Abundance of Migratory and Wintering Geese in Relation to Vegetation Succession in Man-Made Wetlands: The Effects of Grazing Regimes

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Abundance of migratory and wintering geese in relation to vegetation succession in man-made wetlands: the effects of grazing regimes

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The man-made wetlands in young polders in The Netherlands are important stopover and wintering sites for geese. We studied trends in vegetation composition and goose density in two study areas. One was located in a nature reserve situated in a polder reclaimed from an estuary, the other in a reserve in a polder reclaimed from a freshwater lake. In the former we compared an area of spontaneous vegetation succession with a summer-grazed area. In the latter the effect of reed *Phragmites australis* cover and height on field selection of geese was studied in an area grazed year-round by cattle and horses. In both study areas the area of short grassland (reed cover about 1%, reed height <0.5 m) was found to be significantly positively related to the grazing density of cattle and horses. Migrating and wintering Greylag Geese *Anser anser* and Barnacle Geese *Branta leucopsis* preferred to feed on these extensive short grasslands. In the ungrazed part of the study site in the reclaimed estuarine area, there was an inverse relation between goose density and the ousting of pioneer species of saline habitats and short grasses by tall species such as *Calamagrostis epigejos, Phragmites australis*, tall herbs and shrubs. Summer grazing by cattle and horses at stocking rates of about 0.4 to 0.9 animals/ha, retarded the vegetation succession to some extent, which resulted in a goose density being higher in the summer-grazed area than in the ungrazed area. The implications for management are that the more desalinated the area becomes and the higher its clay content, the higher the stocking rate must be to retard the vegetation succession.

Key words: reclaimed areas, livestock grazing regimes, vegetation succession, Greylag Goose, *Anser anser*, Barnacle Goose, *Branta leucopsis*

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Temperate wetlands constitute important stopover and wintering sites for geese (Madsen *et al.* 1999). The abundance of geese in feeding areas is largely determined by factors such as the availability of high quality food, the presence of large-scale open landscapes for feeding, and the availability of open water for safe roosting places (Owen 1980). In wetlands in The Netherlands the food from natural vegetation such as bulbs of *Triglochin* spp., seeds of *Salicornia* spp. and *Agrostis stolonifera* (van Eerden 1984, van Eerden *et al.* 1997), shoots of *Puccinellia* spp., *A. stolonifera, Festuca rubra, Plantago maritima* (Ydenberg & Prins 1981, Prop 1991, Prop & Deerenberg 1991) and rhizomes of helophyte species such as *Scirpus maritimus* (Esselink *et al.* 1997) play an important role in attracting geese populations. This food supply is largely related to early successional stages of the vegetation (e.g. Joenje 1978, Olff *et al.* 1997, Drent & van der Wal 1999). In addition to food supply, the height of the vegetation is also an important factor of the feeding habitats for geese

