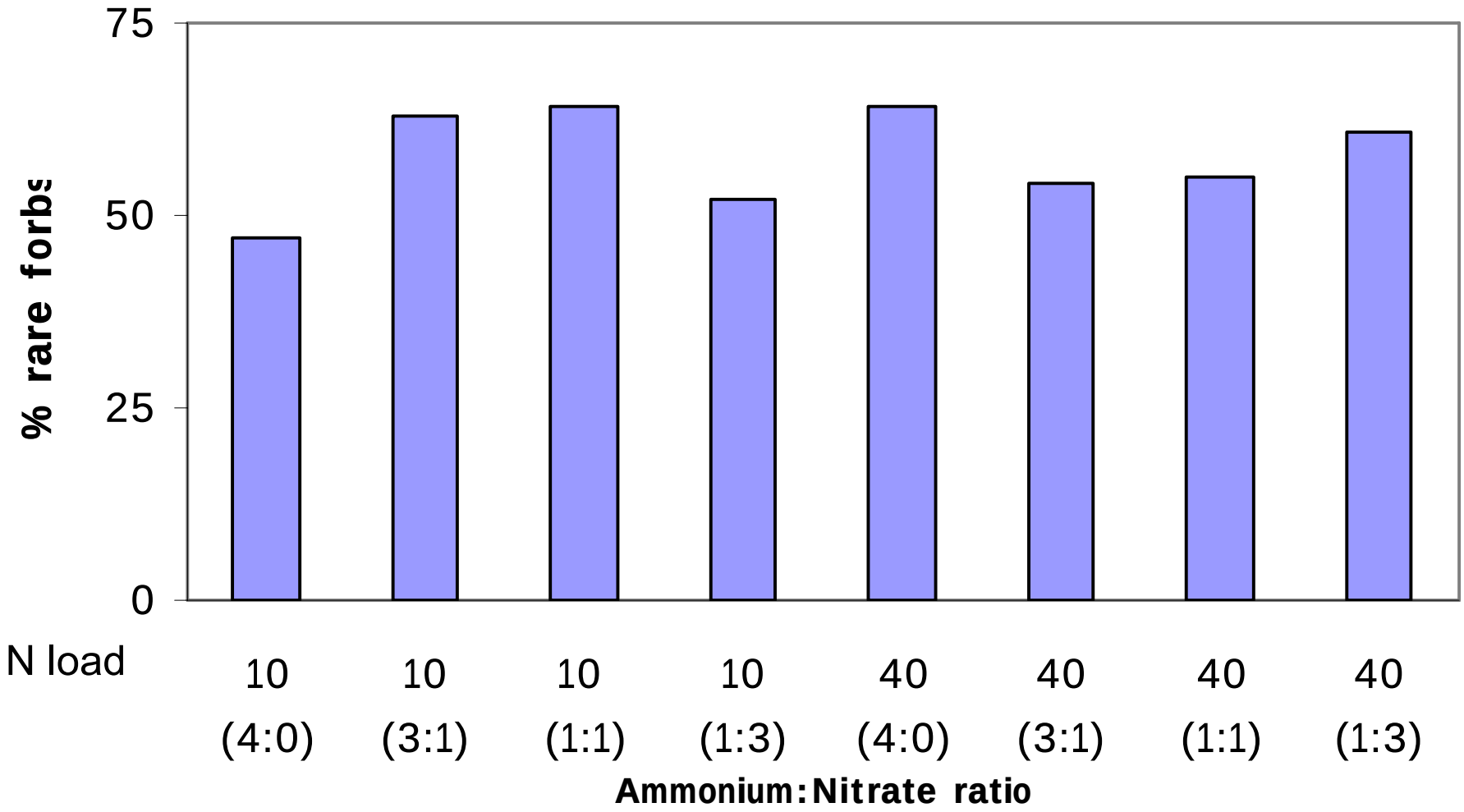
Biomass of grasses (Deschampsia & Danthonia) after 2 yrs



