

Programme

# Biodiversity works



December 2013, The Hague  
Netherlands Organisation for Scientific Research  
Earth and Life Sciences



Netherlands Organisation for Scientific Research  
Earth and Life Sciences

## Colophon

The Research Programme Biodiversity works involves stakeholders in scientific research into the protection of Dutch wildlife. Research is carried out on one or more of the themes dynamic nature, ecosystem services and spatial scarcity. The newsletter provides information about current research and other relevant issues.

Please note:

Reactions and contributions to the newsletter should be sent by e-mail to [alwbiodiversiteit@nwo.nl](mailto:alwbiodiversiteit@nwo.nl)

Illustrations for the contributions (photos, tables, other graphics) are highly appreciated.

Contributing is free!

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# Preface

This is the first newsletter from the Research Programme Biodiversity works (OBW) with contributions from researchers who are carrying out projects within the programme.

The newsletter is for everybody who is interested in research into biodiversity and ecosystem services, and in particular the results from OBW. Via this newsletter, researchers and stakeholders from OBW are informed of each other's progress and results. This promotes synergy and collaboration between the projects and activities. In addition to scientific information, news about relevant policy information, symposia, workshops and the like is most welcome.

The research programme was initiated in 2009 when the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Economic Affairs (EZ) joined forces with respect to biodiversity research.

OBW runs until the end of 2016 and its objective is to generate new knowledge for the policy subjects 'dynamic wildlife', 'ecosystem services' and 'spatial scarcity'.

A total of 14 projects were granted in two funding rounds. In addition, NWO awarded 4 biodivERsA projects with the theme 'Ecosystem Services'.

The research subjects from the OBW programme fit well within the wildlife and biodiversity policy of the Dutch government and also within the so-called economic priority areas to which NWO is devoting a large part of its budget. The collaboration between the Ministry of Economic Affairs and NWO strengthens the policy relevance of the research and provides scientific impulses to the realisation of the wildlife and biodiversity policy.

In the newsletter you will find the first results from research into: wild bee communities who are experiencing drastic declines across Europe of which current intensive agricultural practices are the likely main cause; ecosystem functions of invasive aquatic plants; and large-scale soil transplantation to facilitate rapid vegetation development on former arable fields.

I hope you find this newsletter informative!

**Rob Wolters**

Chair Steering Committee OBW

# Linking community traits to ecosystem processes: A predictive tool to assess effects of biodiversity shifts on soil functions?

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A local community consists of species able to disperse to the site and persist under site-specific abiotic and biotic conditions. These abiotic and biotic factors therefore act as filters removing species from the community that lack specific traits<sup>1</sup>. Environmental changes may cause shifts in the strength of these filters, thereby influencing the structure of communities and, subsequently, underlying ecosystem functions. Although the direct and indirect effects of these shifts remain unknown, understanding how communities respond to environmental changes and what the effect of altered community composition on ecosystem processes is, enhances the predictability of the effect of environmental change on ecosystems.

One important aspect of environmental change in the Netherlands is the increase in frequency, duration and amplitude of extreme weather events (IPCC, 2007). For example prolonged droughts and floods result in strong fluctuations in soil moisture levels. Subsequently, soil water levels have to be regulated to sustain crop production and maintenance of nature reserves. Although it is known that plant and soil animal communities are affected by soil moisture changes, the real effects of these extreme events on communities and subsequently on underlying ecosystem functions are unknown.

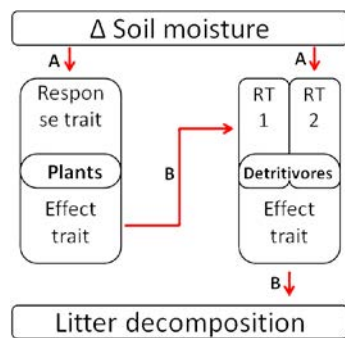
We use a response-to-effect trait framework (Figure 1) to analyse the direct and indirect effect of soil moisture changes on below-ground diversity, soil carbon and nutrient cycling and plant productivity in wet, infertile grasslands. This framework quantifies the correlation between community response traits, which determine how communities respond to environmental changes, and community effect traits, which determine the effect on the next trophic level or the ecosystem (Lavorel et al., 2013). Our aim is to analyse the applicability of this framework in a natural ecosystem. If strong links between response and effect traits exist within and between trophic levels, it should be possible to understand how environmental change will affect ecosystem processes. We will analyse this framework in a long-term field experiment at the Veenkampen near Wageningen. This nutrient-poor grassland is divided in two compartments with different soil water levels, which is ideal for a manipulation experiment with fluctuations in soil water levels. By transplanting terrestrial model ecosystems with assembled communities between plots with contrasting soil water levels, and by shading others from precipitation, inundation and drought events will be mimicked. During the course of this experiment changes in soil properties, such as pH, nitrogen, carbon and phosphate levels, litter decomposition and changes in plant and soil fauna communities will be analysed. Staatsbosbeheer and Natuurmonumenten are involved in this project. They play an important role in decision-making during this experiment and the translation of the results into management practices. This field experiment will start in spring 2014 and will last for three years.

