NATURE DEVELOPMENT AND VEGETATION SUCCESSION IN THE FORELAND OF THE RIVER WAAL (THE NETHERLANDS)

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Abstract: Nature conservation in the Netherlands changed from strict conservation and protection into nature development by restoring natural processes.

By means of permanent plots and repeated vegetation mapping, we investigated the long term changes in vegetation composition in a river foreland under nature development, especially its effect on dry sandy to loamy grasslands of the *Medicagini-Avenetum* (*Sedo-Cerastion*), *Bromo-Eryngietum* (*Artemisietea)* and *'fluviatile species'*. The *Medicagini-Avenetum pubescentis* strongly declined in the Netherlands and became rather rare and strongly threatened. Restoration of this highly valued community has a high priority in nature development projects along the Dutch rivers.

After 14 years of nature management the surface area of the nitrophylous tall forb communities of the *Galio-Urticetea* strongly increased, while the *Bromo-Eryngietum* decreased. The S*edo-Cerastion* ruderalized.

On the levee nature development appeared to have no negative or positive effect on the total cover of *Medicagini-Avenetum* and the fluviatile species. However some fluviatile species decreased while others strongly increased. On former arable land and pastures these species increased due to in-blowing sand. Here *Cirsium arvense* and *Rumex obtusifolius* are replaced by *Calamagrostis epigejos*, which itself is later replaced by the strongly increasing *Rubus caesius*.

Vegetation changes appear to be very dynamic showing both regressive and progressive succession. After 14 years of nature development, still no real improvement of the dry species rich Sedo-Cerastion grasslands occurred. This is most probably due to insufficient grazing intensity.

Keywords: restoration of wilderness areas dry fluviatile grasslands Sedo-Cerastion nature development spontaneous succession:

Introduction

Nature conservation in the Netherlands changed from strict conservation into nature development by restoring natural processes. In 1992 the World Wildlife Fund announced the plan 'Levende Rivieren (Living Rivers Plan)'. About 200,000 ha of new nature were planned. One of the first nature development projects the Millingerwaard'is situated south of the river Waal at 10 km east of the city of Nijmegen (Fig.1).
Until 1990 the pastures on the natural sandy levees were grazed and fertilized. The low-lying flood-plain behind the levee was partly arable field and partly a fertilized pasture. In 1991 grazing started with Konik horses, followed in 1992 by Galloway cattle.
The area studied consists of a river bank, a sandy levee and low lying former arable fields and pastures bordered by a willow scrub and woodland. We investigated the effect of nature development, particularly on 1) the *Medicagini-Avenetum*, (*Bromo-Eryngietum*) both characteristic of the sandy levees and of international conservation importance and 2) 'fluviatile species' (Sykora 2002).

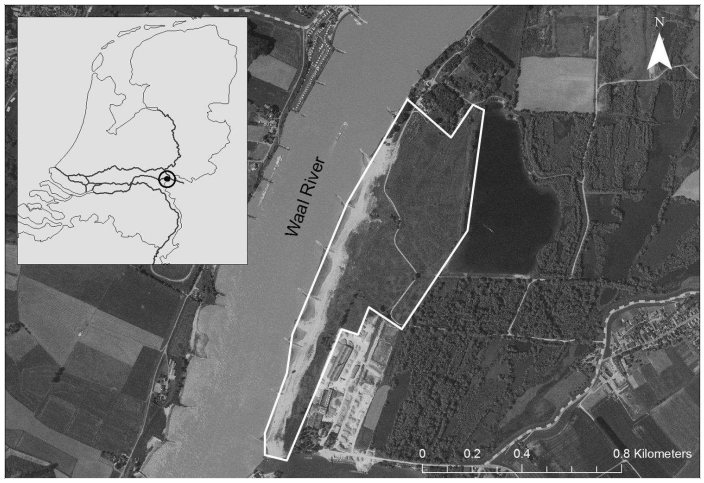

Figure 1. Location of the Millingerwaard in the Netherlands. The research area is outlined.