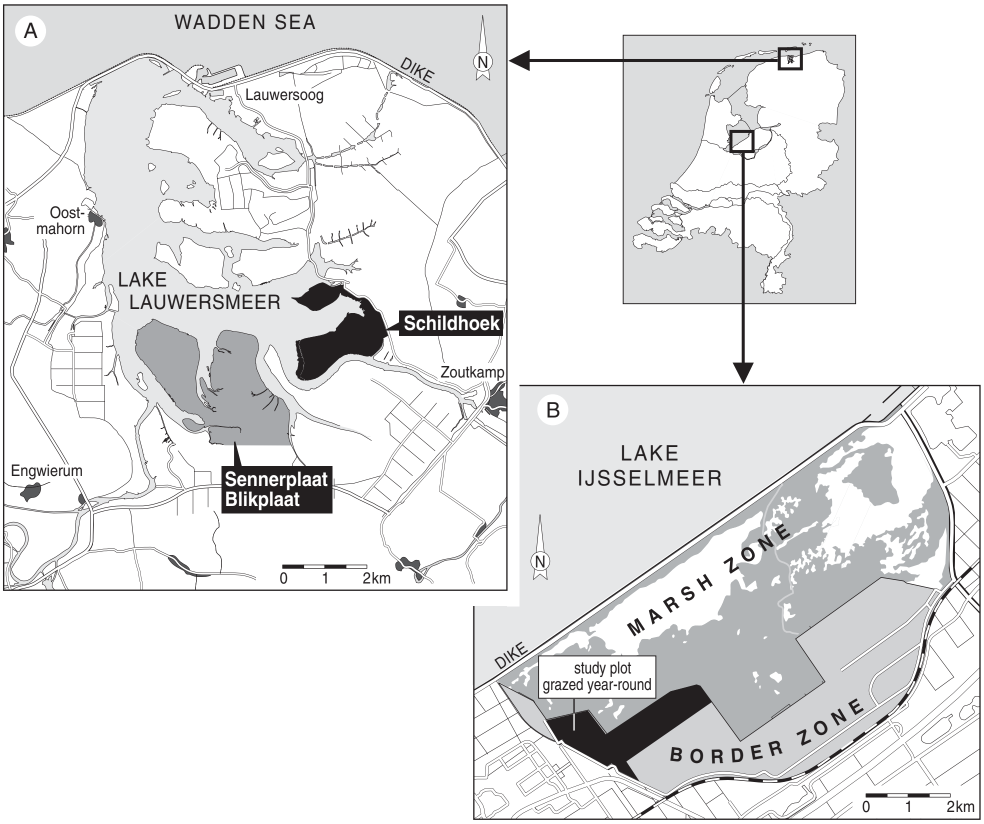

Figure 1. Location of the study areas in the Lauwersmeer and Oostvaardersplassen nature reserves.

(Charman 1979, Summers & Critchley 1990, Aerts *et al.* 1996). A tall vegetation provides cover for predators and hence affects the predation risk.

We examined the relationship between vegetation succession and the occurrence of migratory and wintering geese in large man-made Dutch wetlands. Here, ungulates have been released to maintain habitats of early successional vegetation, especially extensive grassland, by grazing (van Deursen & Drost 1990, Vulink & van Eerden 1998). In our large-scale grazing experiments we tested whether the impact of cattle and horses on vegetation structure might improve the feeding area for geese.

We expected that: (1) geese would prefer parts of the feeding area with short vegetation, (2) tall species would become dominant as vegetation succession proceeded and consequently goose density would decrease, and (3) grazing with livestock would retard vegetation succession and as a result goose density would be higher in grazed vegetation than in ungrazed vegetation.

METHODS

Study areas

The study was conducted in two nature reserves, Lauwersmeer on a sandy to clayey soil (clay content about 1–17%) reclaimed from an estuarine area, and Oostvaardersplassen on a homogeneous clayey soil (clay content about 30%) reclaimed from a freshwater lake (Fig. 1). The Lauwersmeer study area (53°20' N, 6°10' E) is located in the Lauwersmeer polder (9100 ha), which was reclaimed from the Wadden Sea in 1969. For a description of the hydrological and soil conditions, see van Rooij & Drost (1996). The spontaneous vegetation succession and trends in goose numbers were assessed in a 690 ha area, 'Sennerplaat-Blikplaat', henceforth referred to as 'Sennerplaat'. The effect of summer grazing by livestock on the vegetation development and goose density was studied in a 260 ha area, 'Schildhoek', which lies on former tidal flats. Cattle and horses have been released here every year since 1982 (13 years after empoldering), to graze from June to

September. Average stocking rate was about 0.9 animals/ha during the period 1982–1987 and about 0.4 animals/ha during the period 1988–1998.