In preparation for this field experiment, we are conducting an analysis to explore which traits best explain the effects of soil moisture changes on detritivore communities. We collected many Dutch isopod, millipede and earthworm species from dry, moist and wet locations. Under standardised conditions we measured inundation and desiccation resistance, together with body size and mass. Oxygen consumption in air and under water and the survival time when submersed were also measured. Desiccation resistance was measured by exposing animals to an air humidity of 85% and then recording

<sup>1</sup> Traits are physiological, morphological and phenological characteristics of an organism.

water loss rate, fatal water loss and survival time . Finally, these results will be correlated with soil fauna distribution data (EIS database Soil fauna) to analyse which traits explain the distribution of the soil fauna in the Netherlands. These traits will then be used to assemble communities in the field experiment.

I will present these results in spring 2014 at the NWO Biodiversity works symposium.



**Figure 1** | A response-to-effect trait framework is used to analyse the direct and indirect effect of environmental change on ecosystems. This framework quantifies the correlation between community response traits (RT) (A), which determine how communities respond to environmental changes, and community effect traits (B), which determine the effect on the next trophic traits or the ecosystem.



**Figure 2** | Taking soil cores in the Veenkampen near Wageningen.

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# Linking resource availability to pollinator diversity and pollination services in agricultural landscapes

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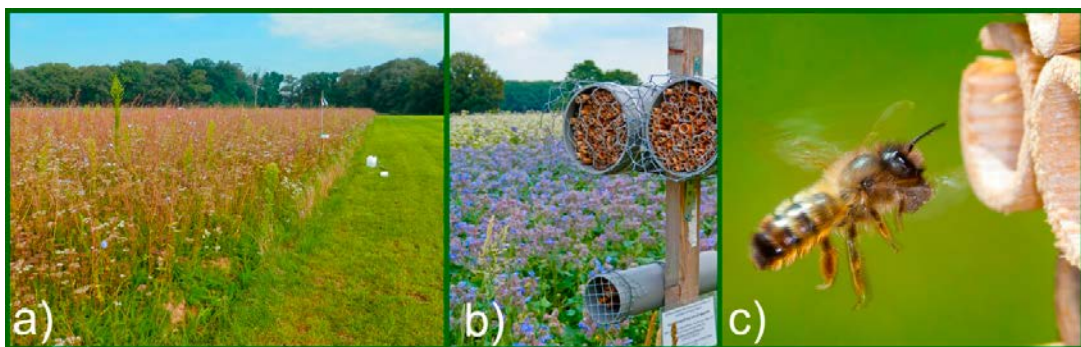
## Introduction

Wild bee communities are experiencing drastic declines across Europe and current intensive agricultural practices are the likely main cause<sup>1</sup>. Against this backdrop of population decline is the important role wild bees fulfil as pollinators of both wild and cultivated plants, and with the increasing demand for quality fruit products their economic importance is likely to further increase. It is not only the abundance of pollinators, but also their species richness, which together determine the maximum pollination efficiency of plants<sup>2</sup> and we can only continue benefiting from natural pollination services, if agro-ecosystems are able to support abundant and species rich wild bee communities<sup>3</sup>. To realise this goal, we need to quantify the role of factors, such as floral abundance, that are essential in sustaining wild bee communities. Several studies have begun uncovering the effects of landscape composition on pollinator communities, with focus on changes in abundance and diversity, and in a few cases, on pollination success<sup>4-6</sup>. Scarcity of floral resources in intensive agro-ecosystems is a purported main driver of wild bees decline. There are several knowledge gaps however, which thwart efforts to quantify the landscape-level effects of floral resources on pollinators. First, studies typically take a correlative approach, where the different factors are quantified and tested for their effect sizes on pollinators. The shortcoming of this approach is the possible confounding effects of variables, such as flower abundance being correlated with habitat types that also provide other subsidies for pollinators. Second, studies typically examine effects of flower provisions within a single year, making it impossible to separate local aggregation responses of pollinators from effects on reproductive success and population growth. Third, the few studies that manipulate floral abundance do so at relatively small spatial scales, where this effect of flower addition may be swamped out by the variation in flower abundance across the surrounding landscape elements. As a result, many studies address the question how local populations of pollinators depend on flower addition within a landscape context. In contrast, we take a different approach to ask the question, how variation in flower abundance affects pollinators at the landscape level. Within a series of reference landscapes, spread across the southern provinces of the Netherlands, we experimentally manipulate the quantity of flower abundance at relatively large spatial scales (0.5 – 5.5 ha). The average (i.e. landscape-level) responses of wild pollinators and associated ecosystem functions are then observed. We quantify the effects of flower addition on wild pollinators not only between landscapes that have or have not received flowering fields, but also across three years. As fields with flowers will only be blooming in the second and third year, variables of interest are then compared to the baseline first season, where the variation in wild pollinator communities across landscape types is quantified (before-after control treatment approach). Third, we employ a range of different tools to simultaneously monitor wild pollinator abundance and diversity, wild bee population growth and pollination of crops. Our main hypothesis is that flower addition to landscapes will increase pollinator abundance and diversity across an entire reference landscape. We expect that flower addition will also increase reproductive output and population growth of wild pollinators and that this increase will translate into an increase in pollination rates. We expect that compared to control landscapes (no flowers added), the effect-size of adding flowers to landscapes on wild pollinators will increase across