Materials and methods

We sampled 61 relevés of 9 m^2 in two transects perpendicular to the river, using the Braun-Blanquet cover-abundance scale as modified by Barkman et al. (1964) after transformation into a nine-point ordinal cover/abundance scale. TWINSPAN was used for classification. DCA and CCA, forward selection of environmental variables and Monte Carlo permutation tests were used for multivariate analysis.

Five pooled soil samples were taken per plot (depth 10 cm). The soil samples were analysed for: percentage moisture, total amounts of N, P and K, available N and P in KCl, available Na+, Mg^2+, K+ and pH in $CaCl_2$, % Organic matter; % $CaCO_3$; CEC, and base saturation Ca, Mg, K and Na, soil texture. Besides the altitude of each relevé was measured and grazing density was determined.

GIS was used to determine changes in surface area after repeated vegetation mapping in 1994, 1998 and 2002. Community shifts of relevés between 1994 and 2005 were studied by repeated sampling of 70 PQs. The total cover in m^2, of different syntaxonomical elements and of the fluviatile species group in the different years was calculated. DCA was run on the cluster centroïds and the axes were related to total cover of the different species groups, weighted mean Ellenberg indicator figures, flooding in days per preceding year), grazing density and diversity indices.

Results and discussion

Species composition appears to be clearly related to differences in inundation, moisture, CEC, the content of finer sediments, organic matter, N, P, K, Mg, and Na. Along rivers the hydro- and morfodynamics are of primary importance (Wolfert et al 2002). Due to the recent restoration of river dynamics, sand deposition increased with a positive effect on the fluviatile species and on the flora of pioneer stages. Due to this process locally *Salvia pratensis, Sanguisorba minor, Ononis repens* ssp. *repens, Campanula*

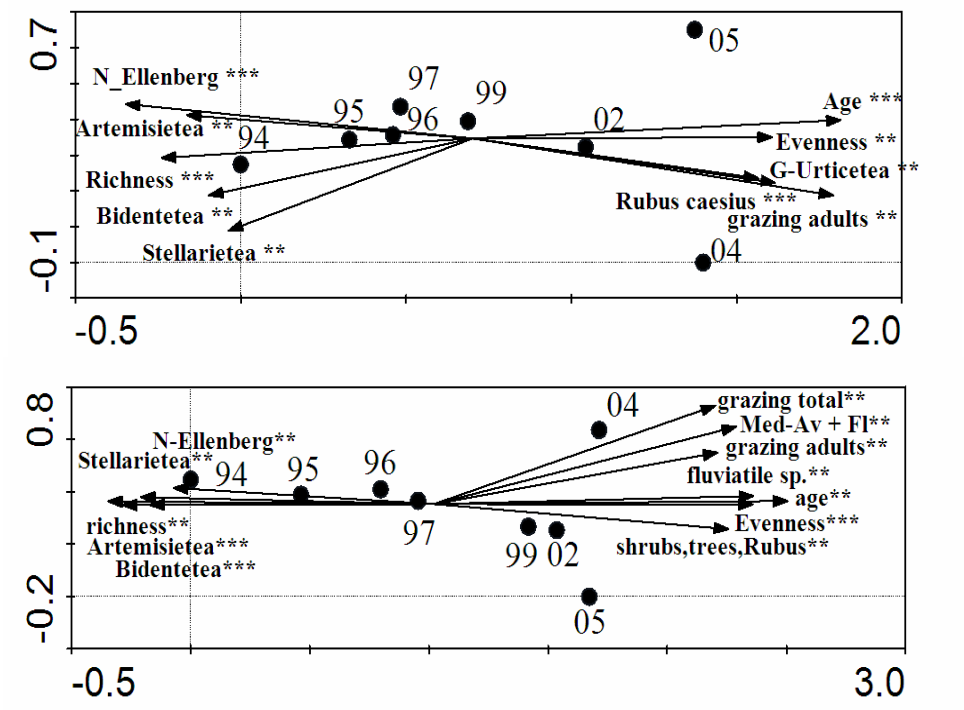

Figure 2. DCA of clustercentroïds of the pq's on the levee (upper diagram) and arable field (lower diagram) in different years. The relation with the first two axes of significant environmental factors is indicated as arrows. *** P < 0.01, ** P <0.05 and > 0.01. Med-Av = *Medicagini-Avenetum*, Fl = fluviatile species.

