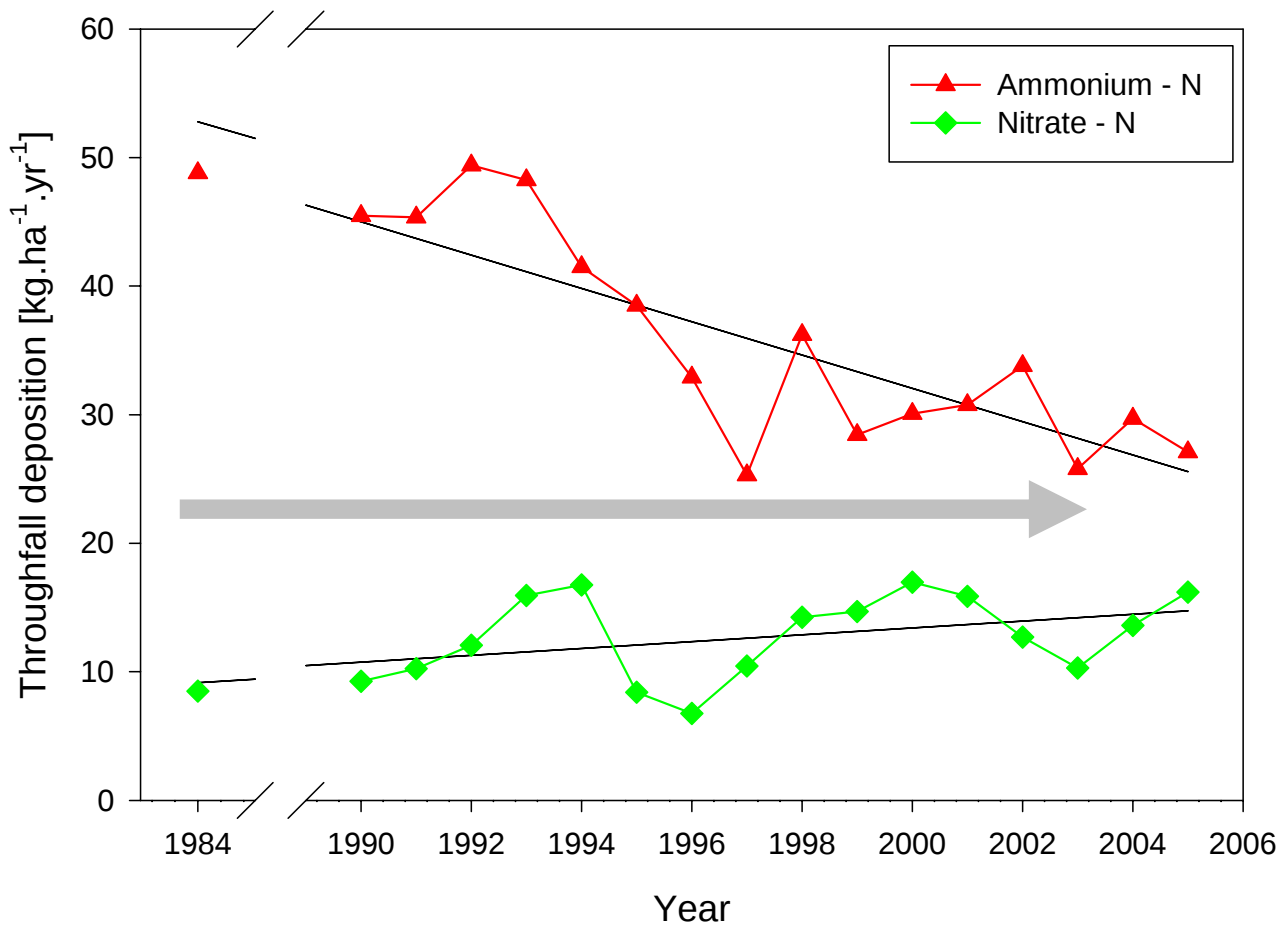


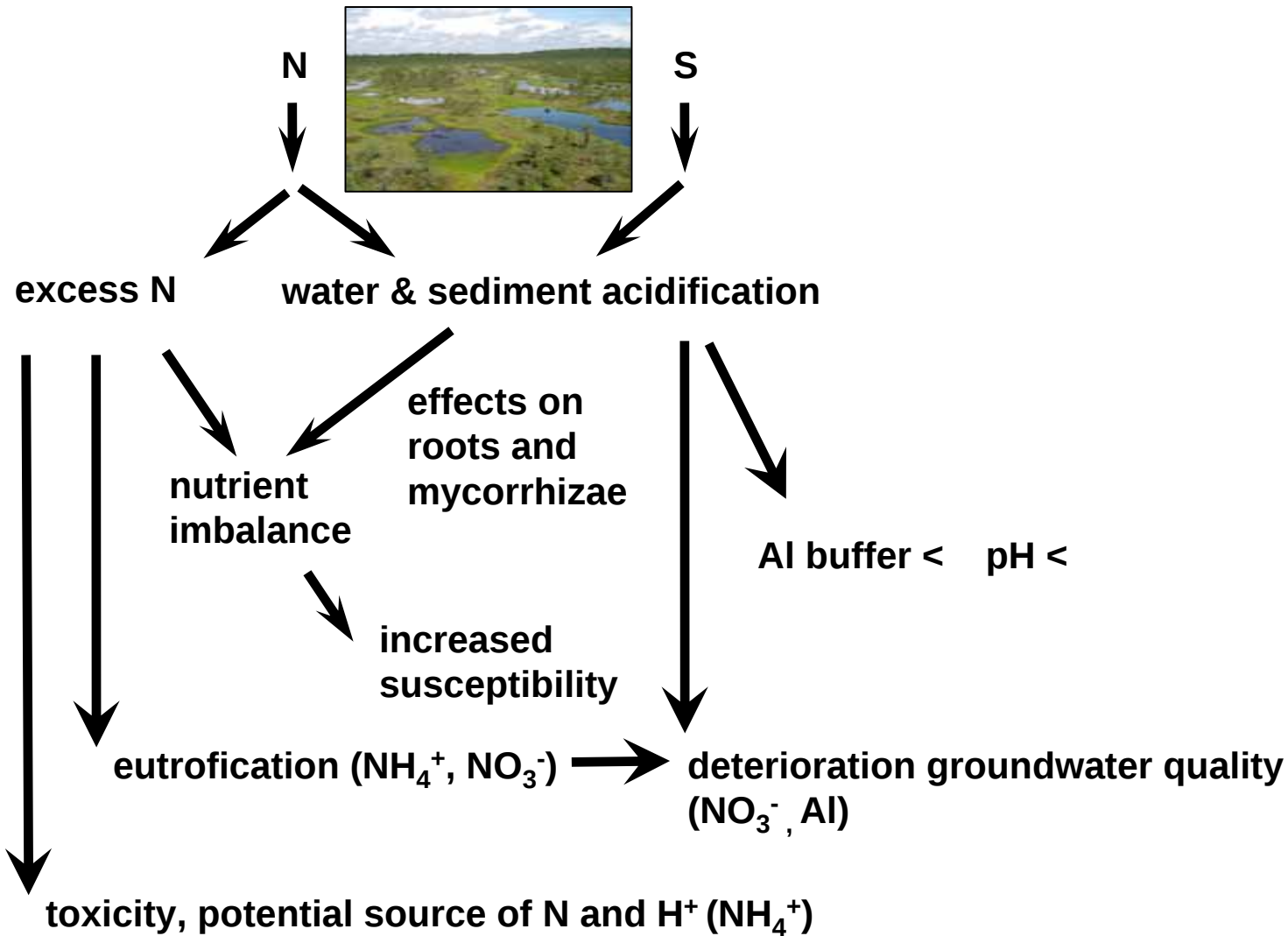
Effects of *reduced* versus *oxidized* nitrogen on wetland and aquatic vegetation

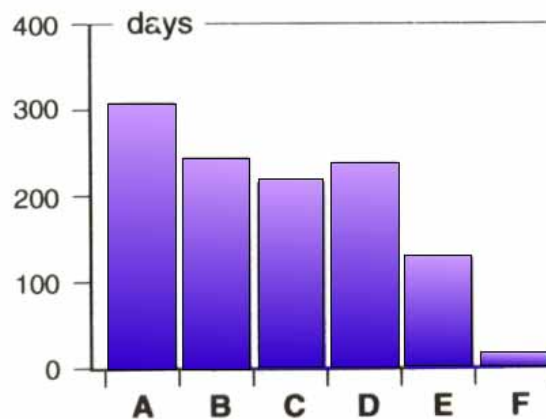
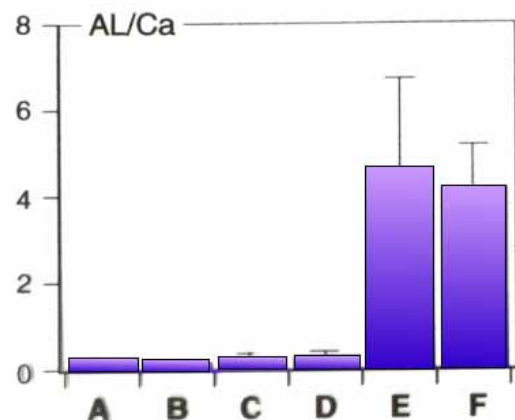
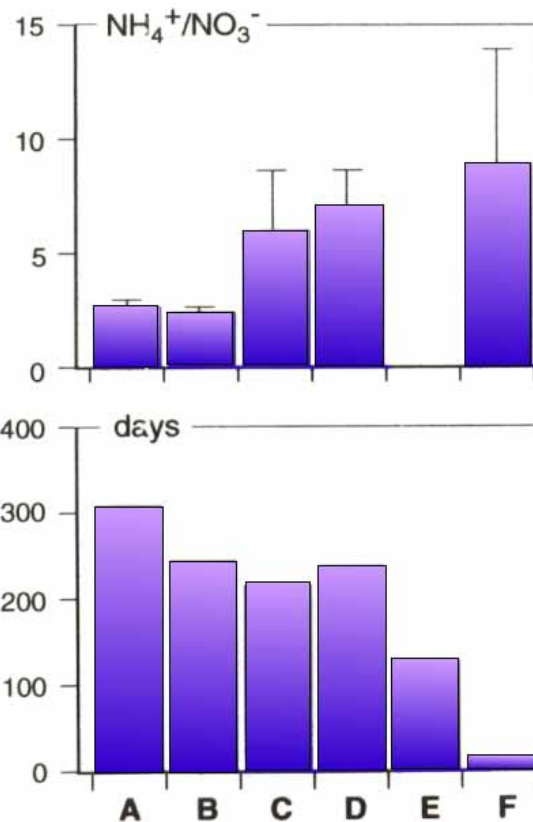
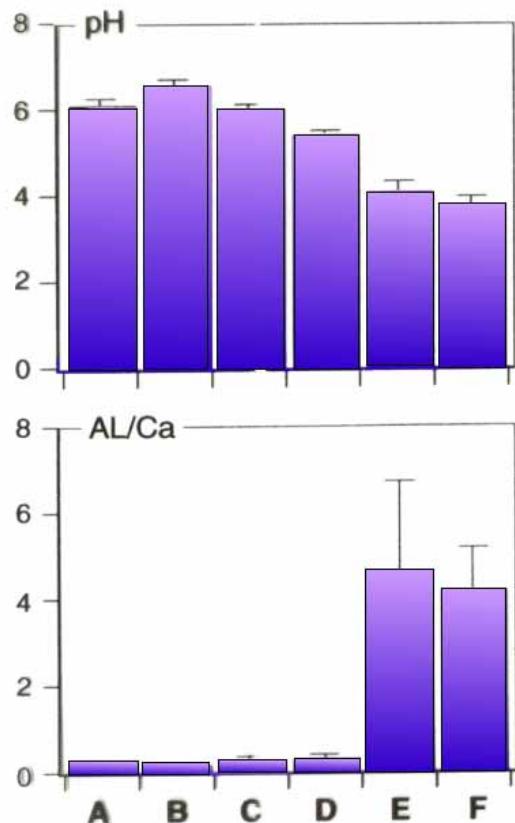
- wet grasslands
 - bogs
 - fens
- softwater lakes
 - estuaries