the three years. We are currently in the process of collecting data from the second season and analysing the dataset of the first “baseline” year, where the variation in the composition of different landscapes is correlated with pollinator abundance, population growth and pollination services. What follows is an overview of our approach and some preliminary results from the first season. Our expectation for the first year was that with an increasing amount of arable land (crops, pastures) within a landscape, a negative trend in wild bee abundance, population growth and pollination would be observed. This expectation is based on the scarcity of floral food in these landscape elements and on the high disturbance regimes that habitats in these landscapes experience.

## Methods

Twenty reference agricultural landscapes (50 ha each) have been selected across the southern part of the Netherlands arranged in 10 pairs. Within each of the 10 pairs, one of the landscapes has received a flower field, ranging in size between 0.5 ha and 5.5 ha (Figure 1a). Fields were sown with the same standardised flower mixture. For each of the landscapes, the land cover by arable fields (annual and perennial crops, grassland) was quantified using ArcGIS 10.0. To study the native bee populations and pollination services, different experimental set-ups were placed in field boundaries bordering agricultural fields. To measure pollinator abundance and species richness of wild bees, we used pan traps placed in comparable vegetation background. Six trapping stations were spread across each landscape with a minimum distance of 100m between traps, so that landscape-averaged samples of abundance can be acquired. Traps operated over two to three censuses in the summer months. To quantify the potential effect of landscape context on reproduction and population growth of cavity-nesting solitary bees, we placed trap-nests (or ‘bee hotels’; tubes containing reed stems for cavity-nesting bees) in each of the landscapes. Similar to pan traps, six trap nests were placed in each landscape and operated from April until October (Figures 1b and 1c). In the winter, the colonised reed internodes were carefully opened and the numbers belonging to different groups (genus level) of cavity-nesting bees were counted. To compare the effects of landscape composition on pollination, insect-pollinated crop plants such as strawberry (*Fragaria x ananassa* Duchesne ‘Elsanta’) and onion (*Allium cepa* L.) were used as phytometers. Plants were grown in a screen house until just before the onset of flowering when they are transported to the fields. Fruits were harvested and pollination was determined.



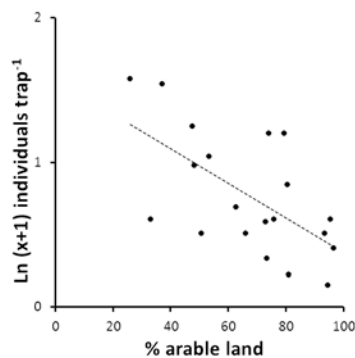
**Figure 1** | Picture of a) a field of flowers next to grassland (Sint Odiliënberg), b) a trap nest used to measure solitary bee populations and c) the mason bee *Osmia bicornis* L. returning to a nest.  
Photos: a) and b) by Esther Klop and c) by T. Bukovinsky.

## Preliminary results

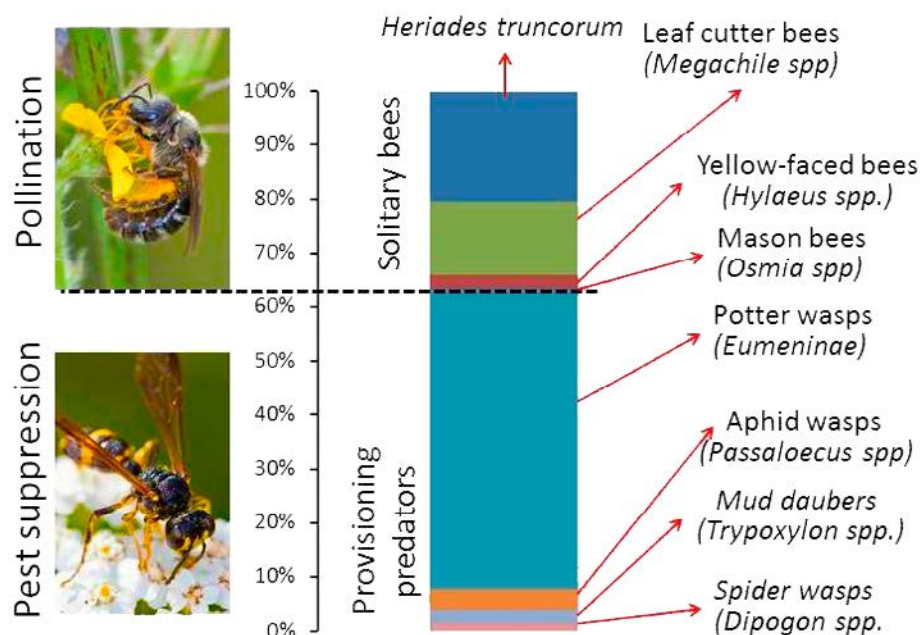
Pan trap catches revealed that the considerable variation in pollinator abundance across the landscapes was related to the variation in the amounts of different landscape elements. Landscape composition appeared to influence catches of pollinators, with fewer pollinators being caught in landscapes containing high percentages of arable land (Figure 2). Eight taxa of cavity-nesting Hymenoptera have



