Appendix 1: Development of the vegetation over the growing season

Plant cover of emergent and submerged macrophytes increased over the growing season. This increase was much stronger inside the exclosure compared to the control plot. We observed strong herbivore effects on plant cover of different species groups already one year after placing the exclosures (Table A1.1, Fig. A1.1).

Table A1.1. Effects of time and exclosure treatment on cover of emergent species and submerged and floating species over the growing season in 2011 and 2012. Chi-squares (χ^2) and significance (*P*) calculated with general linear mixed models with paired plot nested within study area and month as random factor (See methods in the main manuscript). Degrees of freedom (d.f.) are 1 for all analyses, because *P* values were obtained by comparing two models: with and without the term of interest.

	Emergent cover		**Submerged and floating cover**	
	χ^2	***P***	χ^2	***P***
2011				
Time (T)	14.41	<0.001	14.76	<0.001
Exclosure treatment (E)	36.92	<0.001	23.94	<0.001
Interaction (T*E)	12.73	<0.001	9.64	0.002
2012				
Time (T)	15.44	<0.001	10.21	0.001
Exclosure treatment (E)	67.21	<0.001	22.11	<0.001
Interaction (T*E)	7.26	0.007	4.06	0.044

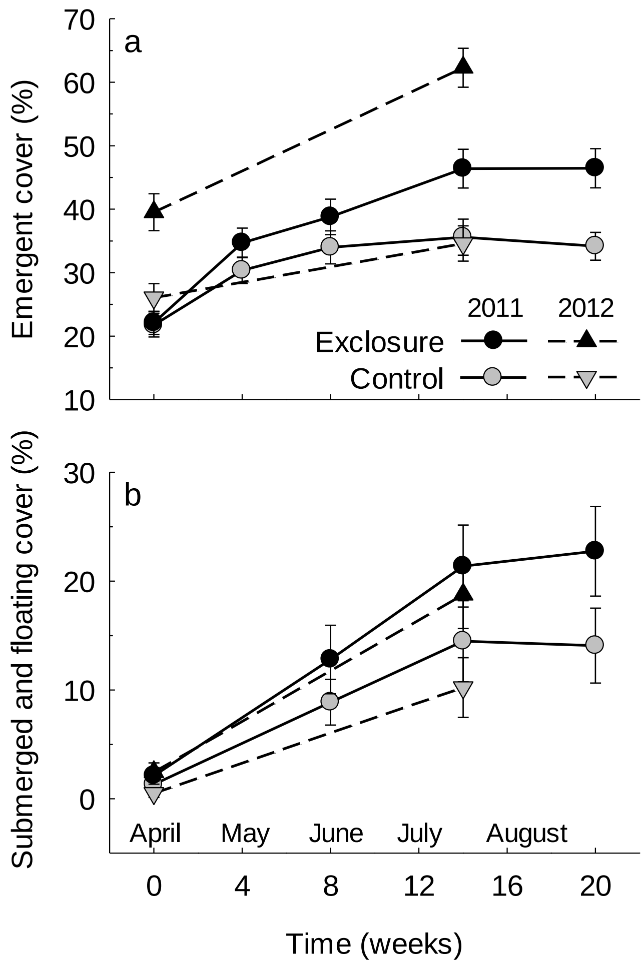

Figure A1.1: Cover of a) emergent plant species and b) submerged and floating species in exclosures and control plots over the growing season of 2011 (starting end March, early April till the end of August) and the growing season of 2012 (starting mid-March till mid-July, which was week 14 of the previous year).

Appendix 2: Herbivore identity

Herbivore density itself is often hard to quantify, and previous attempts to relate herbivore density to the effect size of grazing have found a weak or no correlation (Marklund and others 2002), which may explain the absence of a direct correlation between aquatic herbivores and vegetation characteristics. However, our areas contained different herbivore types and some are more and others are less likely to be the potential main herbivore.

Herbivore densities over time

Whereas Mallard and Mute swan densities remained stable over the past ten years in the Netherlands, the number of Graylag geese breeding pairs increased with 21% and their total population increased with ca 8% per year (Boele and others 2012; Hornman and others 2013). Hunting of Graylag geese is restricted and may only occur between 15 august and 30 september.

Muskrat is an invasive species which arrived in the Netherlands around 1950. After an initial fast increase, large efforts have been taken to decrease population densities by muskratcatchers. Since around 2000 the number of caught muskrats per year have decreased considerably whereas the catching efforts (hours of hunting) remained the same or increased. In the central catching district in the netherlands (where most of our study areas were located), the total number of muskrats caught decreased from 174 000 in 2004 to about 24 000 in 2010, 19 000 in 2012 and nearly 16 500 in 2013 (Anouk Prins, Muskrat control agency, Huizen, the Netherlands).