Effects of *reduced* versus *oxidized* nitrogen on wetland and aquatic vegetation



Boxman *et al.* Forest Ecol. Manag. 2001 & unpublished





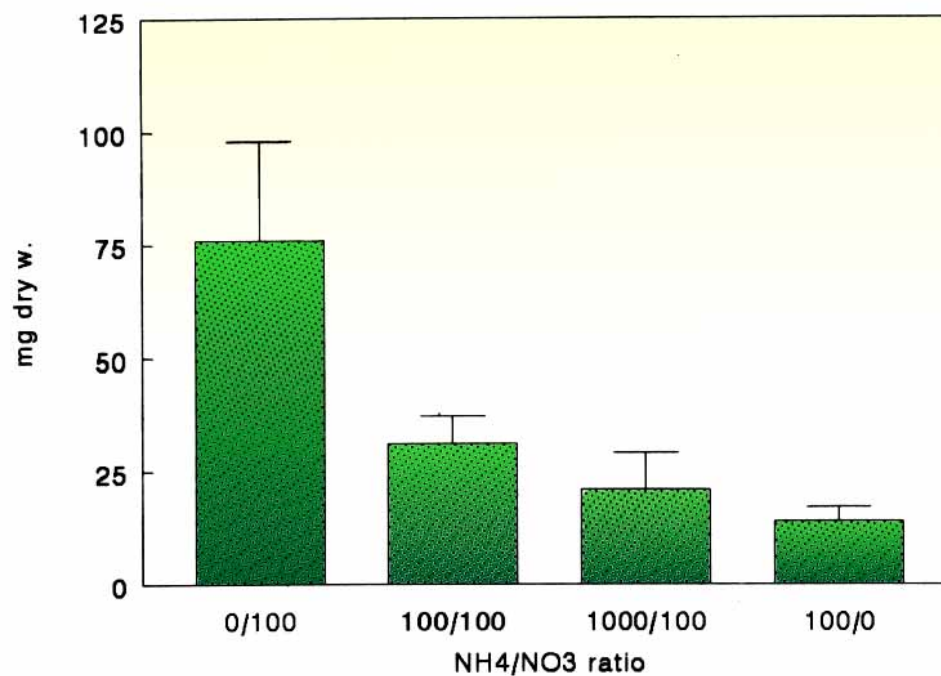
sedges

wet grassl.