been recorded in the trap nest material, with half of them belonging to pollinators, the other half to predatory species, which in most cases provisioned their offspring with herbivorous insects such as caterpillars (e.g. potter wasps, Figure 3). Similar to the pan trap data, the number of colonised reed internodes in trap nests was also negatively correlated with the percentage arable land. When the dominant pollinator leaf-cutter bees (*Megachile spp*) and the predatory potter wasps (*Eumeninae*) were compared across landscapes, a similar picture was observed: land use intensity was negatively correlated with colonisation rates by these two species groups (Figure not shown). A significant part of the variation in the observed levels of pollination of strawberry plants could be explained by land use intensity. This relationship appeared to be non-linear, with pollination limitation in landscapes cleared of most semi-natural habitats, whereas maximum pollination levels were reached at relatively low percentages of semi-natural landscape elements. In other words, there are landscapes where the pollination of even a small group of (eight) plants by insects appears to be limited by the quality of the landscape. In the starting year, virtually all flowers available for pollinators could be found in non-productive landscape elements, such as extensively managed meadows, road verges and field edges. It will therefore be very important to measure whether besides the effects observed this first year, i) the experimental flower additions to landscapes have resulted in any measurable effects on pollinator communities and ii) if there are “threshold” levels of flower addition that must be present to maintain stable pollinator communities and associated pollination functions in our agricultural landscapes.



**Figure 2** | Effect of landscape intensification (% arable land) on abundance of solitary wild bees. Note that this is preliminary data set based on rough estimates, detailed landscape mapping is currently underway.



**Figure 3** | Distribution of the taxa of different pollinator and predatory hymenoptera colonising the trap nests. Data based on 1247 internodes.

## Acknowledgement

This project would not be possible without the following organisations. NWO Biodiversity works, Syngenta, Bloeiend Bedrijf, Horster Landschap, De Ploegdriever, Gemeente Groesbeek, Stichting Limburgs Landschap, Natuurmonumenten, Staatsbosbeheer. In addition, we are grateful for the collaborations with several farmers and contact persons without which we could not carry out this research.

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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.



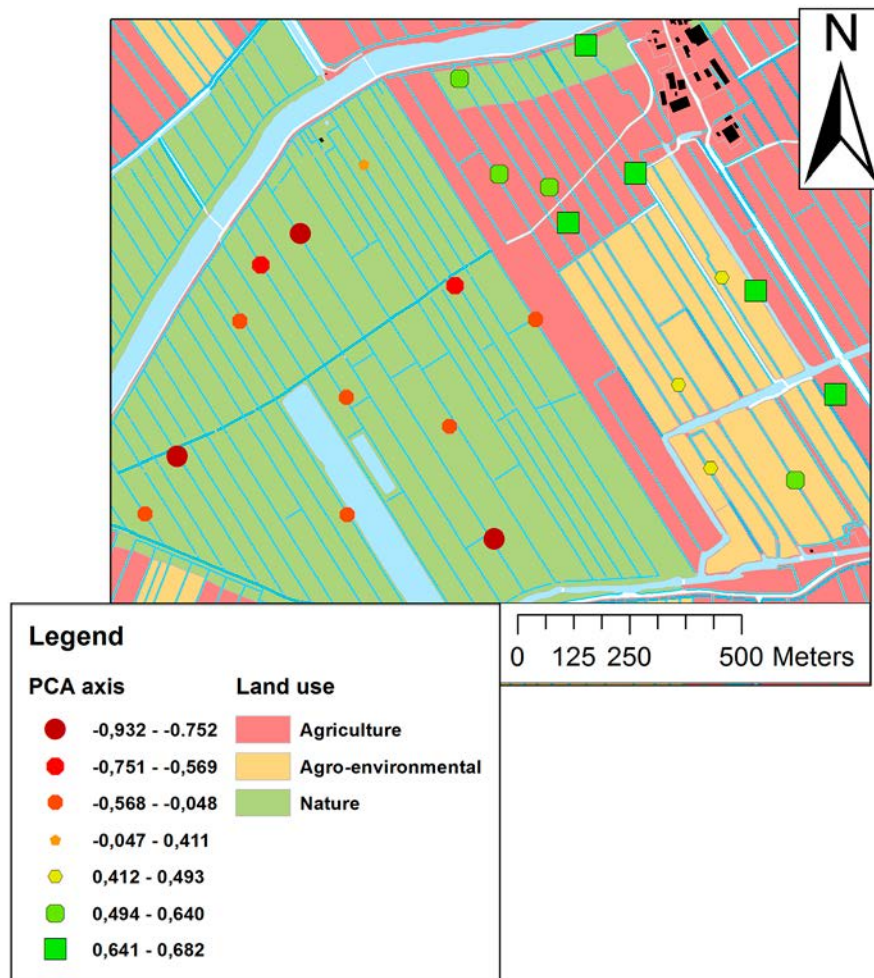
Figure 1 | Zooplankton sampling in the field. Photography: Lisa Freitag