If livestock was present in the area, it was only allowed on the meadows in late summer (august), at the end of the bird breeding season. When conditions become to cold or too wet in autumn they were taken from the fields.

Aquatic herbivores

Visual inspection of the grazing damage on stems matched the feeding behavior of swans and goose as scars were found mostly between 10 and 50 cm above the water (van den Wyngaert and others 2003). Besides, the number of stems with signs of herbivory was highest on the vegetation fringe (data not shown) and vegetation cover of both emergent and floating and submerged plants was decreased outside the exclosures (Fig. A2.1), which points towards herbivores coming from the water. We therefore assume that waterfowl can be responsible for the observed effects.

In our multiple stepwise regression (See appendix 3), we summed the aquatic herbivores per area which did not result in inclusion of herbivore in any of the models. When waterfowl, muskrats and livestock were entered as separate variables together with the other variables, muskrat density was included as an explanatory variable for i) the emergent cover difference between control plots and exclosures in 2012, ii) the emergent cover increase between 2011 and 2012 in the control plots, iii) the proportion of species colonising the exclosures and iv) species disappearing from the control plots. Our study, in line with the results of a correlative field survey (Sarneel and others 2011), therefore adds (correlative) evidence of a top down control of this invasive species, which still awaits experimental testing.

Because grazing effects decreased with increasing water depth, we, in line with other studies on the role of fish (Marklund and others 2002; Gayet and others 2011), suspect that grazing by fish played a minor role.

Terrestrial grazers

In 4 of the 10 areas, livestock was grazed on the meadows bordering the water bodies in which the control plots and exclosures were placed (Fig. A2.1; MID, on average 287 kg cows ha^{-1}; NKP, 313 kg cows ha^{-1}; GRJ, 84 kg sheep ha^{-1} and WEZ, 152 kg sheep ha^{-1}. For explanation of area codes see the legend of Fig. A3.1). Signs of livestock grazing (leaf and stem damage high above the soil level (up to ca 1 m), hoof prints) were found in 9 of the 50 replicates (MID = 3 accessible replicates, NKP = 2, GRJ = 3 and WEZ = 1) and we removed 2 of those replicates (in NKP) from our analysis because the cattle destroyed the fences of the exclosures. The placement of the other plots was as such that they most likely could not be easily reached by the sheep and cows (See Fig. 1.b) as a dense *Phragmites* stand at the bankward plot end and intermediate to deep water at the open water plot end refrained livestock from entering the plot. As we observed clear herbivore effects at both sites with and without livestock (both regionally; over all areas, and locally, over the gradient from the water to land), we conclude that livestock likely did not play a large role in our study.