We studied the relationship between the vegetation structure of grassland and feeding habitat selection by geese in more detail in the Oostvaardersplassen nature reserve (52°26' N, 5°19' E) in the Zuidelijk Flevoland polder, reclaimed in 1968 from the freshwater lake IJsselmeer. This nature reserve (5600 ha) consists of a central reed *Phragmites australis* marsh (3600 ha) and a well-drained border zone (2000 ha) separating the marsh from the surrounding arable fields (for a detailed description of this nature reserve, see Vulink & van Eerden (1998)). In part of the border zone 900 ha of grassland has been created on former arable fields by sowing mixtures of cultivars of *Lolium perenne, Phleum pratense* and *Trifolium repens* or *Festuca rubra* and *Phleum pratense*. Nomenclature of the plant species follows van der Meijden (1996). The *Lolium/Phleum/Trifolium* mixture has been largely replaced by *Poa trivialis* through natural succession (Jans & Drost 1995). The study was conducted in 270 ha of grassland, which was part of an area grazed year-round by Heck cattle *Bos taurus* (cross-bred from various races) and Konik horses *Equus ferus* (a primitive breed of horses, originating from Poland). This area grazed year-round also included spontaneous plant species such as *Poa trivalis, Calamagrostis epigejos, Phragmites australis*, tall herbs (mainly *Cirsium arvense, Urtica dioica*) and shrubs (*Salix* spp. and *Sambucus nigra*). The stocking rate was tuned to the forage available for cattle and horses during winter. It ranged from 0.5 to 1.2 animals/ha during summer and from 0.25 to 0.45 animals/ha during winter. The study area was gradually expanded in accordance with the growth of the herds, from about 650 ha in 1988 to about 1300 ha in 1995.

Vegetation development

Long-term vegetation development in the study areas in the Lauwersmeer nature reserve was derived from vegetation maps (scale 1:5000 or 1:10,000) based on interpretation of satellite images (1972, 1975) and aerial photographs (1980, 1984, 1989, 1998), combined with ground surveys in order to identify the different vegetation zones by means of data from quadrats (Küchler & Zonneveld 1988). Four vegetation structure types were distinguished: pioneers of saline habitats; short grasses; tall vegetation, grasses and herbs; shrubs. The dominant plant species and the most important food plants of geese in the vegetation types distinguished are shown in Table 1. For the purpose of analysing the relationship between the incidence (%) of area of short vegetation and goose density, the vegetation composition of the years for which no data were available was interpolated.

The most important plant species invading the grasslands in the Oostvaardersplassen was *P. australis*. Reed height was used as an index to describe the development of the vegetation structure of the grassland. It was measured with a measuring staff. Reed cover was estimated by eye. Three vegetation structure types were distinguished, based on reed height and reed cover (Table 2). The parts of grassland that were under these three vegetation types were determined from aerial photographs (1:10,000) and data on reed height along transects. For the latter, measurements were taken in circular plots (radius 2 m) every 30 m along transects of 1–1.25 km in November and March over the period 1988 to 1994.

Sward heights were measured on the same plots, using a measuring staff with a sliding polystyrene disc (radius 50 cm, weight 320 g) that was gently lowered on to the sward, so that the height of the vegetation

Table 1. Vegetation structure types distinguished in the Lauwersmeer study area, the dominant plant species in each vegetation type and the food plant species for geese.

Vegetation structure type	Dominant plant species	Food plant species
Pioneers of saline habitats	*Salicornia europaea*	*Salicornia europaea, Puccinellia maritima, Agrostis stolonifera, Triglochin* spp.
Short grasses	*Agrostis stolonifera, Puccinellia maritima*	*Agrostis stolonifera, Puccinellia maritima, Festuca rubra, Alopecurus geniculatus, Triglochin* spp.
Tall vegetation (grasses and herbs)	*Calamagrostis epigejos, Phragmites australis, Cirsium arvense, Urtica dioica*	*Agrostis stolonifera, Poa trivialis, Festuca rubra, Trifolium repens, Trifolium fragiferum*
Shrubs	*Salix alba, S. cinerea, S. caprea, S. repens, Hippophae rhamnoides, Sambucus nigra*	*Agrostis stolonifera, Poa trivialis*

could be read off on the measuring staff in the centre. When reed cover was too high to be able to use the disc, sward height was read off directly on a measuring staff. Sward height was measured at the start of the winter, November 1991 and 1992, and at the end of the winter, March 1992 and 1993, the period when field selection of wintering geese was studied in more detail.

Goose counts

At the time of the fieldwork, Greylag Geese *Anser anser* and Barnacle Geese *Branta leucopsis* were present in greater numbers in the Lauwersmeer nature reserve, than on arable fields in the Lauwersmeer polder (Zijlstra *et al.* 1996). Data on numbers of Greylag Goose and Barnacle Goose were derived from complete counts of all bird species in the entire nature reserve. For the purpose of these counts, the Lauwersmeer nature reserve and some arable fields bordering the nature reserve were divided into 28 sectors (Zijlstra *et al.* 1996). Counts took place twice a month from August to March and once a month during the rest of the year and were carried out on foot, by car or from boat depending on the sector visited. Data from the two study sites from 1981 onward were used for this study.