## Some preliminary results

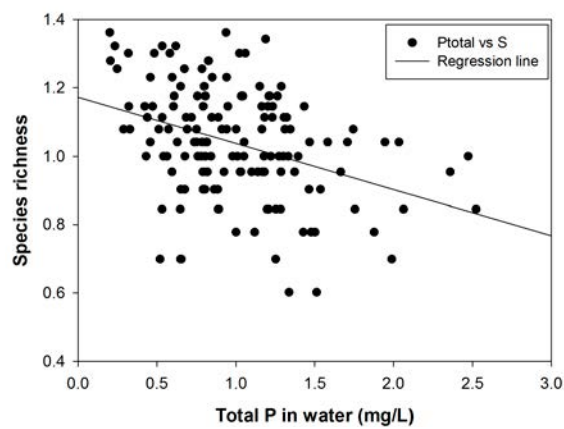
In the course of two field seasons (2012, 2013) we have sampled 360 ditch reaches, encompassing over 3000 hectares of land in 15 different study areas. Preliminary analyses of these field data show some distinct small-scale community patterns that seem to be associated with heterogeneous land use. Figure 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:  $R^2_{\text{adj}} = 0.134$ ,  $F = 22.98$ ,  $p = 0.001$ ), 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).

# Predicting changes in ecosystem functioning from shifts in plant traits

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Stakeholders: Netherlands Environmental Assessment Agency (PBL), State Forestry Service (SBB),

National Authority for Data concerning Nature (GAN)

## Background and aim

Ecosystem functioning depends not just on species diversity but also the functional diversity within plant communities based on functional traits of species. A better understanding of how functional diversity is influenced by environmental change is a prerequisite for predicting changes in ecosystem functioning and for realising cost-efficient management strategies. To link environmental changes to ecosystem functions and associated ecosystem services, we will distinguish between two aspects: on the one hand traits determine the response of the plants to environmental change and on the other hand traits are instrumental for the effect that plants impose on ecosystem functions and ecosystem services (response-to-effect framework). By using traits of known importance to ecosystem functions, shifts in trait composition within communities can be used as indicators (proxies) for changes in ecosystem functions and associated ecosystem services.

The objectives of this project are:

1. To develop a set of trait-based indicators of ecosystem functions and associated ecosystem services;
2. To link changes in habitat quality and connectivity to shifts in indicators of ecosystem functions and services.

By combining recent trait databases with the Dutch National Vegetation Database, containing over 562,000 geo-referenced site descriptions of species composition and habitat characteristics (see Schaminée et al. 2012; Bongers et al. 2013), we can achieve our objectives in a way that was not previously possible. For the analysis of trait-environment relationships we have developed a new generalised linear mixed model approach (see Jamil et al. 2013). We have established collaborations with several other research groups.

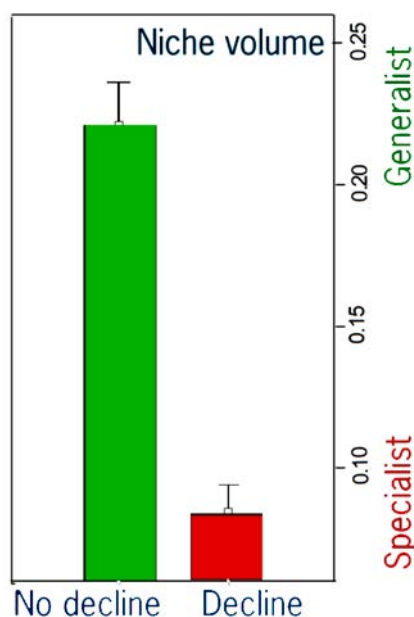
## First results

In the first phase of the project we focused on the response-side of the story by looking at the performance of specialists and generalists across ecological and evolutionary scales. We combined species-level information on species co-occurrences in small plots, habitat requirements, phylogeny, life-history traits and long-term trends. Using the Dutch Vegetation Database, we quantified niche volumes of Dutch plant species and used sister taxon comparisons to compare specialist and generalist sister taxa for the relative numbers of descendants across two temporal scales: ecological and macro-evolutionary (see Ozinga et al. 2013).