Soil pH ca. 6.8

Tomassen et al 1999

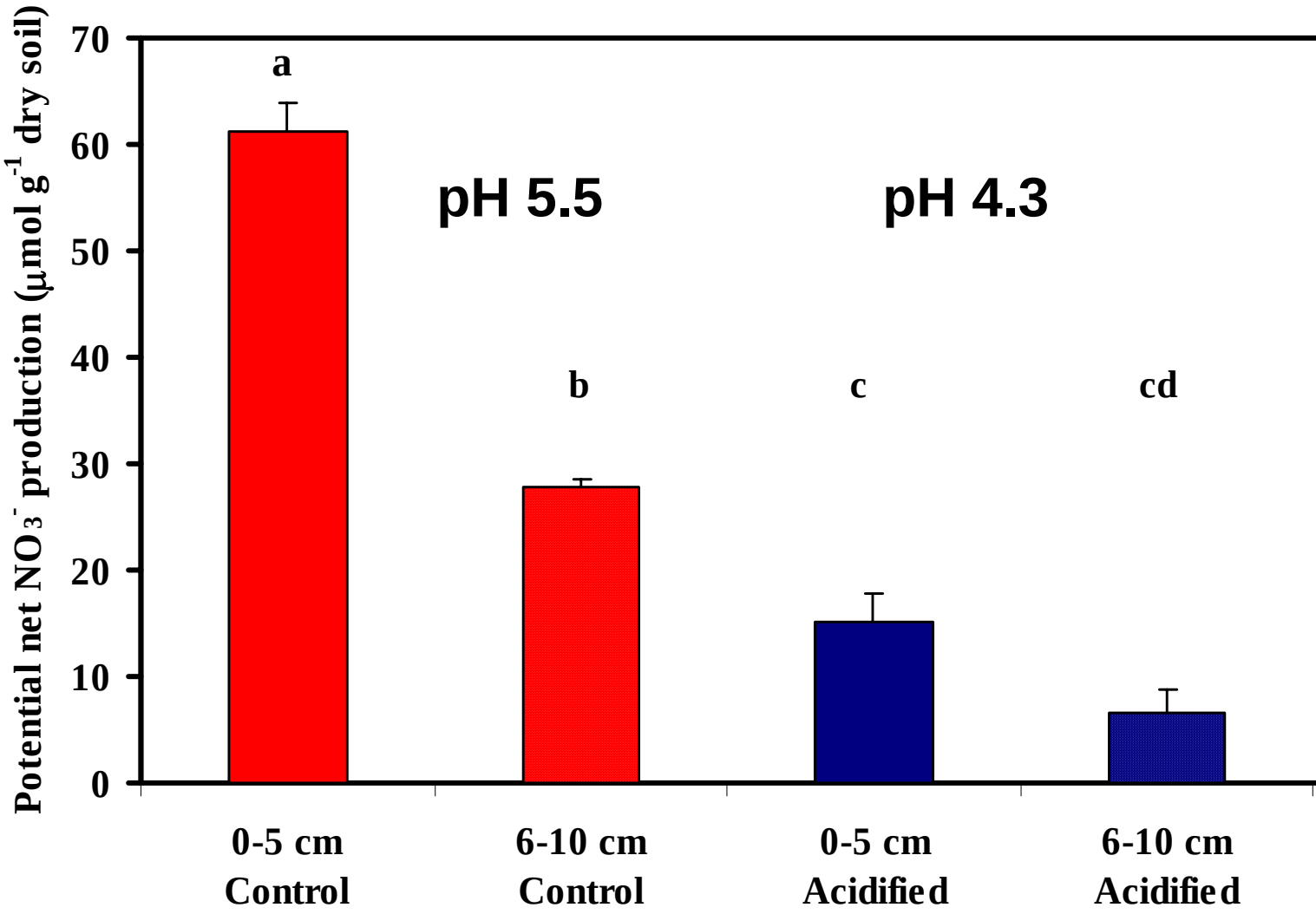
Cover of endangered forbs (as % of total) after 2 yrs addition of ammonium or nitrate