Goose counts in the Oostvaardersplassen took place twice a week. They were done from a car, along an ordinary road. Binoculars and telescopes (20–60×) were used to observe geese at greater distances. For orientation, the study area was divided into sections of about 250×250 m. Data from the grassland grazed year-round were used for this study, because these grassland contained all three vegetation structure types distinguished in Table 2. During counts, the numbers of geese per section were recorded. Each section was designated a structure type, based on November data of reed height along transects and aerial photographs (1:10,000). Goose counts made during October to March in 1991, 1992 and 1993 were used to determine the selection of vegetation types.

Table 2. Reed height and reed cover in the three vegetation structure classes distinguished in the grassland–*Phragmites* vegetation in the Oostvaardersplassen. Data were collected in grassland that was grazed year-round at low stocking rate in July 1993.

Vegetation type	Reed height (m)	Reed cover (%) Mean ± SE	*n*
Short grassland	0–0.5	1.1 ± 0.3	33
Grazed reed	0.5–1.0	8.0 ± 3.4	18
Ungrazed reed	>1.0	56.4 ± 6.5	25

Statistical analysis

For the purpose of analysing the relationship between goose density and the incidence (%) of area of short vegetation, the data on the latter were arcsine-transformed. The SPSS package (Norušis 1997) was used for all statistical analyses.

RESULTS

Vegetation development

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In the years immediately after empoldering, the vegetation of the continuously ungrazed Sennerplaat study area and that of the Schildhoek area, which was grazed every summer since 1982, was dominated by pioneers of saline habitats (Fig. 2A and B). As the flats became less saline, halophytic pioneers were gradually replaced by a vegetation of short grasses, mainly *Puccinellia maritima* and *Agrostis stolonifera* and by tall species such as *Aster tripolium*. Ten to fifteen years after empoldering *Calamagrostis epigejos* and *Phragmites australis* started to expand over the former tidal flats. Shrub vegetation, mainly *Salix* spp., also expanded: at Schildhoek, this started about five years after empoldering, but at Sennerplaat it started about ten years after empoldering.

After summer grazing was introduced in Schildhoek in 1982, the vegetation developed differently from the ungrazed area. In the summer-grazed area, the expansion of tall vegetation halted for a few years after grazing was introduced, but resumed in later years, probably in response to the lower stocking rate from 1987 onwards (van Deursen & Drost 1990). The vegetation succession towards tall vegetation continued, regardless of the summer grazing regime. The incidence of shrubs, however, which showed a gradual increase in the ungrazed area, remained fairly constant in the summer grazed area after grazing was introduced.

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About 145 ha of the total 270 ha grassland grazed year-round in Oostvaardersplassen was mowed annually until August 1988. By that time about 40% of the original sown area had already become a *P. australis* vegetation (reed height > 0.5 m) (Fig. 3). Due to the low animal density (0.45 animals/ha, calculated on the orginal 270 ha grassland) another 20% of the short grassland (reed height < 0.5 m) became overgrown by *P. australis* within one year after mowing stopped. From 1989 onwards the incidence of short grassland increased again, because stocking rates rose as the herds of Heck cattle