De Graaf PhD Thesis 2000

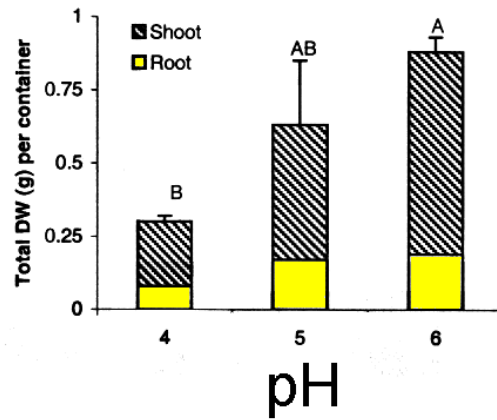


Plant dry weight *Cirsium dissectum*

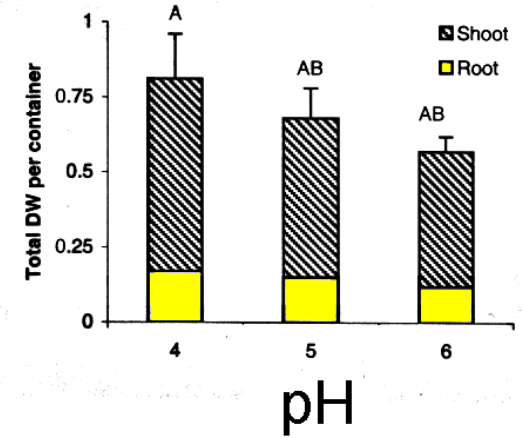


De Graaf *et al.* Plant Ecol. 1998

Ammonium



Nitrate



Lucassen *et al.* Plant Ecol. 2003



Draved Mose, Denmark 1955

Aaby 1994



Draved Mose, Denmark 1961

Aaby 1994



Draved Mose, Denmark 1987

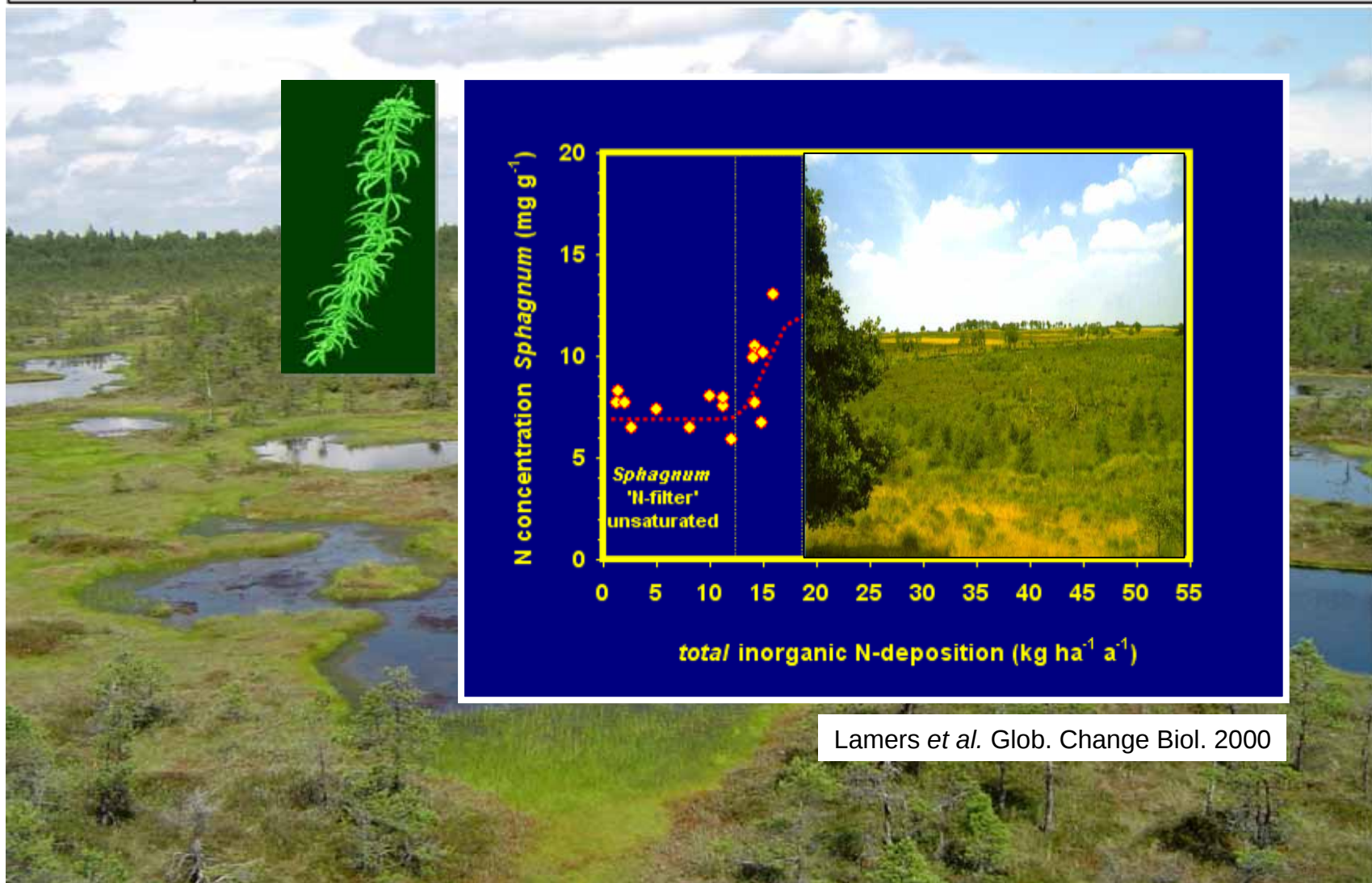
Aaby 1994



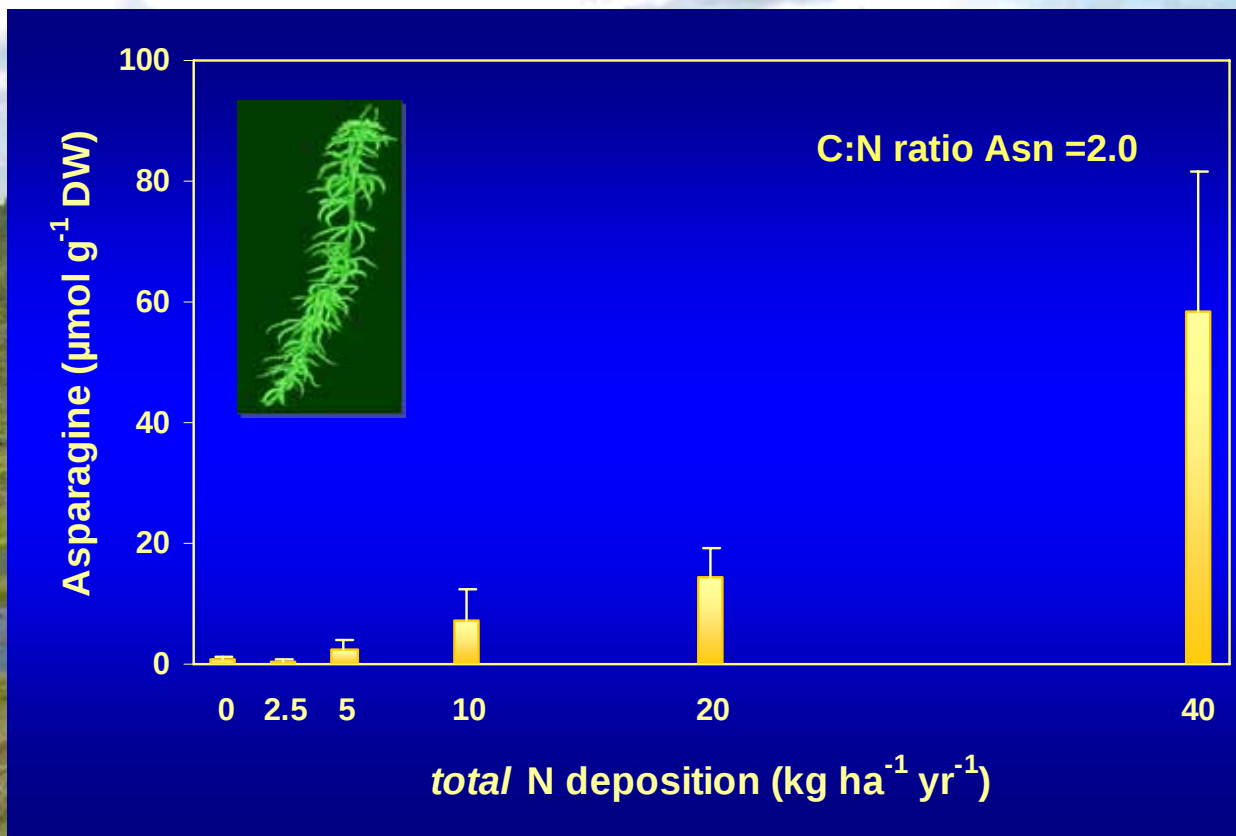
Aaby 1994

	N-deposition (kg N ha ⁻¹ yr ⁻¹)	NH ₄ ⁺ pore water (μmol l ⁻¹)	NH ₄ ⁺ surface water (μmol l ⁻¹)
Ireland			
<i>Clara bog</i>	5.6	2 - 9	2 - 7
<i>Sharavogue</i>	-	2 - 3	3 - 13
The Netherlands			
<i>Bargerveen</i>	19.0	20 - 50	15 - 100
<i>Haaksbergerveen</i>	25.1	20 - 70	60 - 80
<i>Mariapeel</i>	25.7	30 - 220	95 - 300
<i>Pikmeeuwenwater</i>	19.0	70 - 90	25 - 70

