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Regional biodiversity in ditches in relation to land use

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Project goal

The conservation of aquatic biodiversity is a central objective of Dutch nature conservation policy. In the face of ongoing land use changes, this endeavour is particularly challenging due to the limited availability of space and resources. Management schemes for wetlands predominantly focus on individual water bodies, whereas an integrated, landscape-oriented approach offers much better guarantees for the effective and sustainable conservation of regional aquatic biodiversity. However, scientific knowledge on how such an approach can best be implemented is lacking. The limited resources available for nature conservation should be allocated to measures that have a maximum effect. Land use potentially has strong effects on regional or gamma diversity through a variety of mechanisms. Intensive land use results in the deterioration of local habitat quality and leads to reduced local or alpha diversity. Large-scale intensive land use can also lead to a decline in beta-diversity through homogenisation of the environment and changed connectivity patterns. There is still a major lack of understanding about which of these alternative mechanisms have the strongest impact on regional biodiversity. Yet such knowledge is a prerequisite for remediating negative effects of changing land use on aquatic biodiversity and developing an effective and affordable conservation strategy for agricultural landscapes.

The aim of the project is to (1) provide a mechanistic understanding of the factors that determine aquatic biodiversity in Dutch agricultural landscapes, with special attention for rare species, species of conservation concern and functional groups, (2) reveal the pathways through which land use change (agricultural intensification and de-intensification, urbanisation) can affect landscape biodiversity, (3) identify how the response patterns of ecologically contrasting groups of aquatic organisms differ and (4) use this information to develop a strategic framework for the cost-effective management of landscape biodiversity for multiple organism groups.

Study design

We selected the ditch networks of the Western Peat district as study system. The ditches are home to a wide variety of aquatic plants and animals. Land use in this region encompasses three main categories of management: intensive agricultural land use (crops and dairy farming), agro-environmental schemes (low-intensity dairy farming with nature management schemes) and nature management (primarily extensively managed grass and peatlands). Based on accessibility and prevailing land use, we selected 15 areas of approximately 200 hectares each. Within each area, we sampled the ditch network at 24 localities that were selected according to a stratified random design. At each of these localities, we assessed the community composition and biodiversity of zooplankton (water fleas) and macrophytes and measured key environmental factors that are generally known to be important in driving the community composition and diversity of these organism groups (e.g., water and soil nutrients, turbidity, ditch morphology and fish presence). A fundamental difference between our study and other meta-community studies is the replicated factorial design, which will allow a more formal analysis of the effect of land use practices on the spatial structure of aquatic biodiversity. In cooperation with another 'Biodiversity works project (*'Linking microbial diversity to the functioning of soil food webs' – Prof. P. de Ruiter*), we will also investigate the microbial diversity of ditch banks, adding another group to our data set.

Figure 1 | Zooplankton sampling in the field. *Photography: Lisa Freitag*

Some preliminary results

In the course of two field seasons (2012, 2013) we have sampled 360 ditch reaches, encompassing over 3000 hectares of land in 15 different study areas. Preliminary analyses of these field data show some distinct small-scale community patterns that seem to be associated with heterogeneous land use. Figure 2, for example, shows a major trend in the community structure of aquatic macrophytes in relation to land use type. What immediately stands out is that the nature reserve (west) and the agricultural part of the area (east) seem to have different communities. Though anecdotal, this illustrates the importance of land use variation at small spatial scales. Furthermore, we have found a clear negative association between the local species richness of zooplankton communities in ditches and the total phosphorus content of the water (Figure 3, regression: R^2_{adj} =0.134, F=22.98, p=0.001), a key environmental factor that is known to be strongly influenced by agricultural land use.

Future prospects

The next step will be to carry out an extensive statistical analysis (multivariate spatial modelling combined with variation partitioning) with the aim of disentangling the importance of spatial factors from environmental factors. This will enable us to better understand the relative roles of alternative processes in shaping community structure and diversity at both local and regional scales as well as how these processes depend on prevailing land use practices and traits of the organism groups under study. The end-goal of the project is to use these insights to develop cost-efficient measures for the conservation and promotion of aquatic biodiversity at the landscape scale.