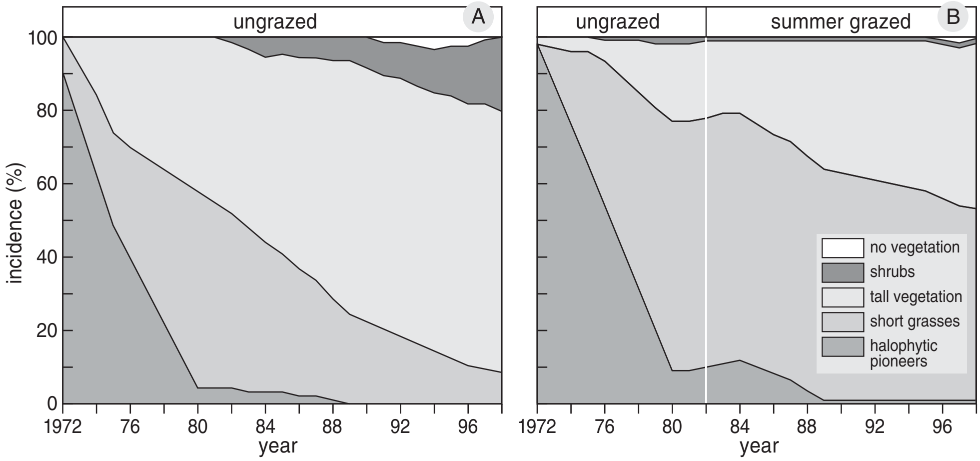

Figure 2. Vegetation development on former tidal flats in the Lauwersmeer nature reserve; (A) continuously ungrazed (Sennerplaat, 690 ha), (B) summer grazed since 1982 (Schildhoek, 260 ha). The stocking rate in the summer-grazed area was 0.9 animals/ha during the period 1982–87 and 0.4 animals/ha during the period 1988–98.

and Konik horses increased in size. In 1991 the area grazed year-round was expanded, leading to a lower animal density and resulting in some decrease in the incidence of short grassland. The stocking rate (animals/ha) during summer, the period when *P. australis* is most intensively grazed, was 0.45 in 1989, 0.50 in 1990, 0.75 in 1991, 0.70 in 1992, 1.0 in 1993 and 1.2 in 1994. The stocking rate was calculated from field-use data on free-ranging Heck cattle and Konik horses. There was a significantly positive linear relationship between the incidence of short grassland and the stocking rate during summer ($R^2 = 0.91$, $P < 0.01$).

The vegetation types distinguished on the grassland grazed year-round in the Oostvaardersplassen nature reserve differed not only in reed height and reed cover, but also in sward height (Table 3). Sward heights at short grassland (reed height < 0.5 m) and grazed *P. australis* (reed height 0.5–1.0 m) decreased in the course of the winter. In the vegetation type with reed height > 1.0 m, grasses had almost disappeared. On average, the sward height of short grassland was significantly shorter than that of grazed *P. australis* vegetation (Mann–Whitney U-test, $P < 0.001$). The differences in sward height reflect differences in the density of the free-ranging cattle and horses. The average annual stocking rate on short grassland was 0.67 animals/ha in 1991 and 0.45 animals/ha in 1992. On grazed *P. australis* vegetation it was 0.50 animals/ha in 1991 and 0.35 animals/ha in 1992.

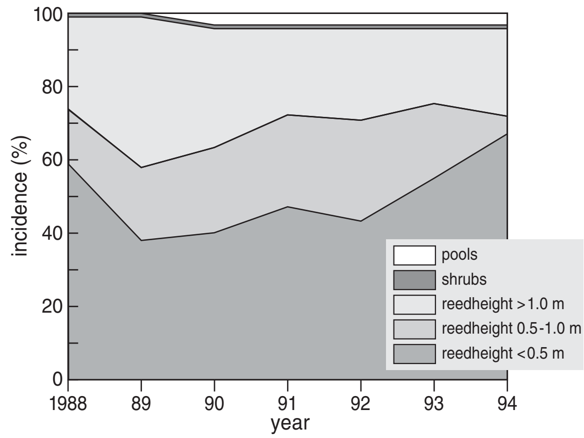

Figure 3. Development of vegetation of *Phragmites australis* (incidence and height, November situation) on the grassland grazed year-round (total 270 ha originally) in the Oostvaardersplassen nature reserve. Additional mowing took place until August 1988.

Table 3. Mean sward height (cm, ±SE) in short grassland (reed height < 0.5 m) and grazed *Phragmites australis* (reed height 0.5–1.0 m). *P*-values refer to Mann–Whitney U-tests.