Soil pH ca. 6.8

Tomassen et al 1999

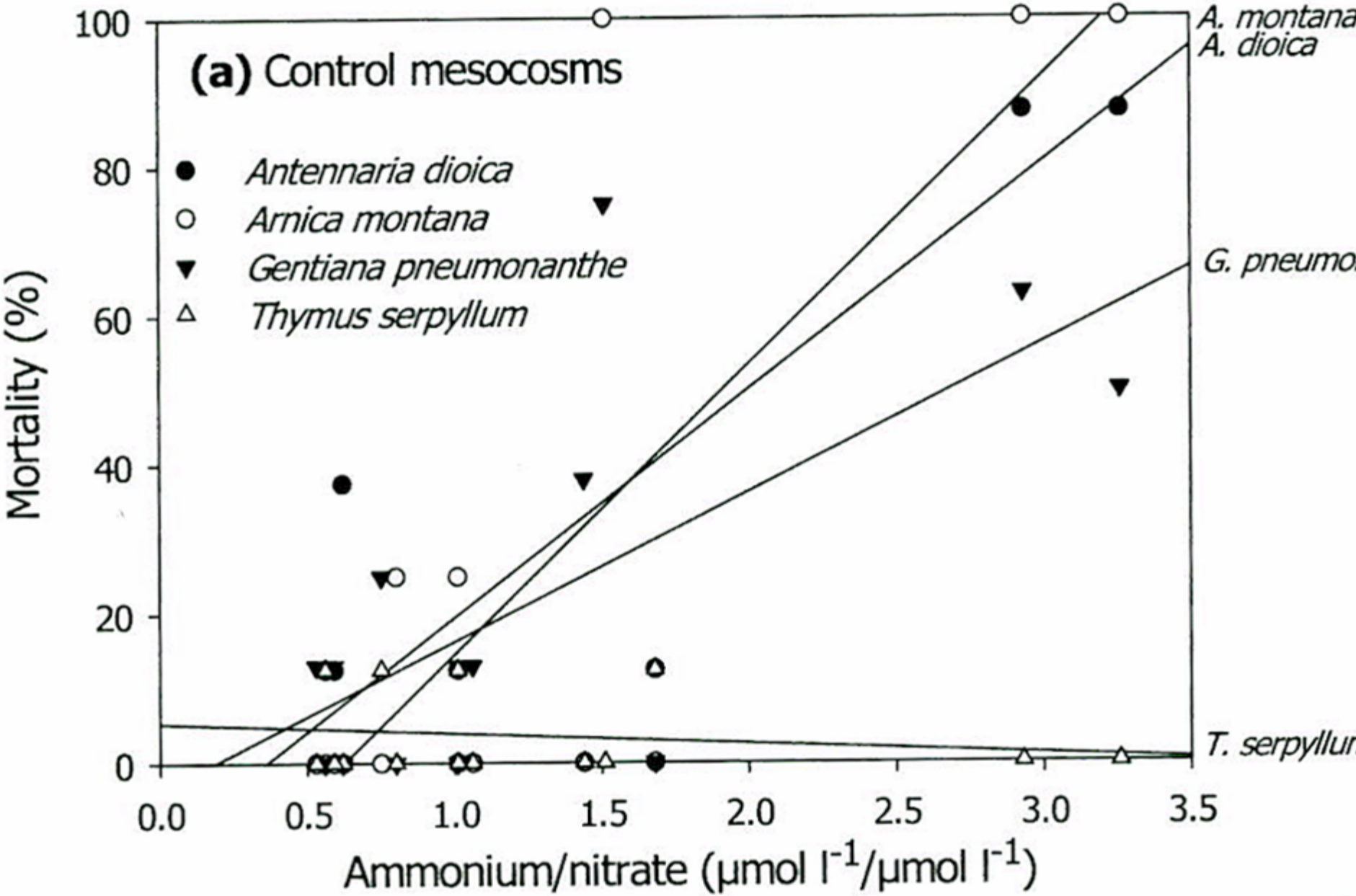
Mechanism: full nitrification in grassland or heath soil; → hardly any ammonium in soil! (Dorland et al. 2004)



Influence of ammonium:nitrate ratio

(second experiment; 3 grasses; 6 endangered species)

Mortality of typical species (Van den Berg et al submitted)