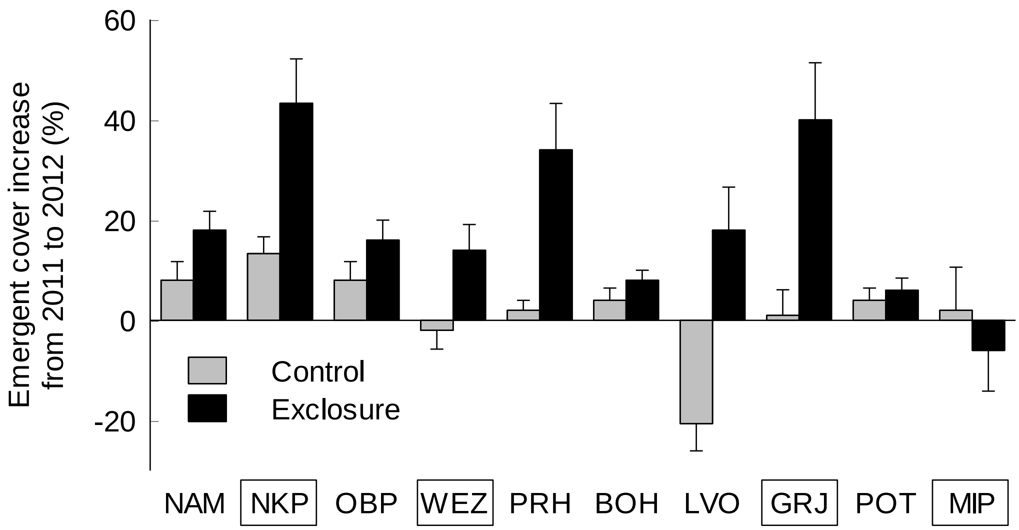

Figure A2.1: Emergent cover increase (%, ±S.E.) from July 2011 to July 2012 in the control plots and exclosures per study area. Area order along the x-axis indicates an increasing muskrat density. Squares around the area name indicate the presence of large grazers in those areas. Abbreviations of area names are Naardermeer (NAM), Nieuw Keverdijkse polder (NKP), Oostelijke Binnenpolder (OBP), De Westbroekse Zodden (WEZ), Polder Ronde Hoep (PRH), Botshol (BOH), Loenderveen Oost (LVO), Groene Jonker (GRJ), Polder Tienhoven (POT), Middelpolder (MIP). See Table 1 in the main manuscript for more site descriptions and muskrat densities.

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Appendix 3: Correlation between environmental variables

Methods

We first correlated all measured and calculated environmental variables with each other using Pearson correlation in SPSS (SPSS 19.0; IBM Corporation, Armonk, New York). We selected a set of variables that were not correlated and provided representative measures of relevant growth conditions (Table A3.1). Subsequently, we performed multiple stepwise regressions (in SPSS) with these selected independent variables to determine which of them affected vegetation development and species turnover (Table A3.2).

Because water depth and vegetation N:P ratio appeared most often as determining vegetation characteristics, those were selected for further analyses.

Table A3.1. Pearson correlation coefficient between the environmental variables. Variables in the first row and first column follow the same order and abbreviations are indicated in the first column. Methods are described in the main text. Variables in the gray area were included in the regression analysis. Bold numbers are significant at the 0.05 level and underlined numbers are significant at the 0.01 level

	N:P	**Mass**	**Depth**	**Fetch**	**Graz.**	**Algae**	**Secchi**	**Rat**	**Bird**	**L.St.**	**N**	**P**
N:P - Vegetation N:P ratio (gg^{-1})	1											
Mass - Standing biomass (kgm^{-2})	0.198	1										
Depth - Water depth (m)	0.04	0.092	1									
Fetch - Wind fetch (m)	0.24	0.246	-0.199	1								
Graz. - Aquatic grazers ($kgha^{-1}$)	-0.153	0.107	0.172	0.135	1							
Algae - Algae density (μgL^{-1})	**-0.306**	-0.086	**-0.375**	0.102	-0.102	1						
Secchi - Secchi depth (cm)	**0.342**	0.115	**0.453**	0.244	0.011	**-0.407**	1					
Rat - Muskrat density ($kgha^{-1}$)	0.225	0.238	0.046	**0.304**	-0.238	0.11	**0.477**	1				
Bird - Waterfowl density ($kgha^{-1}$)	-0.153	0.107	0.172	0.135	**1.000**	-0.102	0.011	-0.238	1			
L.St - Livestock density ($kgha^{-1}$)	**-0.314**	0.054	-0.145	-0.029	-0.037	**0.335**	**-0.397**	**-0.325**	-0.037	1		
N - N in biomass (%DW)	-0.056	-0.202	**-0.297**	-0.014	-0.28	0.155	-0.232	0.049	-0.28	0.065	1	
P - P in biomass (%DW)	**-0.834**	**-0.336**	-0.102	-0.284	-0.068	**0.403**	**-0.431**	-0.195	-0.068	**0.305**	**0.425**	1
Water level fluctuations (m)	**-0.331**	-0.15	**-0.609**	-0.058	-0.167	0.28	**-0.593**	**-0.391**	-0.167	**0.587**	**0.411**	**0.398**

Table A3.2. Results of stepwise regression analyses on vegetation characteristics (emergent cover differences between control plots (C) and exclosures (E), species richness, species turnover and changes over time). For each significant model, the goodness of fit (R^2), F and P-value of significant model selected, the independent variables included and their regression coefficients (between brackets) are given. Independent variables were: N:P ratio of the vegetation in 2012, aboveground biomass m^{-2} 2012, water depth averaged over the transect (cm), wind fetch (m), and density of aquatic grazers (kg ha^{-1}). Ns indicates when no model could be fitted.