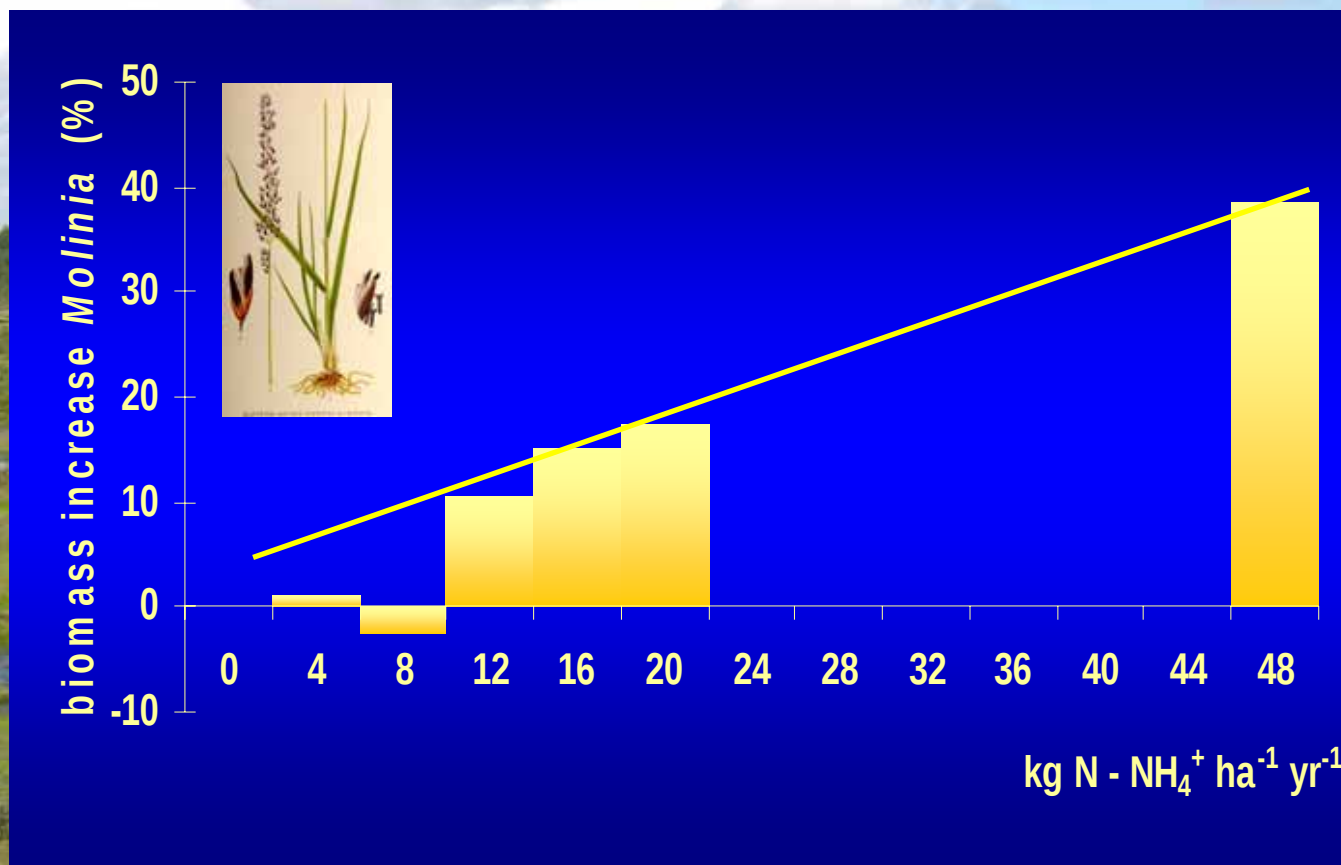
Schouwenaars et al. 1997



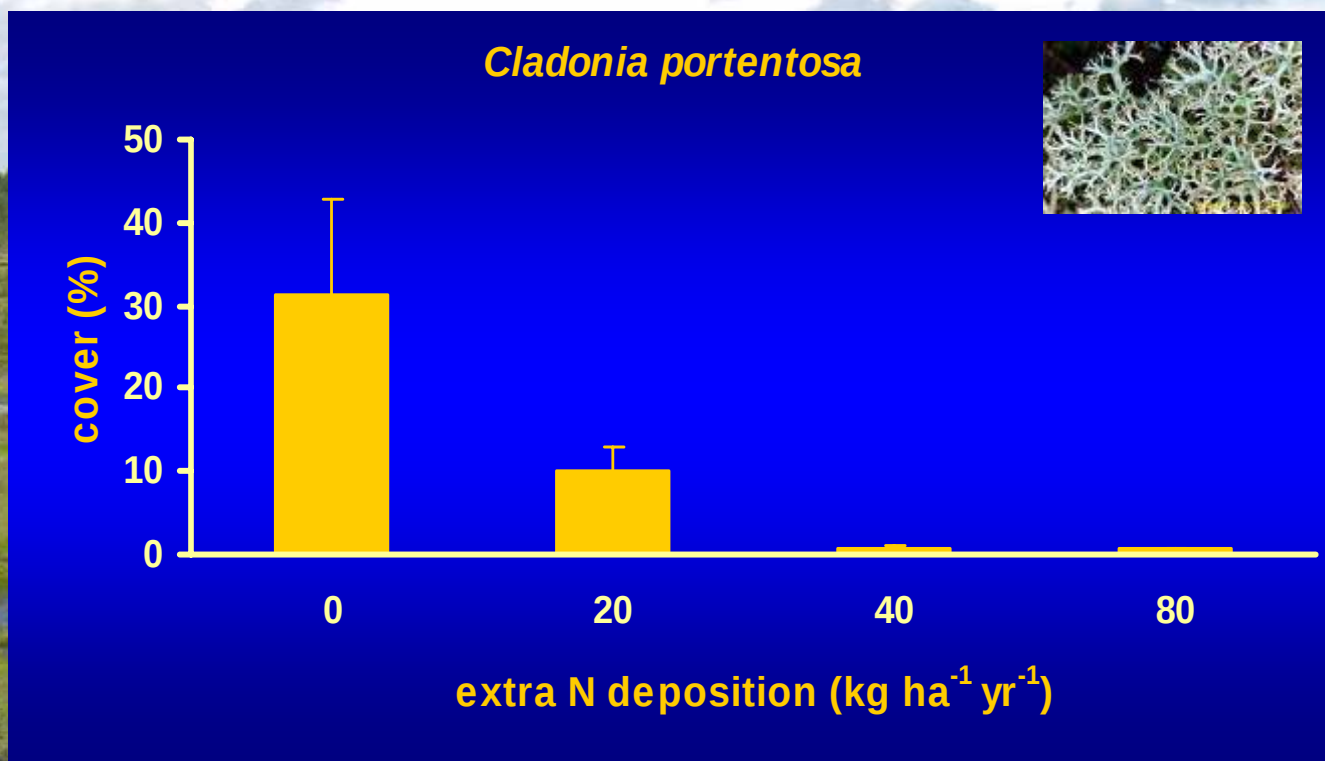
Lamers et al. Glob. Change Biol. 2000



Tomassen *et al.* J. Appl. Ecol. 2004



Tomassen et al. J. Appl. Ecol. 2004

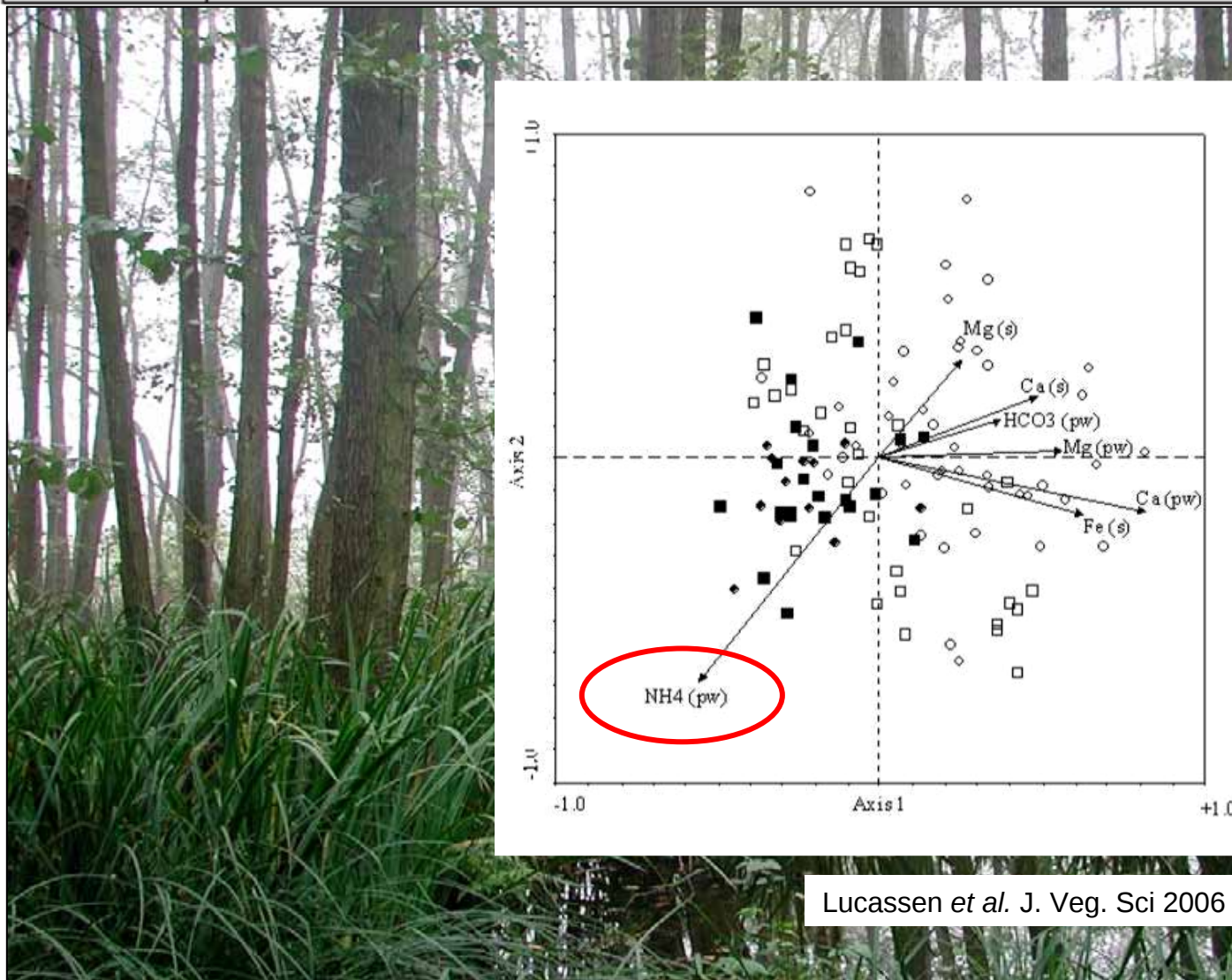


Tomassen et al. J. Appl. Ecol. 2004

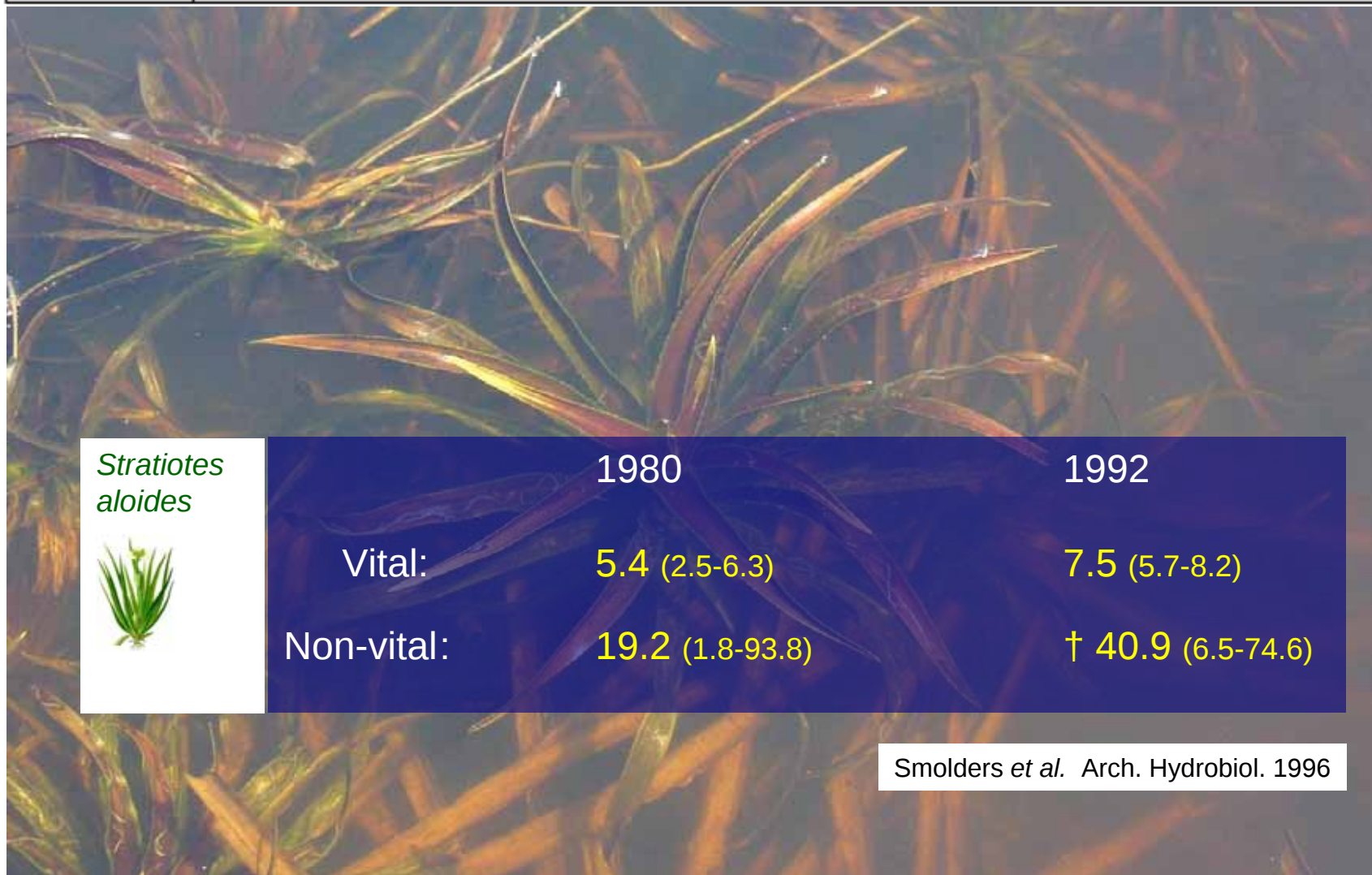




Boxman *et al.* 2000
Lucassen *et al.* Plant Soil 2005
Lucassen *et al.* Wetl. Ecol. Manag. 2005