Low ammonium / nitrate ratio

High ammonium / nitrate ratio

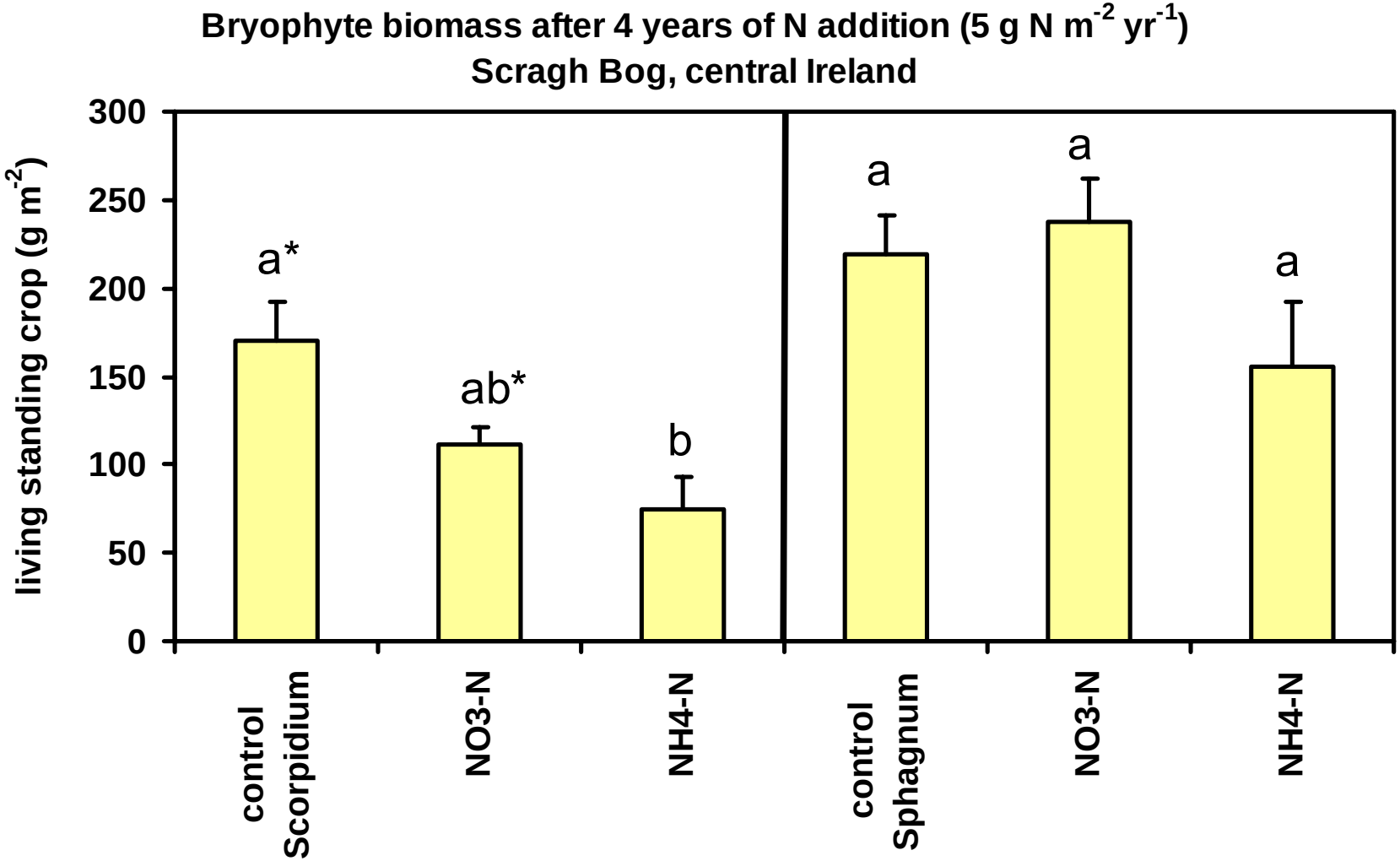
Van den Berg et al submitted

And now: field addition experiments with both reduced and oxidized N

PROBLEM: no DATA at all in grassland or heaths!!!!