We showed, first, that specialist species are more likely to be currently in decline, i.e. to leave only few descendant populations. Second, most specialist clades left fewer descendant species within a region than their generalist sister clades. These results held after accounting for species life histories.



Differences between specialist and generalist sister clades increased with clade age, suggesting that they reflect differences in rates at which specialists left descendants (rather than differences in ecological limits to the numbers of specialists and generalists). We conclude that specialists left only few descendants within a region (i.e. the Netherlands), at both the ecological and macro-evolutionary scales. While specialists may leave numerous evolutionary descendants at a global scale, these might be absent from most regions. Humans, by threatening specialist species, may therefore further accelerate biotic homogenisation, with descendants of generalist lineages proliferating within regions while specialist lineages disappear.



**Figure 1** | Relationship between niche volume of species and their declining or non-declining population trend in the Netherlands during the 20<sup>th</sup> century (from Ozinga et al. 2013). Analyses were based on phylogenetically independent contrasts: small-niche species were declining while large-niche sister species were not in 76% of 115 non-zero sister-species comparisons (sign test;  $Z = 5.41$ ;  $P = 10^{-4}$ ; all tests two-tailed).

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## Ecosystem functions of invasive aquatic plants

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Invasive species are considered one of the major threats for worldwide biodiversity. They are linked to degradation of habitat quality, loss of species, spread of disease and economic loss. Estimated costs of maintenance, mitigation and eradication programmes related to invasive species are in the range of millions to billions of dollars. However, there are also situations known in which invasive species represent a desired part of ecosystems. For example in the IJsselmeer, exotic mussels are staple food of waterfowl. Comparing invasive species with their native counterparts will increase our knowledge of how invasive species affect ecosystem functioning.

The model system of choice are submerged aquatic plants. These have a wide range of ecosystem functions like water quality (clear macrophyte-dominated or turbid green soup), providing food for higher trophic levels, providing habitat and shelter for macrofauna and nutrient cycling. A selection of these has now been tested in experiments where we compared native and exotic species on equal terms. A large outdoor experiment using cattle tanks (Figure 1) was initiated, and is still running, in which we are comparing native and exotic submerged species and their competitive ability against a 'native plant community'. Additionally, macroinvertebrate diversity is known to be strongly affected by the vegetation composition. To compare native and exotic species, another outdoor experiment was conducted to check how an assemblage of macroinvertebrates would function in monoculture of various plant species (Figure 2). The results will be analysed during the winter. As this study does not provide insight into the palatability of exotic species, a separate lab experiment has been initiated. We are investigating how different plant species of varying origin and with different plant traits are consumed by snails of a different origin (Figure 3).



**Figure 1** | Outdoor experiment to test the impact of exotic and their native counterparts on a 'standardized plant community'.



**Figure 2** | Experimental design to compare macroinvertebrate assemblages on monocultures of various native versus exotic species.



**Figure 3** | Snail herbivory experiment utilising lots of beakers.



Water quality is particularly important, especially in a water-rich country like the Netherlands. Therefore, a field study was conducted to gain insight into the water quality and floral diversity of peatland waters invaded by exotic plants (Figure 4).

Some results have already been presented in Poznan (Poland) and Niagara Falls (Canada) during conferences about macrophytes and invasive species respectively.



Figure 4 | Sampling during field work.

# Restoration groundwork: testing large-scale soil transplantation to facilitate rapid vegetation development on former arable fields

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In small densely populated countries like the Netherlands nature is under constant pressure and very few opportunities for the development of new natural areas exist. So in the Netherlands we should try to get the very best out of the limited areas available for nature.

Former arable fields that have been abandoned due to the economic demise of the farms they once served present one opportunity for new nature. Unfortunately, ecological succession is a slow process and the development of a biodiverse community of plants and animals on these fields can take many decades. Important problems for restoration of these areas are the high level of nutrients and the lack of proper seeds in the soil. This leads to the dominance of competitive weeds, which make for low quality nature reserves. On the bright side, however, it has been shown that particular communities of soil organisms can speed up succession and benefit the growth of target species. This fundamental research has so far been restricted to pots in greenhouses and validation in the field has been lacking.



**Figure 1** | Satellite image of the Reijerscamp, clearly visible are the four large excavation areas – the darker areas within them are the soil transplantations.





**Figure 2** | One of the excavation areas immediately upon transplantation in 2006. In the foreground an area treated with donor soil, in the back no soil was added.