Lucassen *et al.* J. Veg. Sci 2006



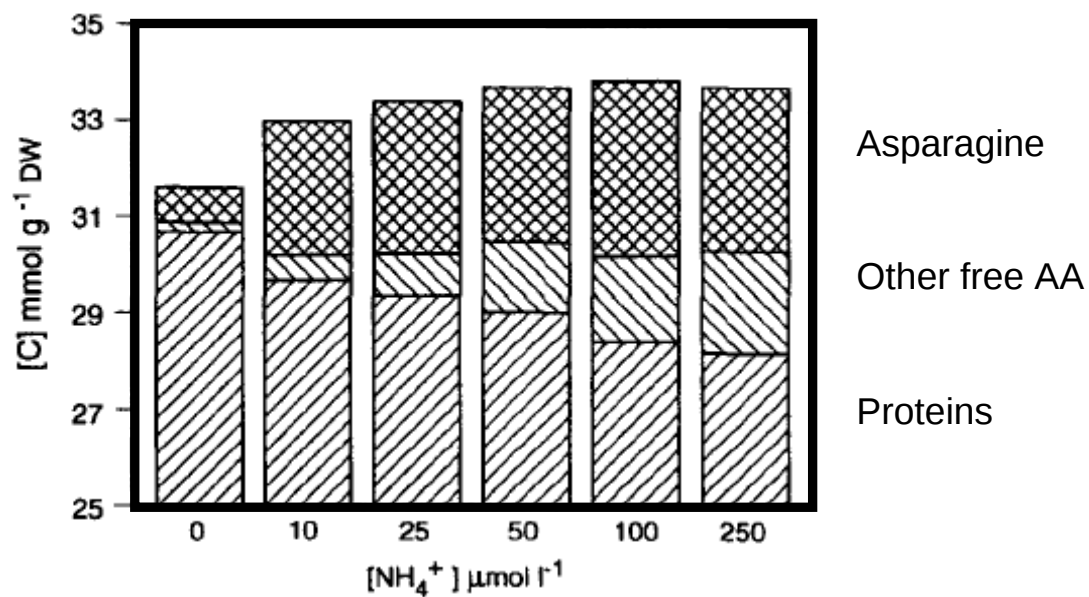
*Stratiotes
aloides*



	1980	1992
Vital:	5.4 (2.5-6.3)	7.5 (5.7-8.2)
Non-vital:	19.2 (1.8-93.8)	† 40.9 (6.5-74.6)

Smolders *et al.* Arch. Hydrobiol. 1996

*Stratiotes
aloides*



Smolders *et al.* Aquat. Bot. 1996





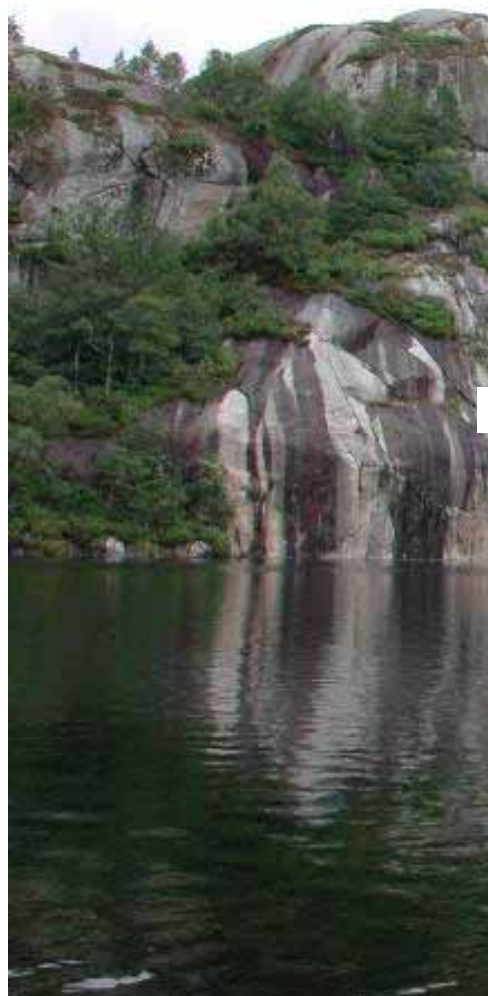
Lobelia dortmanna



Isoetes echinospera



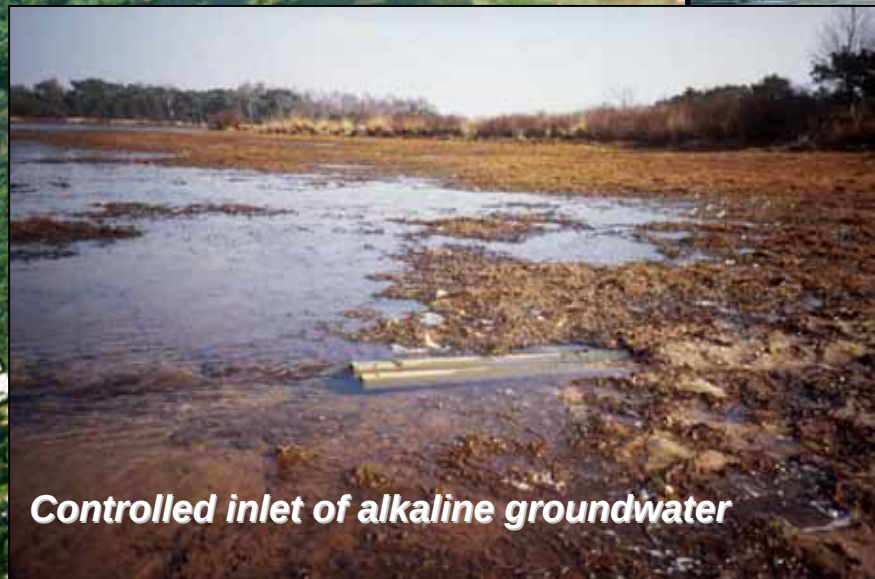
Isoetes lacustris

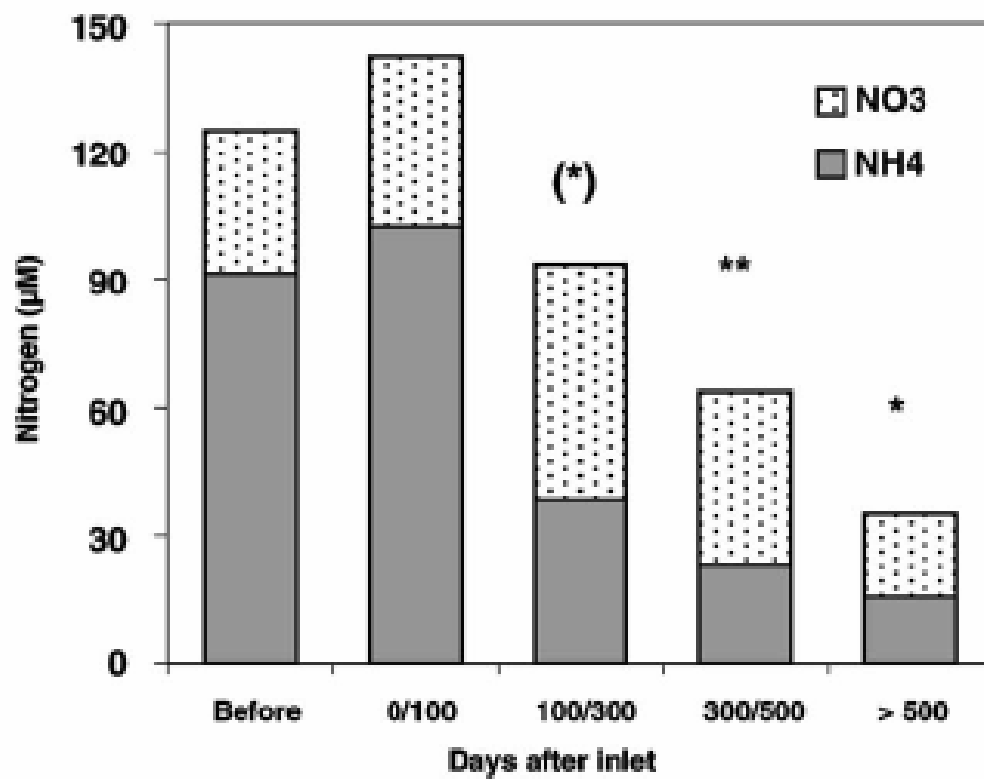


Water layer	n	$\mu\text{mol L}^{-1}$		
		CO ₂	NH ₄	NO ₃
<i>Elatine hexandra</i>	7	<20	3	5
<i>Littorella uniflora</i>	23	<50	5	10
<i>Luronium natans</i>	32	<50	13	115
<i>Eleogiton fluitans</i>	29	<50	17	134
<i>Juncus bulbosus</i>	107	>100	40	7
<i>Sphagnum spp.</i>	59	>500	46	7