Rich fen: Addition study of reduced or oxidized N (small scale / large scale exp)

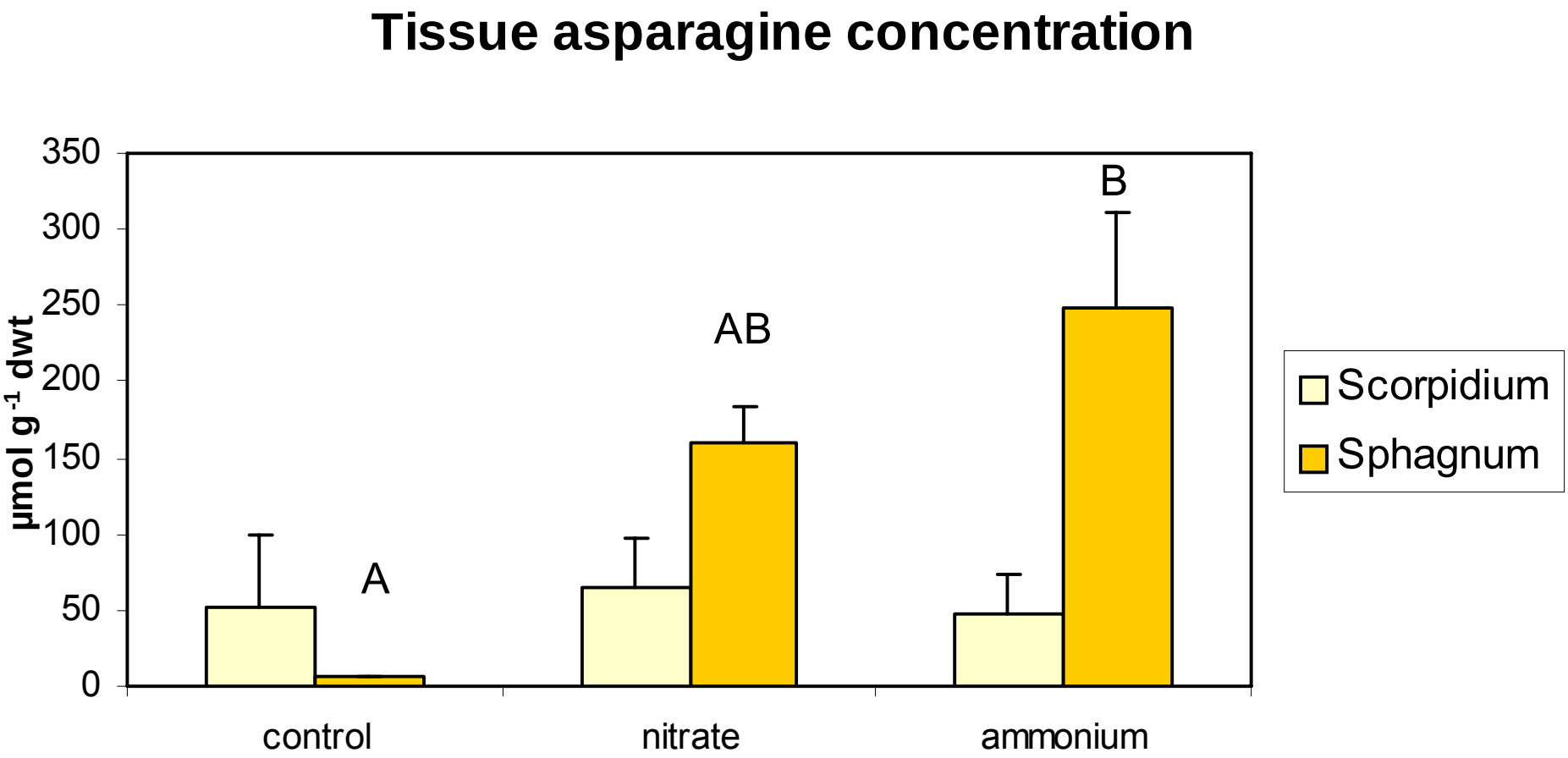