	Short grassland		Grazed *P. australis*		
	Mean ± SE	*n*	Mean ± SE	*n*	*P*
November 1991	5.9 ± 0.3	90	9.8 ± 0.4	80	< 0.001
March 1992	2.8 ± 0.2	90	4.3 ± 0.3	80	< 0.001
November 1992	8.0 ± 0.2	105	9.1 ± 0.6	63	0.117
March 1993	2.4 ± 0.1	117	2.9 ± 0.2	31	< 0.001

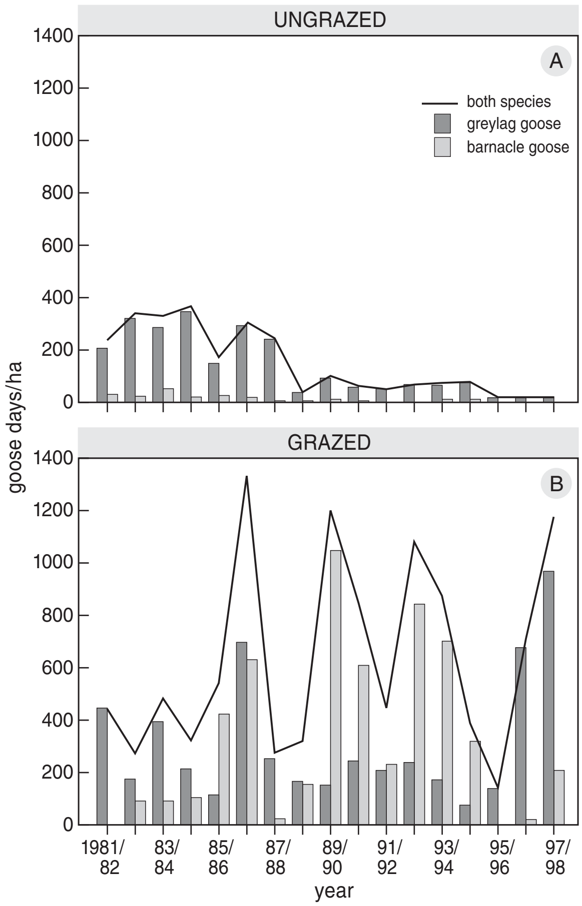

Figure 4. Densities of Greylag Goose, Barnacle Goose and the sum of both species (goose days/ha) on former tidal flats in the Lauwersmeer nature reserve; (A) never grazed by livestock (690 ha), (B) summer grazed since 1982 (260 ha). The stocking rate in the summer grazed area was 0.9 animals/ha during the period 1982–87 and 0.4 animals/ha during the period 1988–98.

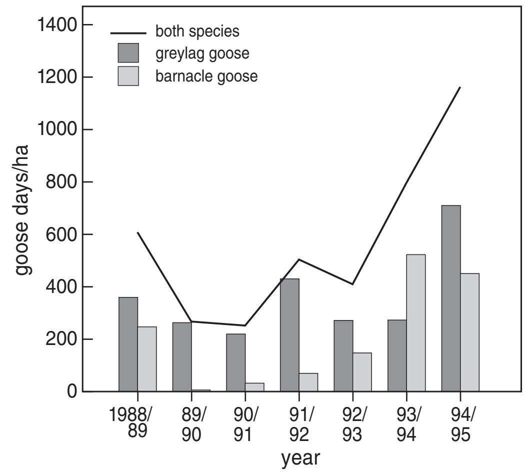

Figure 5. Densities of Greylag Goose, Barnacle Goose and the sum of both species (goose days/ha) on the grassland grazed year-round (total 270 ha originally) in the Oostvaardersplassen nature reserve. Additional mowing took place until August 1988.

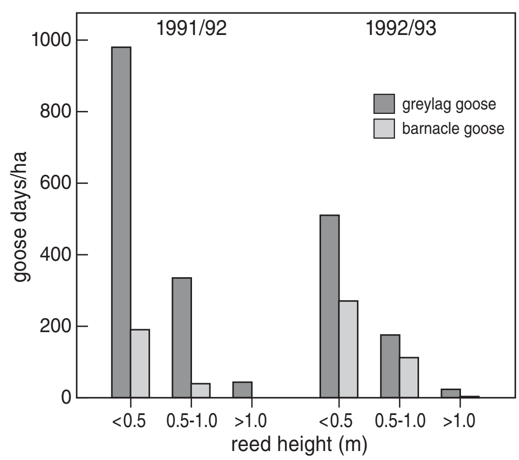

Figure 6. Densities of Greylag Goose and Barnacle Goose (goose days/ha) on vegetation types that differed in reed height and reed cover on the grassland grazed year-round (total 270 ha originally) in the Oostvaardersplassen nature reserve.