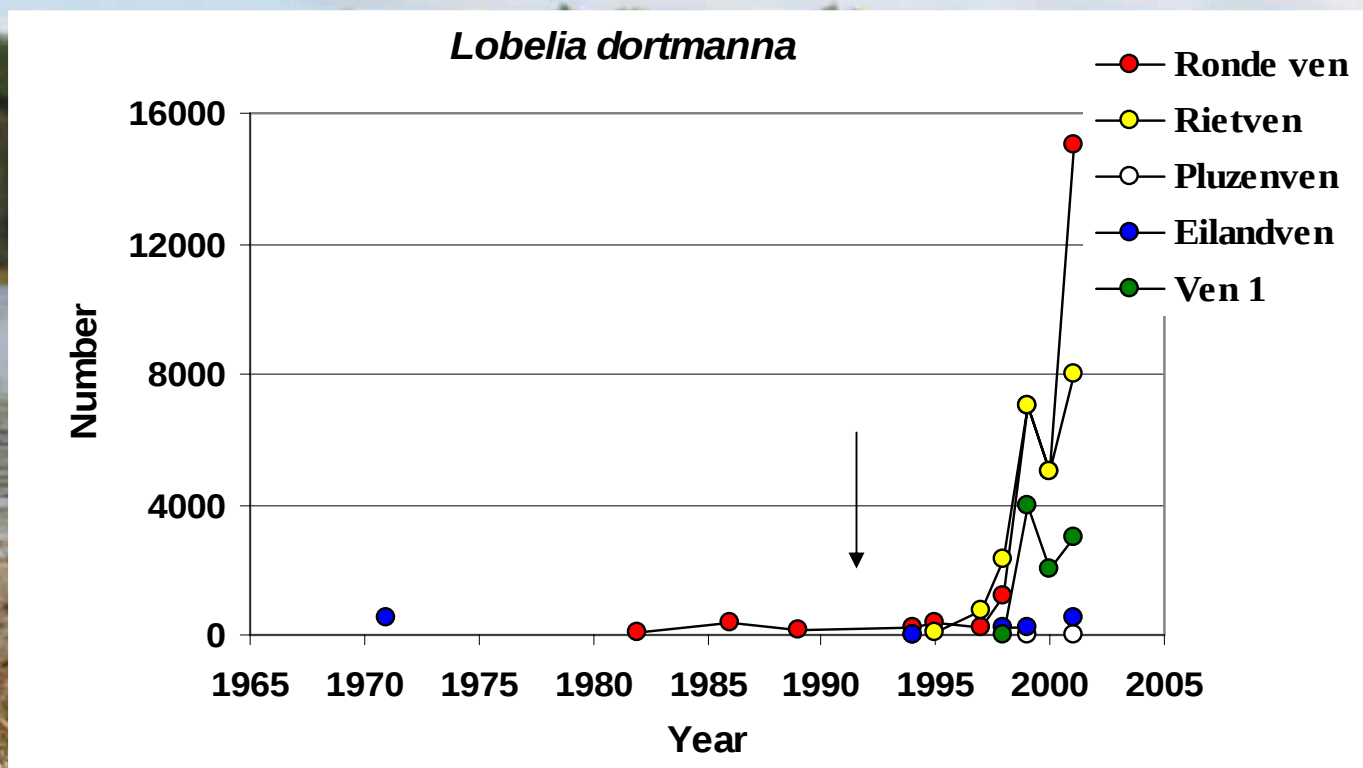
Roelofs Aquat. Bot. 1983





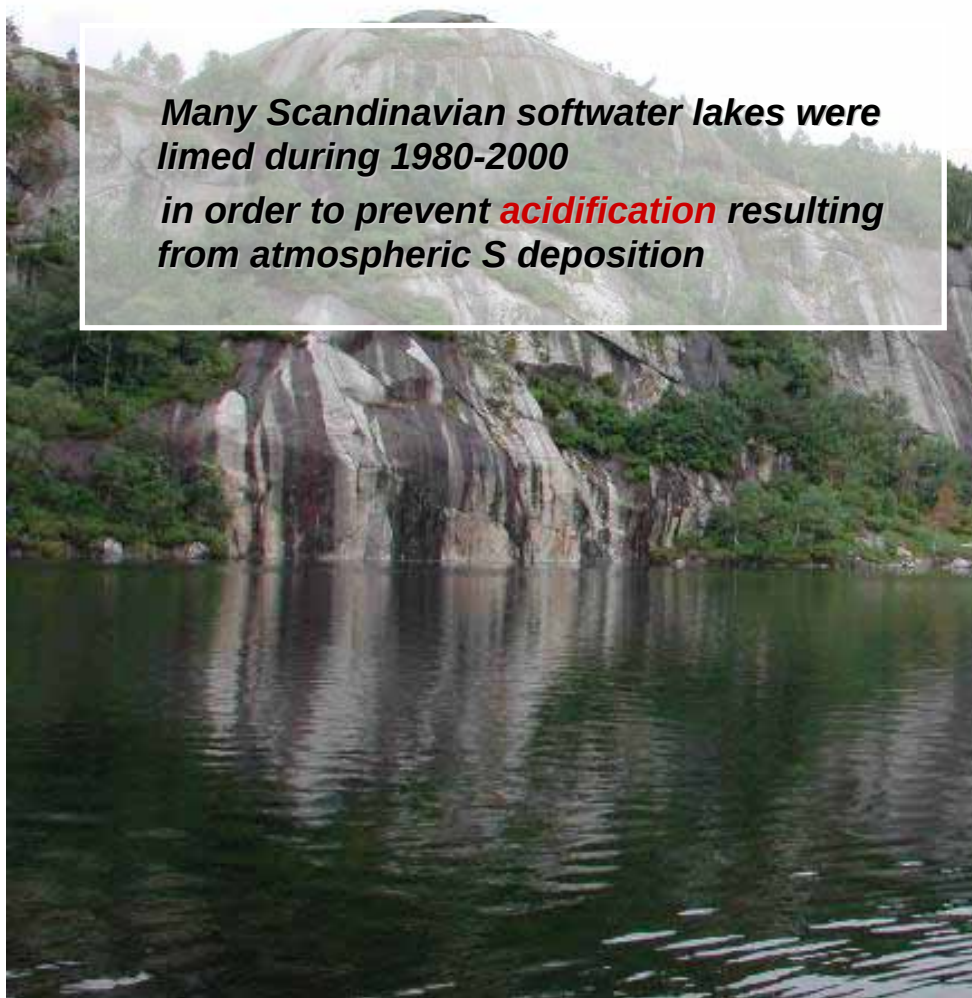


Brouwer *et al.* Aquat. Bot. 2002

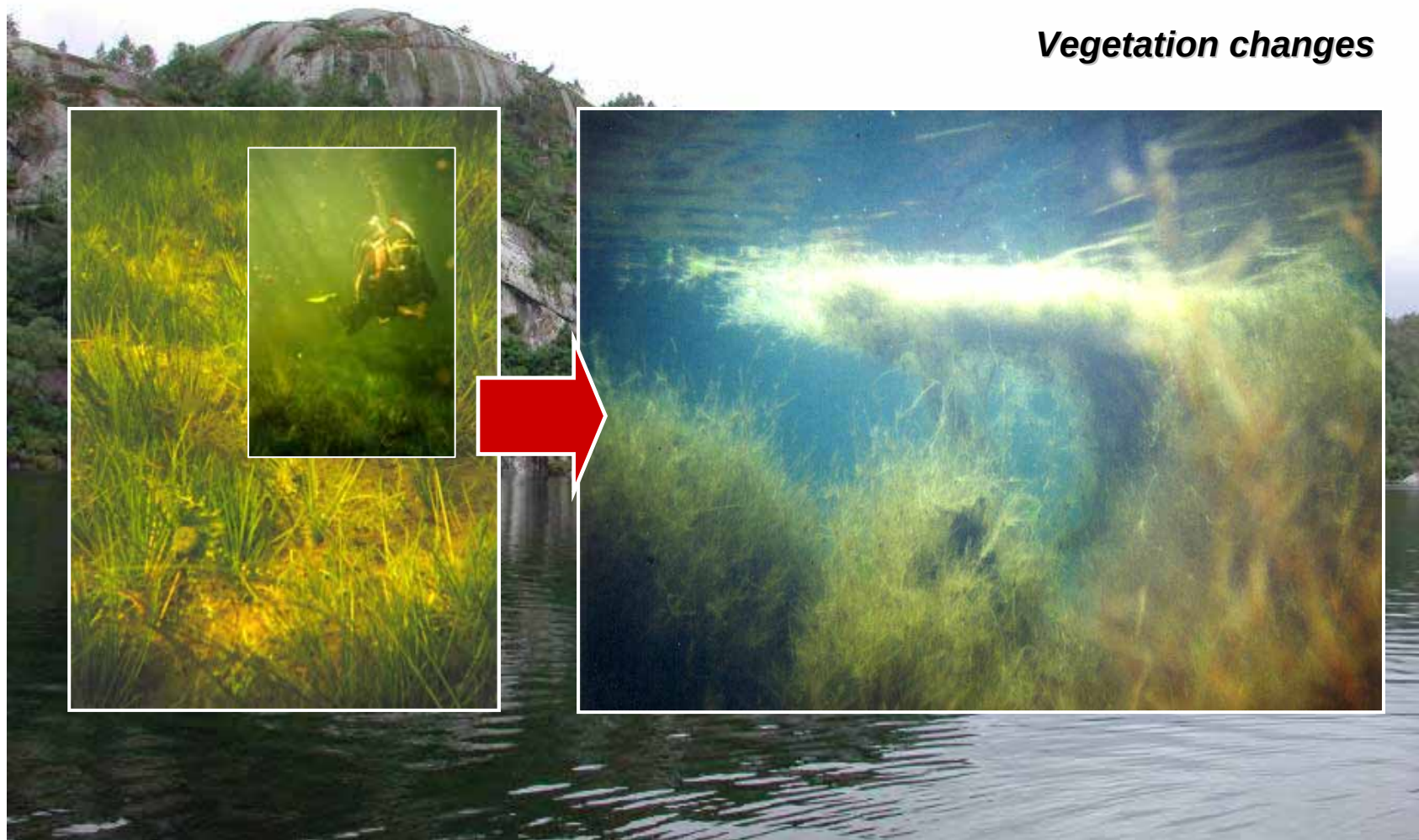


Brouwer et al. Aquat. Bot. 2002

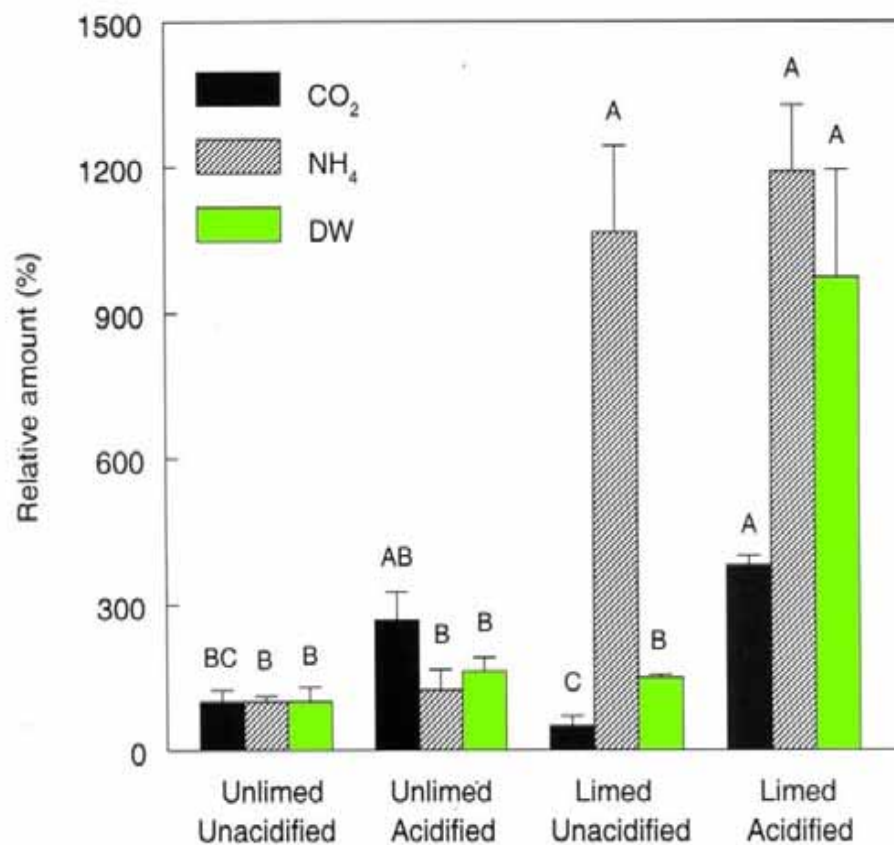
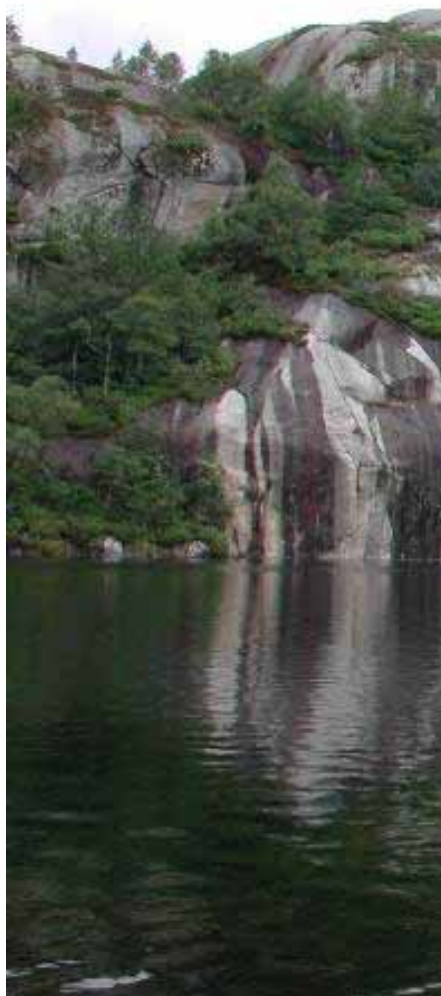
*Many Scandinavian softwater lakes were limed during 1980-2000
in order to prevent **acidification** resulting
from atmospheric S deposition*