Small-scale addition experiment 4 yrs



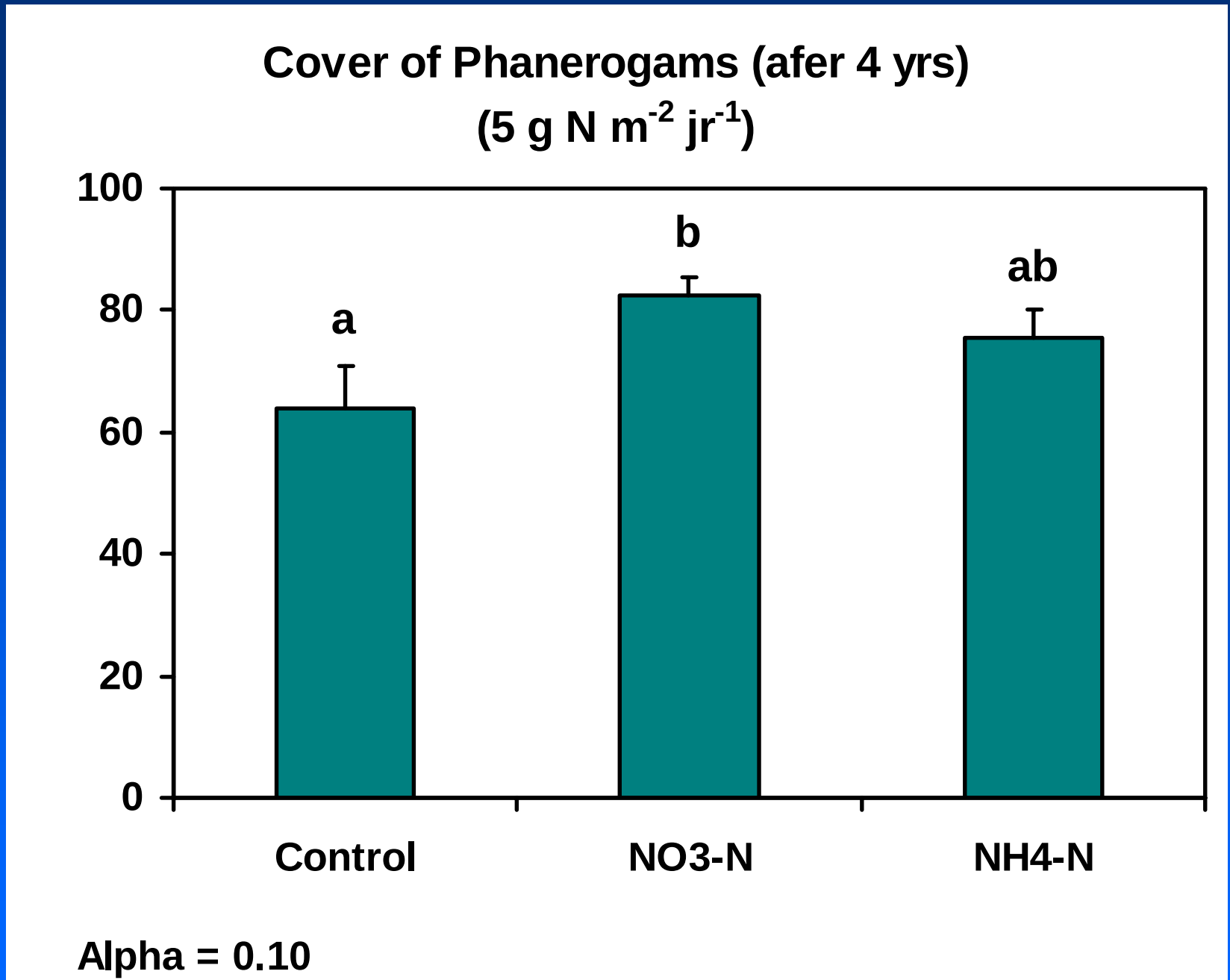
* differ significantly at the 10 % level

(Paulissen et al in prep)