Goose density and vegetation succession

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During the years of the study, goose density decreased in the Sennerplaat area which underwent a spontaneous vegetation succession (Fig. 4A). There was a significant positive correlation between goose density and the total incidence (%) of area under halophytic pioneers and under short grasses (Greylag Goose, Pearson correlation, $R^2 = 0.66$, $P < 0.01$, $n = 14$; Barnacle Goose, $R^2 = 0.59$, $P < 0.01$, $n = 14$; sum of both species, $R^2 = 0.76$, $P < 0.01$, $n = 14$).

In the summer grazed area, goose density showed large variability between the years, especially for Barnacle Goose (Fig. 4B). The average density of Greylag Goose, of Barnacle Goose and the sum of both species did not show a significant decrease, despite the gradual decrease in the proportion of halophytic pioneers and short grasses.

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Goose density on the grassland grazed year-round in the Oostvaardersplassen (Fig. 5) showed the same trend on average as the incidence of short grassland (reed height < 0.5 m) (Fig. 3). There was a significantly positive correlation between goose density and the incidence (%) of area of short grassland (Greylag Goose, $R^2 = 0.59$, $P < 0.05$, $n = 7$; Barnacle Goose, $R^2 = 0.69$, $P < 0.05$, $n = 7$; sum of both species, $R^2 = 0.88$, $P < 0.005$, $n = 7$). The data on goose density in the different vegetation types show that both species preferred short grassland (Fig. 6).

DISCUSSION

During the early years after empoldering, the vegetation composition of the Lauwersmeer (a former estuary) was largely determined by abiotic influences such as soil salinity and clay content and by hydrological conditions (Joenje 1978, van Rooij & Drost 1996). In that period the extensive area under halophytic pioneer species and short grasses offered food such as seeds, leaves and bulbs for herbivorous waterbirds such as geese and Eurasian Wigeon *Anas penelope* (van Eerden 1984, van Eerden *et al.* 1997). As the habitat became less saline, tall plant species such as *P. australis* invaded the vegetation of halophytic pioneers and of short grasses on the low-lying loamy soils. On the higher-lying sandy soils the succession proceeded to a vegetation dominated by *P. australis, C. epigejos* and *Salix repens* mainly. In Oostvaardersplassen (a former freshwater lake), much of the grassland on clayey soils grazed at a low stocking rate was invaded by *P. australis* within one year after mowing stopped.

Our results show that the encroachment of tall species in vegetation of halophytic species and short grasses in the Lauwersmeer was followed by a decrease in goose density. This confirms our hypothesis that goose density in natural vegetation will decrease as the vegetation succession proceeds. The decrease in goose density in relation to short vegetation being ousted by tall species was supported by data from grassland seeded with cultivars in the Oostvaardersplassen nature reserve. Geese preferred extensive short grassland with short reed heights and little reed cover. This area of short grassland was also most intensively grazed by free-ranging Heck cattle and Konik horses. It is probable that grazing by large herbivores improves the quality of the sward (Vulink & Drost 1991). Summers & Critchley (1990) found a negative relationship between sward height and nitrogen content of the live proportion of the sward. A low goose density in areas with tall vegetation such as *P. australis* (this study), fields of old thistle stalks *Cirsium* spp. (Summers & Critchley 1990) or salt marshes where the tall grass *Elymus athericus* dominated the vegetation (Olff *et al.* 1997) might be attributable to a low food quality and an unfavourable vegetation structure. The expansion of tall species provided more cover for predators such as Red Fox *Vulpes vulpes*, thereby increasing the risk of predation, and hence possibly discouraging the geese from frequenting these areas.

Summer grazing at stocking rates of 0.4–0.9 animals/ha delayed the vegetation succession in the Lauwersmeer to some extent, resulting in a higher goose density in the summer grazed area than in the ungrazed area. The large fluctuations in the density of both goose species over the years in the summer grazed area might be due to the rather low counting frequency and to differences in water table in the feeding area between years. The finding that goose density in the summer grazed area did not decrease despite the decrease in the area of short grasses, can be explained by an overall increase in goose numbers in the Lauwersmeer nature reserve (Zijlstra *et al.* 1996) together with a concentration in grazed areas, because the ungrazed areas were no longer suitable as feeding site.