Vegetation changes



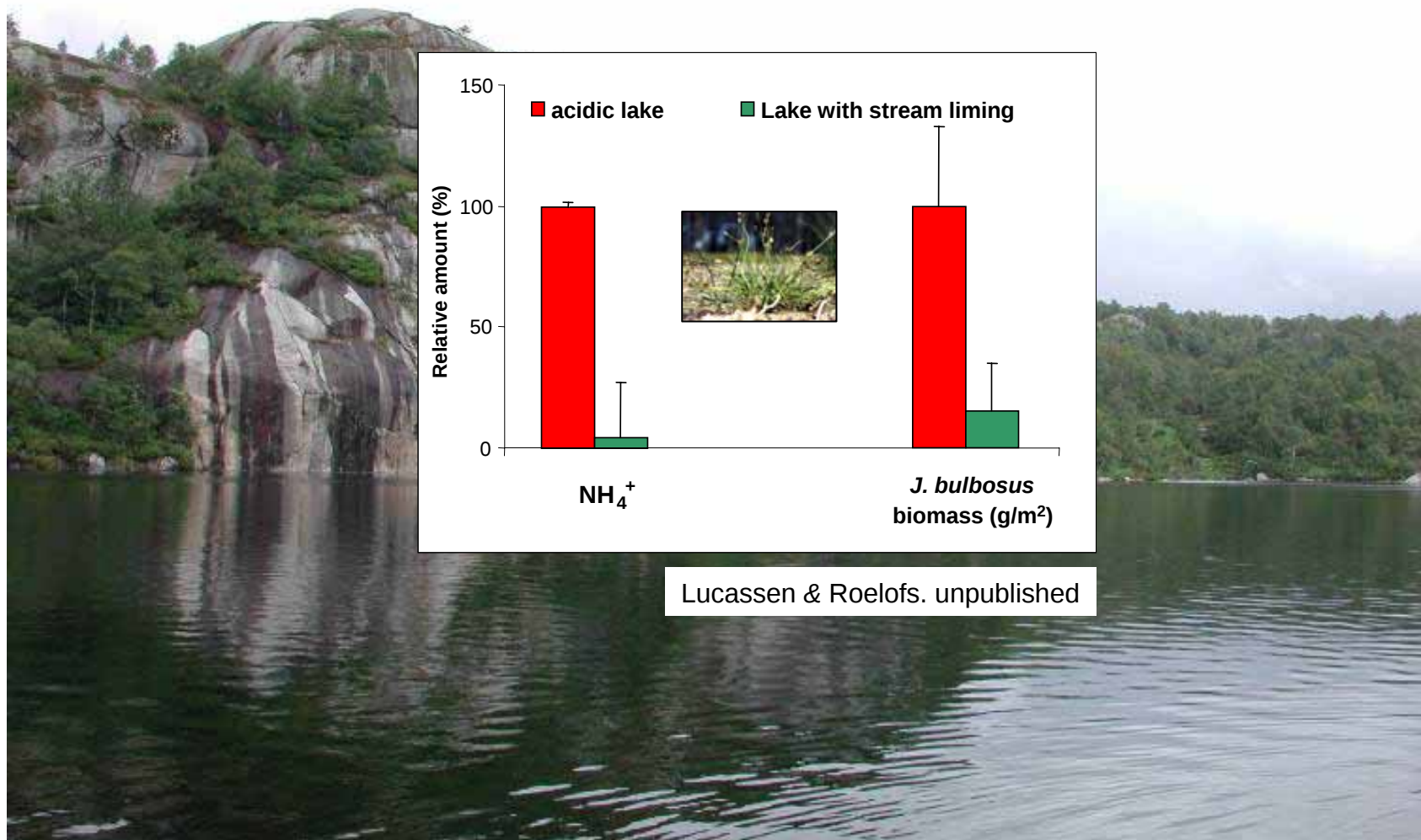




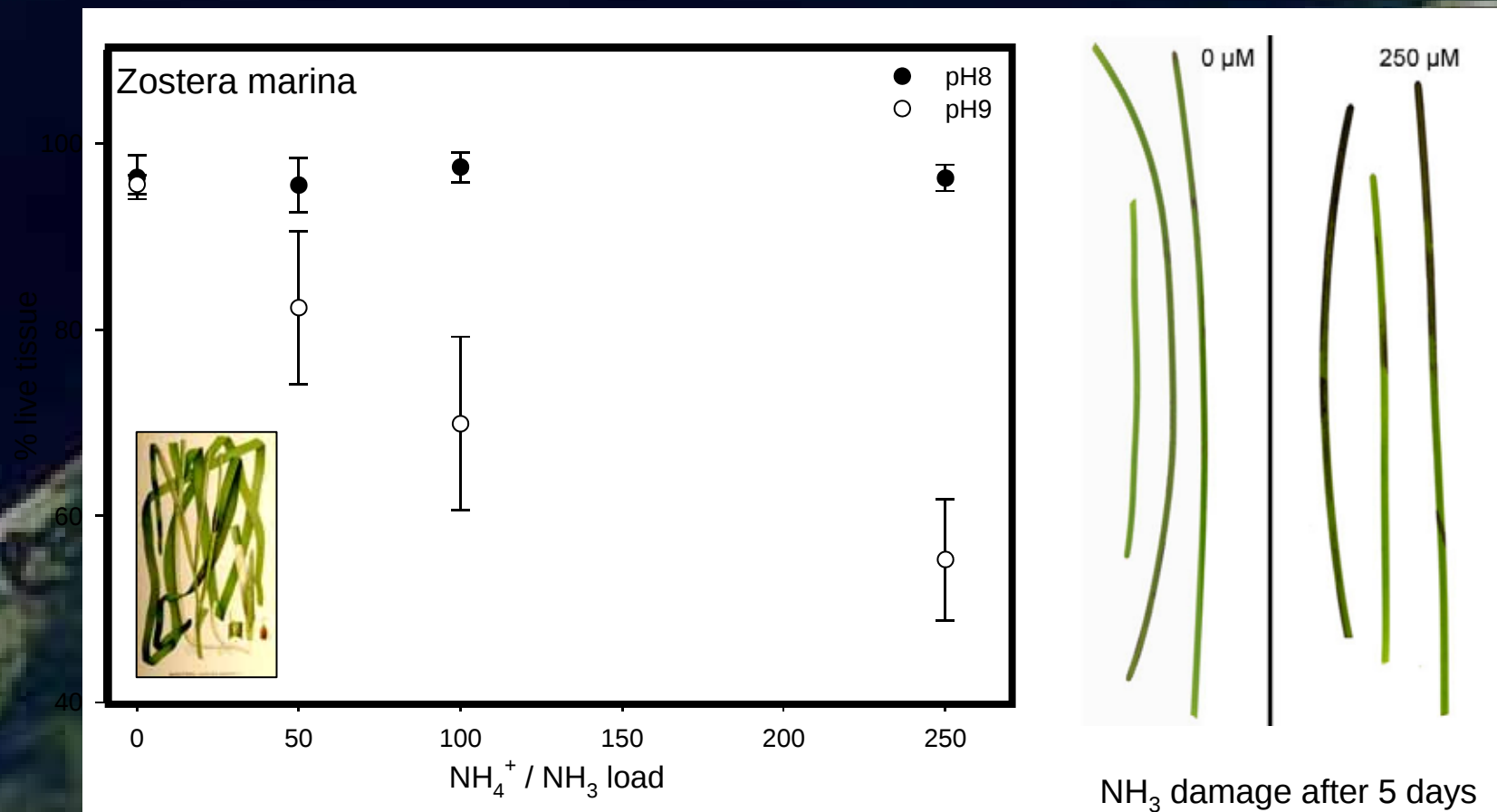
Lucassen *et al.* Aquat. Bot. 1999



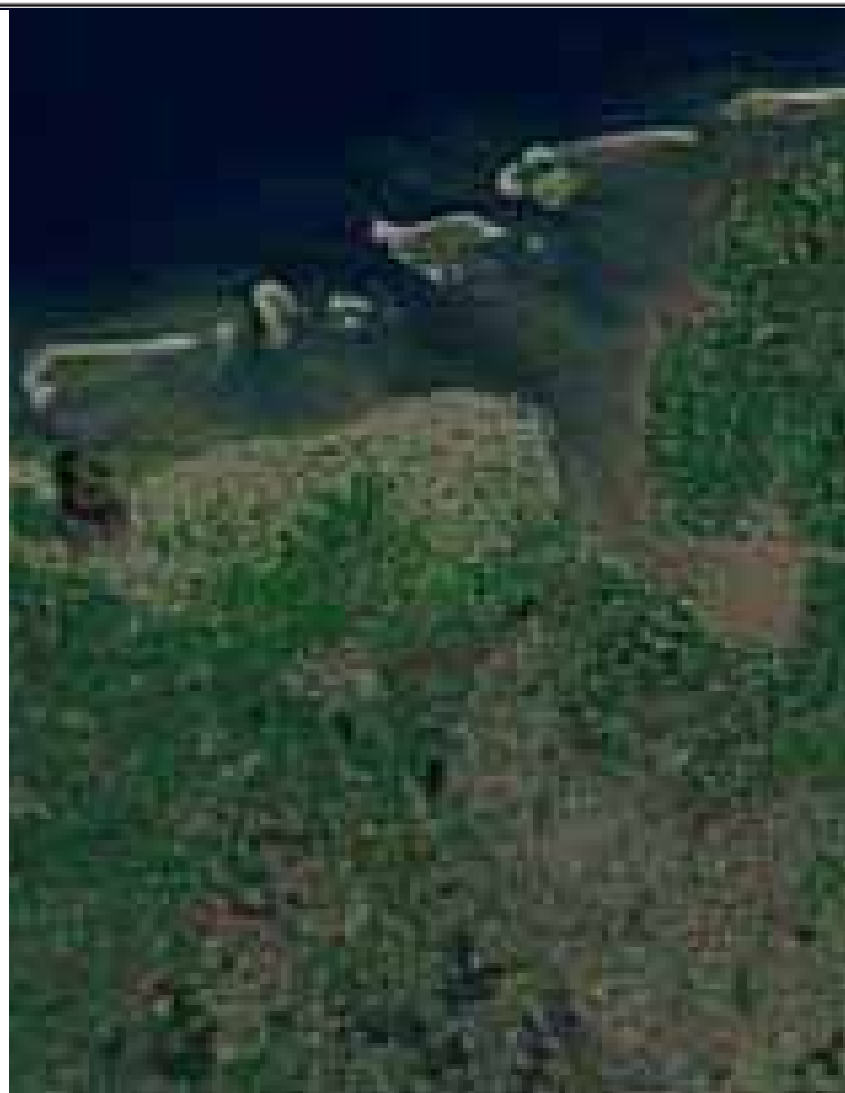
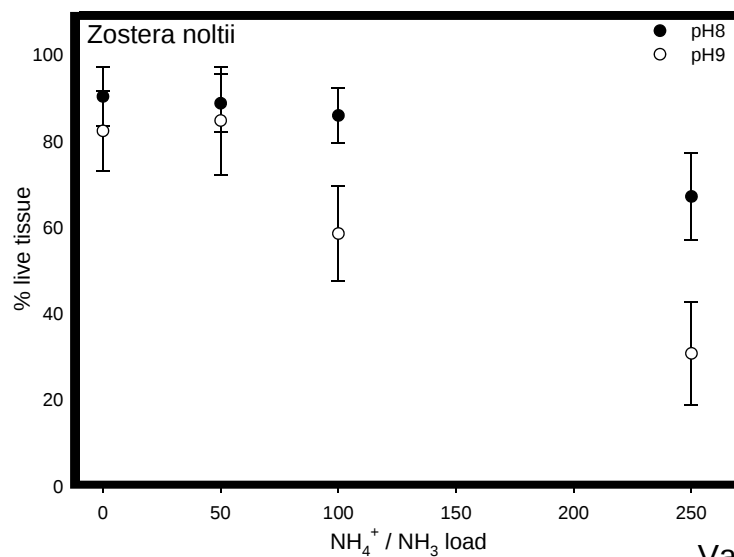
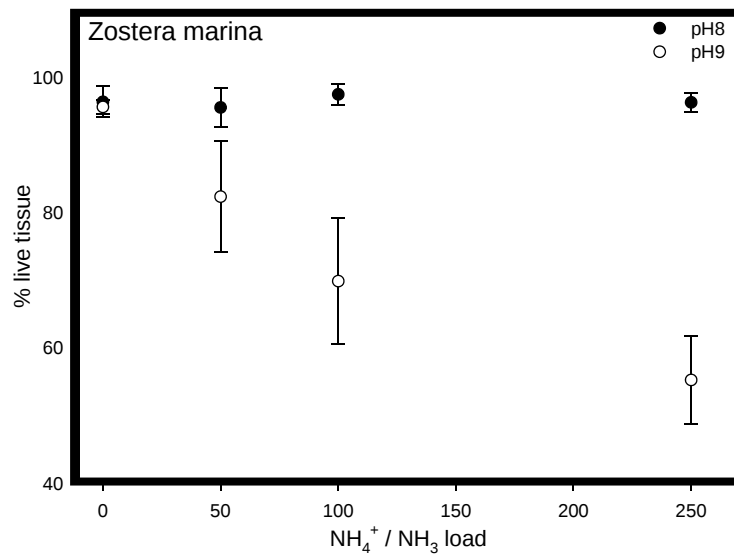




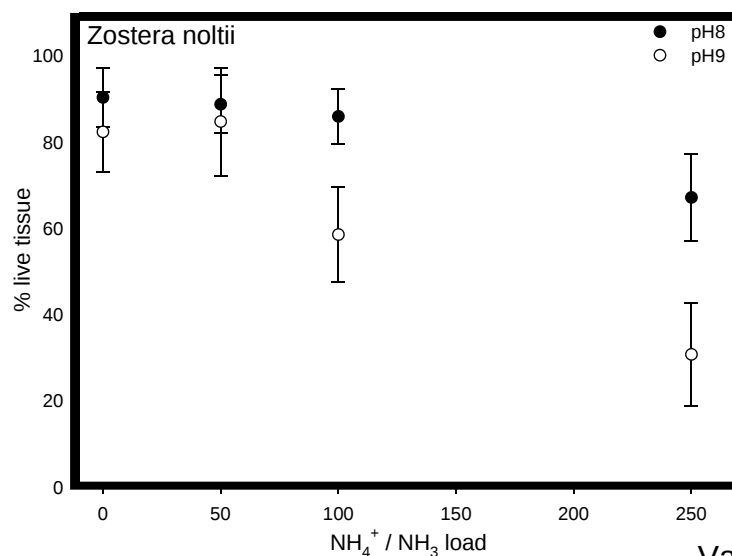
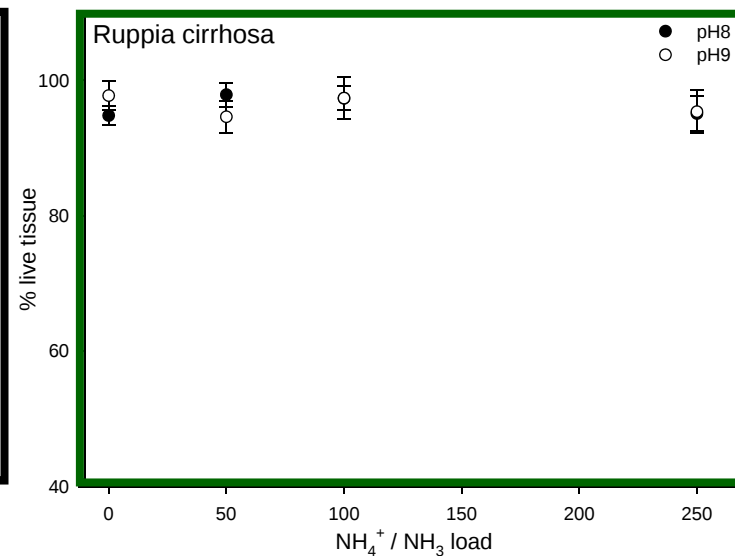
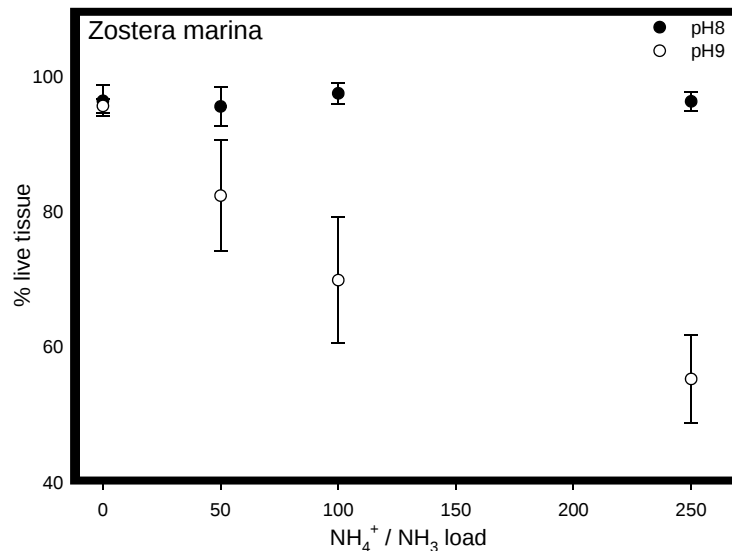




Van der Heide *et al.* in prep.



Van der Heide *et al.* in prep.



Van der Heide *et al.* in prep.

Effects of *reduced* versus *oxidized* nitrogen on wetland and aquatic vegetation

Conclusions:

- NH_4^+ (and NH_3) toxicity throughout ecosystems
- general detoxification mechanisms
- $\text{NH}_4^+ / \text{NO}_3^-$ ratio important
- species shift and biodiversity loss
- impact depends on total N fluxes and the ratio between reduced and oxidized nitrogen