Small-scale addition experiment 4 yrs

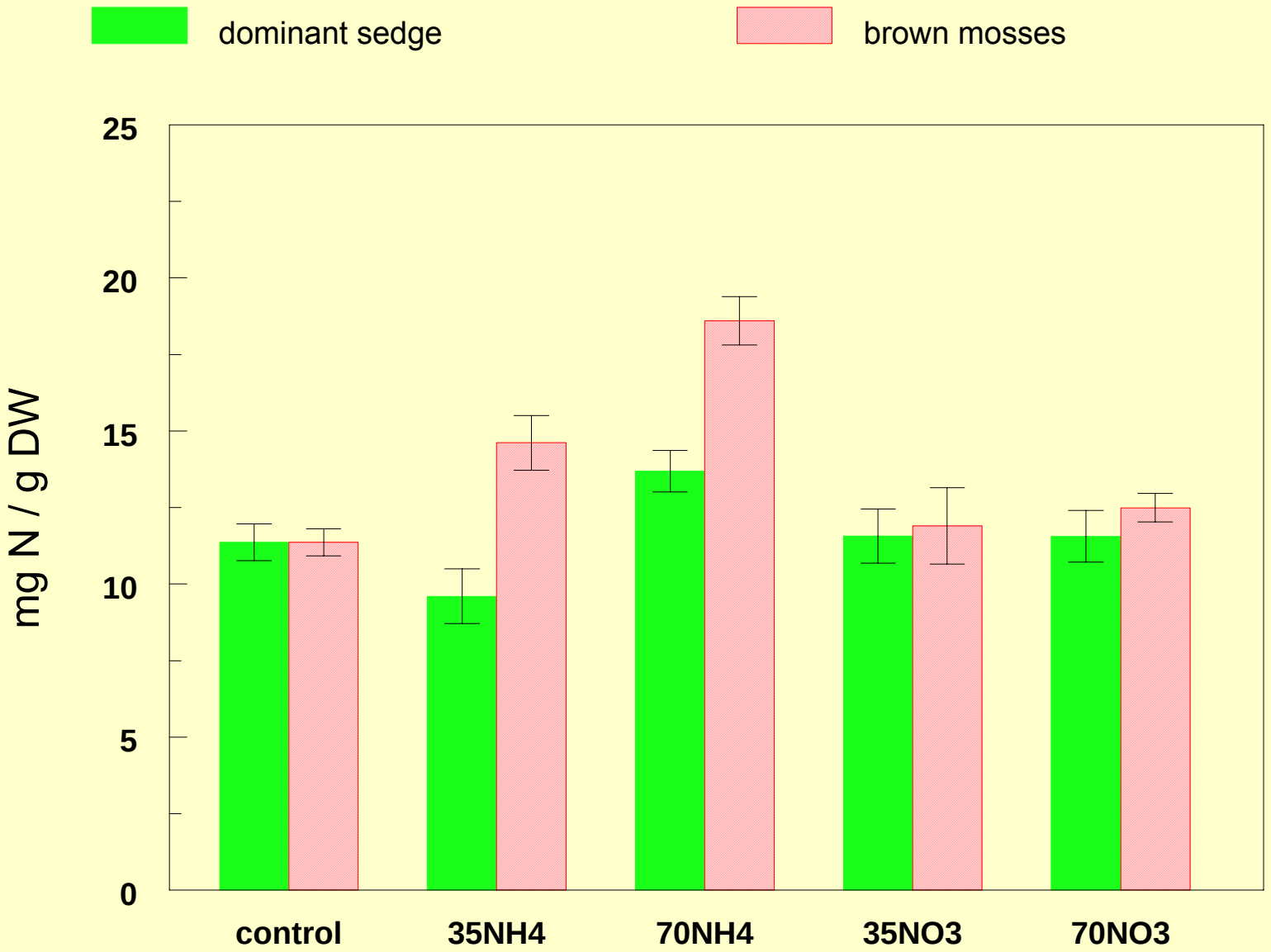


(Paulissen et al in prep)


Cover of Phanerogams (afer 4 yrs)
(5 g N m-2 jr-1)
100
80
60
40
20
0
a
b
ab
Control
NO3-N
NH4-N
Alpha = 0.10

N content rich fen Ireland (3 yrs)

New 5-10 yr experiment



Conclusions:

- **Toxic impacts of reduced N much larger than those (if any) of oxidized N;**
- **Most sensitive systems (and their endangered plants) have intermediate soil pH (4.5 – 6.5);**
- **Most sensitive plants for reduced N: bryophytes & lichens (full shoot uptake!);**
- **Effects of reduced N mediated by (potential) nitrification rate.**

- **(Long-term) field additions with both reduced and oxidized N highly needed !! (ESF-BEGIN)**
- **Development of critical loads for reduced N and oxidized N separately.**