The general conclusion is that grazing by cattle and horses affects the food plants of geese as well as the tall species, such as *P. australis*, tall herbs and woody species, that largely determine the vegetation structure. The overall effect of grazing on both groups of plant species will ultimately determine to what extent an area may remain suitable as feeding habitat for geese.

Implications for conservation management

Nature reserves located in polders are characterised by a low level of physical perturbations such as flooding by fresh, brackish or salt water and erosion by waves and ice, which might reset or slow down vegetation succession. Therefore maintenance of feeding sites for herbivorous waterbirds in these nature reserves largely depends on management measures which prevent short species from being overgrown by tall species. One such a management measure is grazing by livestock.

The grazing management of feeding areas for geese is based on facilitative interactions between large grazers (cattle and horses) and small grazers (geese). Facilitation can only occur if there are large differences in body size between both species of grazer (Prins & Olff 1998), or differences in type of herbivore ('browser' vs. 'grazer'; see the interaction between Brown Hare *Lepus europaeus* and geese: Drent & van der Wal 1999). Grazing by large herbivores and even by smaller ones such as geese (Ydenberg & Prins 1981, Cargill & Jefferies 1984) can maintain a higher food quality (greater protein content, lower content of indigestible structural carbohydrates) of intensively grazed vegetation compared to lightly grazed or ungrazed vegetation. Grazing by livestock also delays maturation of grasses, improving the quality of grasses for geese (Vulink & Drost 1991, Vulink *et al.* 2001.

The 'hospitality' of the temperate wetlands for avian herbivores migrating from the Arctic, such as geese, thus depends on mechanisms that prevent vegetation succession in these wetlands. To this end, grazing by large herbivores has to be maintained at rather high stocking rates. If this is not possible, the vegetation succession must be 'reset' frequently by burning, mowing, flooding, and/or resalinisation. Only in this way can a country like The Netherlands continue to play an important role in providing refuge to migrating waterbirds as part of international co-operation agreements.

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SAMENVATTING

De kunstmatige moerasgebieden in de jongste polders van Nederland zijn belangrijke tussenstops en overwinteringplaatsen van ganzen geworden. In deze studie werd gekeken naar de samenstelling van de vegetatie en de dichtheid van ganzen in de Oostvaardersplassen (deel van een voormalig zoetwatermeer) en het Lauwersmeer (een voormalig zout estuarium). In het Lauwersmeer hadden de ganzen de keuze uit spontaan ontwikkelde vegetaties en uit gebieden die in de zomer met vee werden begraasd. In de Oostvaardersplassen ging het om een grasland dat jaarrond door paarden en runderen werd begraasd. Het bleek dat de ganzendichtheid in spontane vegetaties in het Lauwersmeer geleidelijk afnam onder invloed van de vegetatiesuccessie. In de zomerbegraasde delen fluctueerde de dichtheid van Grauwe Gans en vooral Brandgans aanzienlijk zonder een duidelijke afname over de tijd. Dit laatste werd vermoedelijk veroorzaakt doordat de ganzen in de loop van de tijd geconcentreerd raakten in het zomerbegraasde gebied (leegloop uit onbegraasde gebieden) en doordat de aantallen ganzen sowieso toenamen in het Lauwersmeergebied. In de Oostvaardersplassen hadden beide ganzensoorten een voorkeur voor kort begraasd grasland. De ganzendichtheid nam hier sterk af met toenemende riethoogte (hoogste dichtheid bij <50 cm riethoogte) en rietdichtheid. Deze studie laat zien dat – althans in moerasgebieden in de gematigde klimaatszone – een vrij intensieve begrazing met grote grazers nodig is om de vegetatiesuccessie zodanig af te remmen dat een korte grasmat overblijft die geschikt is om foerageren door ganzen mogelijk te maken. Zonder begrazing zou dat alleen mogelijk zijn indien het gebied geregeld werd afgebrand, gemaaid of geïnundeerd. Bij tijd en wijle de instroom van zout water toestaan zou ook een optie zijn.

Konik horses grazing the border zone of Oostvaardersplassen, The Netherlands. Note the pools in the background, important fishing grounds for herons, egrets and spoonbills (June 2009). Photo by Mennobart R. van Eerden.