To test the potential of natural soil communities to jump start ecological succession on former arable fields, NIOO has created a large field experiment in collaboration with Natuurmonumenten<sup>1</sup>, one of the largest nature conservancies in the Netherlands. On the 160 ha of the Reijerscamp, an arable field near Wolfheze (NL) abandoned in 2006, large excavations have been dug to remove the excess nutrients from the soil (Figure 1). Subsequently large parts have been treated with a thin layer of soil collected from well-developed nature areas to introduce a later successional soil community (Figure 2). Sods, which are cut once in a while as part of the normal management of heathlands, can be used as donor material for such transplantations.

Now, six years after the start of the experiment, we have conducted the first scientific evaluation and the results are striking. While areas that have not been treated with donor soil still appear barren and support little vegetation, the soil transplants already have a well-developed plant cover, which in August and September colours bright purple from the flowering heather plants (Figure 3). These first results were met with great enthusiasm at the 56<sup>th</sup> Annual Symposium of the International Association for Vegetation Science in Tartu (Estonia), where our presentation was part of a special session on the role of soil biota in shaping the species composition of plant communities and received the second prize in the IAVS's Oral Presentation Award.

We are now completing our analysis of the soil community (nematodes, mites, bacteria and fungi) in the area and have started writing up the results for our first scientific publication of this project. In addition, we are preparing a mini-symposium with Natuurmonumenten and a number of people who voluntarily collect data on the Reijerscamp to share experiences and ideas. Furthermore, we are working on several other experiments that aim at a better understanding of the role of spatial heterogeneity in soil communities in relation to plant diversity.

<sup>1</sup> For a short video see: <http://www.youtube.com/watch?v=4Cu7382XGDw>





**Figure 3** | Six years after the start of the experiment little vegetation has developed in the areas where no soil was transplanted (Top). In contrast, the heather is flowering beautifully in the areas that were treated with donor soil (Bottom).

## Exploiting knowledge on habitats used by arthropods to predict value of ecosystem services in agro-landscapes

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Intensification of farming systems and landscape simplification have led to a deterioration of natural biocontrol and pollination services in many parts of the world. Natural and semi-natural vegetation in agricultural landscapes provide refuge and essential resources (e.g. nectar) for beneficial arthropods that provide these ecosystem services. Consequently, these relatively undisturbed habitats have been associated with higher abundance and diversity of natural enemies and pollinators, and with enhanced biocontrol and pollination services in nearby crop fields. The provision of resources is not only a matter of the right spatial distribution; the resources should also be available at the right time in the year to support effective densities of service providers. In this project we aim to clarify the relation between the spatiotemporal distribution of resources in the landscape and the spatial distribution of the ecosystem services of biocontrol and pollination. We put special emphasis on trade-offs and synergies of different landscape configurations for supporting multiple ecosystem services and land use functions. As such, the project aims to guide the design of multifunctional landscapes.

During the first phase of this project we have developed a plant database that collates information on the availability of plant resources for different groups of natural enemies and pollinators, and the time that these resources are available. This information can – in combination with information on the spatial distribution of the plant species in the landscape – provide a detailed overview of the spatiotemporal distribution of resources for ecosystem providers. Preliminary results show that with this approach landscapes can be analysed in a mechanistic and dynamic manner by taking the dynamic resource availability for mobile ecosystem service providers into account.

The trade-offs and synergies between ecosystem services will be evaluated in two case study areas in the Netherlands: the Hoeksche Waard and eastern part of the Flevopolder. We have already organised a number of meetings with stakeholders from both areas for bottom-up input, including farmers, local authorities, landscape and nature conservation organisations and water boards. In the Hoeksche Waard we are also involved in development of a programme by the provincial government for sustainable rural development with ecological intensification of arable production.

The project intensively cooperates with other projects, some of which are in the Biodiversity works programme as well. With several projects in the programme we hold meetings once or twice per year to discuss progress and outcomes and to look for synergies between the projects. In the work in the case study areas we cooperate with two projects (University of Amsterdam: 'Does landscape complementation promote biodiversity and ecosystem services?' and Wageningen University 'Spatial patterns and dispersal of earthworm populations in a complex landscape – implications for soil ecosystem services'). With another project we are cooperating in a field experiment by MSc students (Wageningen University 'Linking resource availability to pollinator diversity and pollination services in agricultural landscapes').





**Figure 1** | A sown flower strip in the Hoeksche Waard for supporting natural enemies with floral resources (*photo Menko Wiersema*).



**Figure 2** | Semi-natural vegetations provide resources for natural enemies and pollinators as well as other ecosystem services (*photo Willemien Geertsema*).