Dependent	**R^2**	***F***	***P***	**Variables entered**
Emergent vegetation cover E	54.0	54.1	<0.001	Water depth (-45.78)
Emergent vegetation cover C	10.3	5.28	0.026	Fetch (-0.012)
Emergent vegetation cover difference E-C 2012	21.3	13.7	0.001	Water depth (-39.7)
Species richness difference E-C 2012			ns	No variables entered
Emergent vegetation cover increase 2011 to 2012 E	17.2	8.00	0.007	Water depth (-25.4)
Emergent vegetation cover increase 2011 to 2012 C			ns	No variables entered
Proportion of species colonised E	21.0	7.24	0.002	Water depth (-27.8) and Vegetation N:P ratio (-2.1)
Proportion of species colonised C	7.7	4.91	0.032	Vegetation N:P ratio (-2.6)
Proportion of species extinct E	34.6	25.9	<0.001	Water depth (-30.6)
Proportion of species extinct C	8.1	5.16	0.028	Wind fetch (0.012)

Appendix 4: Relation between environment and species richness in 2011

In 2011, we found a decreasing cover and species richness in both the control and exclosure plots (Fig. A4A.1), which was consistently higher in the exclosure plots as the interaction between vegetation N:P ratio and grazing treatment was not significant (Table A4.1). The cover decreased with water depth in the exclosures but not in the control plots (Fig. A4.1). Species richness in the plots was not related to water depth, but was affected by grazing (Fig. A4.1; Table A4.1). Similar trends were observed in 2012.

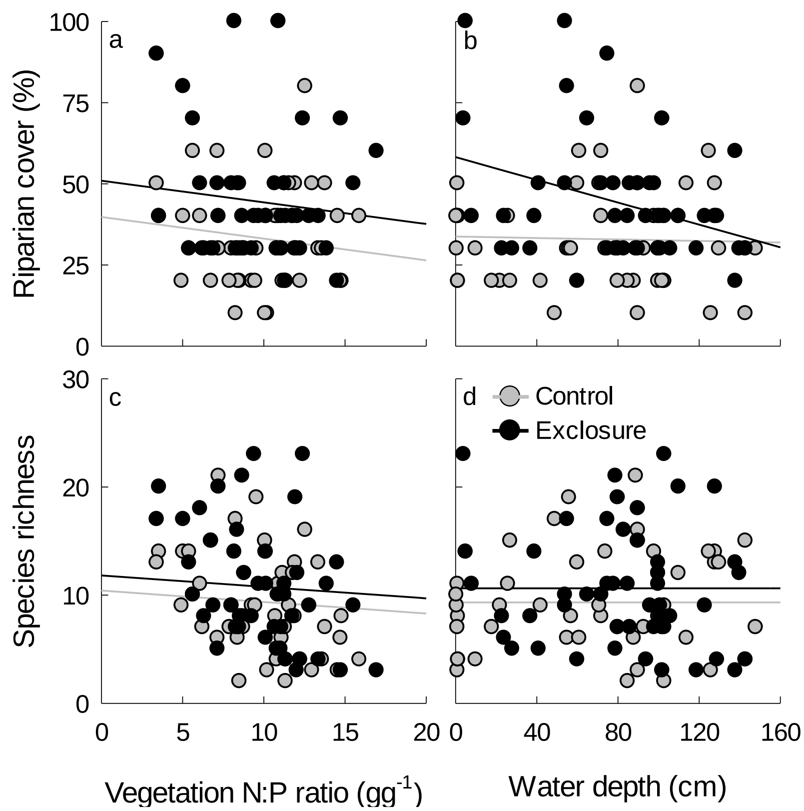

Figure A4.1: Relation between emergent vegetation cover of the transect (a, b) and number of species per transect (c, d) with vegetation N:P ratio and Water depth in the control and exclosure plots for 2011. Vegetation N:P ratio's (gg^{-1}) were determined from the biomass samples taken from the bank side of the plot (see methods). Water depth (cm) was averaged over the entire plot transect. Gray symbols and lines indicate data for exclosures and black symbols and lines indicate data for control plots. Each dot represents one measurement.

Table A4.1: χ^2 and *P*-values of the mixed linear models on the relation between vegetation characteristics and vegetation N:P ratio (gg^{-1}) and water depth (m) in 2011.

Variable	**Environmental covariable**	**Exclosure Treatment**		**Environmental covariable**		**Interaction (Tr x Co)**	
		χ^2	**P**	χ^2	**P**	χ^2	**P**
Emergent vegetation cover 2011 (%)	Vegetation N:P ratio	13.575	<0.001	76.582	<0.001	0.810	0.368
	Water depth	13.880	<0.001	61.257	<0.001	4.792	0.029
Species richness 2011	Vegetation N:P ratio	9.481	0.002	17.348	<0.001	1.460	0.227
	Water depth	7.328	0.007	0.409	0.523	1.676	0.195