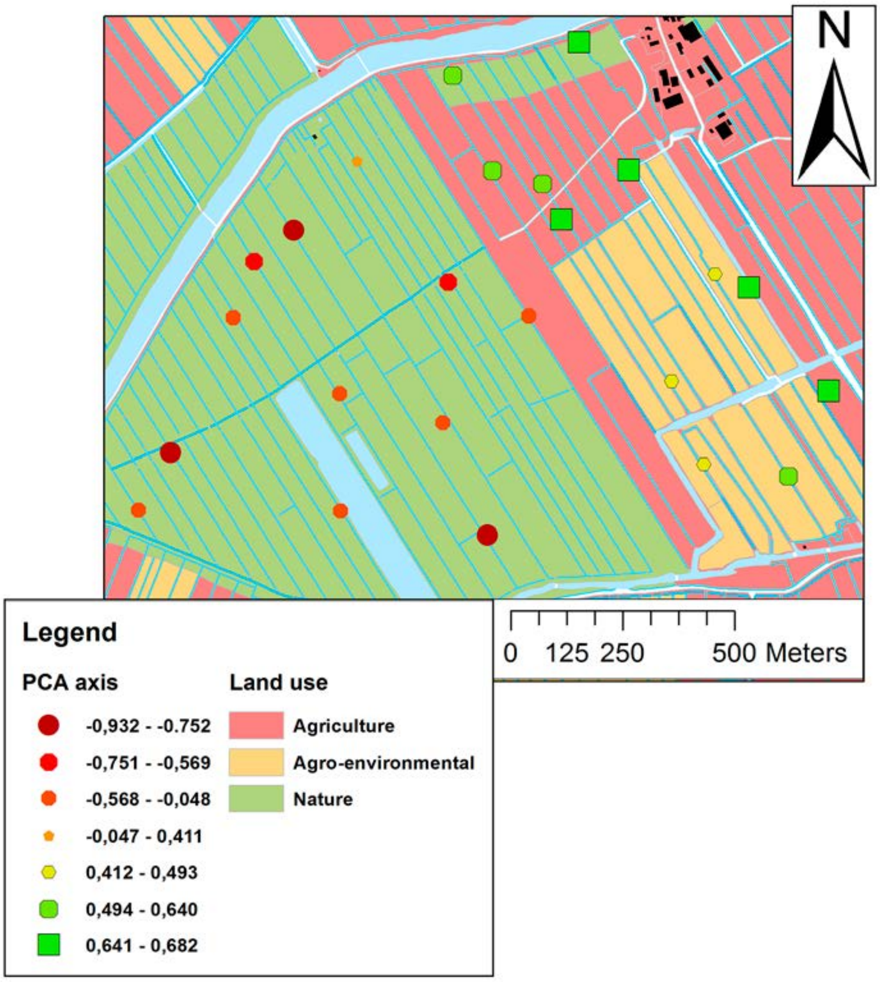

Figure 2 | An overview of a study area with land use indicated for different plots of land. The symbols show study sites (ditch reaches). Symbol shapes and colours represent differences in community composition of aquatic macrophytes (sample scores of the first axis of a principal components analysis on species data).

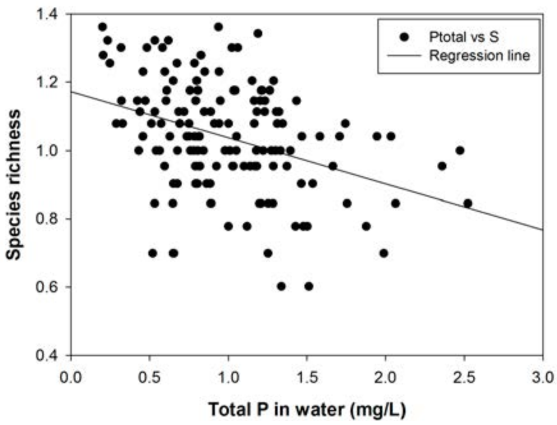

Figure 3 | Total water column phosphorus versus zooplankton species richness (log-transformed).