rapunculus, Veronica austriaca ssp. *teucrium, Origanum vulgare, Thalictrum minus, Cruciata laevipes, Leontodon hispidus, Thymus pulegioides, Silaum silaus* and *Cenaturea scabiosa* etc. (re)established (Peters & Kurstjens 2007).

Management is of immediate second importance. In the Millingerwaard extensive grazing (0.8-1.0 animal/effective ha) resulted in a more than 5 times increase in area of the nitrophylous tall forb vegetation of the *Galio-Urticetea*, while the secondary pioneer species of the *Bromo inermis-Eryngietum campestris* strongly decreased and the dry *Sedo-Cerastion* levee grasslands ruderalized. Besides, the area covered by shrubs and trees increased. The *Bromo inermis-Eryngietum campestris* is strongly depending on sand deposition and other processes like poaching and intensive grazing. As sand deposition is a regularly reoccurring phenomenon it is more likely that in this case, the prolonged extensive grazing is the main cause.

On the levee the *Medicagini-Avenetum* and fluviatile species do not really in- or decrease. Although the *Sedo-Cerastion* ruderalised, the grazing intensity was still sufficient to maintain the presence of the species since 1994. However, on the former arable fields and leys the *Medicagini-Avenetum* and fluviatile species increased as the result of sand blowing in from the levee sand dunes. Due to the abandonment of the

arable fields, silt sedimentation and the extensive grazing, tall forb species of the *Galio-Urticetea* and *Rubus caesius* strongly increased. *Cirsium arvense* became dominant but collapsed after 2 or 3 years. *Rubus caesius* became dominant ± 10 years after abandonment. The grazing intensity was insufficient to preserve the *Ranunculo-Alopecuretum* grasslands characteristic of temporarily flooded, nutrient rich pastures.
The transitions in time show the very dynamic environment in the river forelands. Both progressive and regressive succession occurs. Nevertheless as shown by the DCA (Fig.2), at the same time, overall directional succession takes place. In both landscape units it is mainly related to a decrease in *Artemisietea* species (mainly the *Bromo-Eryngietum*) and to an increase of the nitrophylous tall forbs of the *Galio-Urticetea*, *Rubus caesius*, trees and shrubs. While on the former arable fields the *Medicagini-*Avenetum and fluviatile species are significantly increasing, no significant trend is visible on the levees.
Ellenberg productivity values decreased, while inundation period, Ellenberg moisture, light and acidity values show no significant relation with the first axis and grazing is positively related. In both landscape units species diversity decreased, while evenness slightly increased due to ruderalization and loss of annual species of open vegetation. As yet, species expected to (re)settle due to improved habitat conditions, like *Plantago media, Koeleria macrantha,Thymus pulegioides, Carum carvi, Pimpinella saxifraga, Agrimonia eupatoria, Artemisia campestris, Knautia arvensis, Briza media, Sedum reflexum, Hippocrepis comosa, Sanguisorba minor, Campanula glomerata, Potentilla verna, Scabiosa columbaria, Carex praecox* and *Allium oleraceum* did not (re)appear.

Conclusions

Our results show that in the Millingerwaard under nature development with a rather constant effective grazing intensity of about 0.9 animal/ha the *Medicagini-Avenetum* and fluviatile species on the levee were maintained and even increased in the former arable fields and leys. At the same time however, the vegetation ruderalized and short grazed vegetation diminished considerably. Besides after 14 years of nature development, still no real improvement of the dry species rich *Sedo-Cerastion* grasslands occurred. This is most probably due to insufficient grazing intensity. Lack of supply due to insufficient dispersal of diaspores might contribute to the problem.

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