# Understanding the role of plant traits and their plasticity in N:P stoichiometry and competition

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## Background

Plant species richness in European grasslands has been declining for several decades. In most Dutch nature reserves species richness is also slowly but steadily declining. Restoration areas often show low species richness, even years after agricultural use has been ceased. Nitrogen (N) and phosphorus (P) are thought to play an important role in this plant species decline. Earlier research mainly focussed on the effects of N (e.g. Stevens et al., 2004; Bobbink et al., 2010), but more recently it was found that P also plays an important role (Wassen et al., 2005; Ceulemans et al., 2012). Prevailing plant competition theories suggest that there are trade-offs between plant traits used by the plant to deal with nutrient limitation and that these trade-offs influence the outcome of competition. Recent experiments, however, have shown that several grassland species have the flexibility (phenotypic plasticity) to adapt their plant traits depending on the type of nutrient limitation present (Fujita et al., 2010; Olde Venterink & Güsewell, 2010). We test the hypothesis that the competitive winners in modern grasslands are those species that have a high phenotypic plasticity for plant traits involved in nutrient acquisition, use and recycling. As such, they can adapt their traits more easily to changing nutrient limitations and thus outcompete less flexible species.

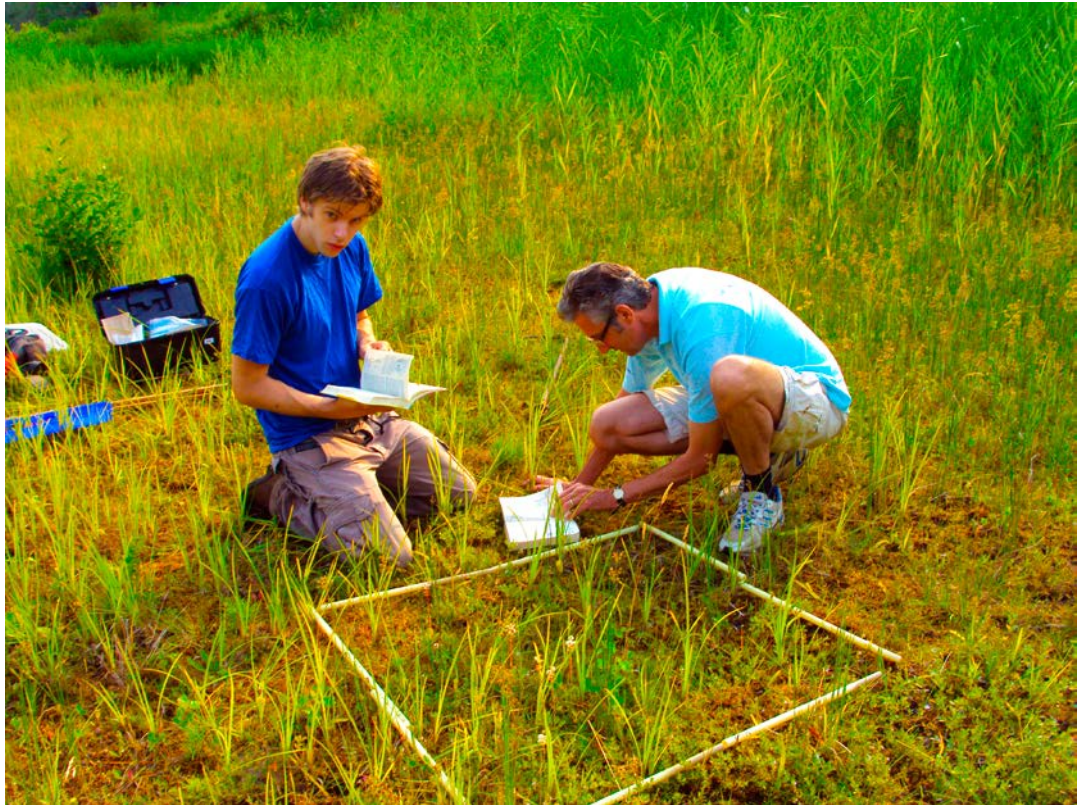
## Identification of opportunist and specialist species

The type of nutrient limitation is based on the N:P stoichiometry (the ratio of N divided by P) of aboveground vegetation. N:P values of 13.5 to 16 indicate co-limitation of nitrogen and phosphorus, values > 16 indicate P-limitation, values < 13.5 N-limitation (Güsewell & Koerselman, 2002). We then used these limitation types to analyse an existing database containing field observations of nearly 700 plots from 11 different European countries (Fujita et al., 2013 in review). If a species occurred significantly more often under P-limited conditions and significantly less under N-limited conditions, it was classified as a P-limited specialist species (and vice versa). Species showing no significant preference were classified as opportunists. We expected these opportunists to have a higher phenotypic plasticity than the specialists.

## Trait plasticity in the Netherlands: preliminary fieldwork

We would like to assess the plasticity of plant traits in the field. To do this accurately, we will focus on several selected species and analyse these along the full N:P range. We expect to find more N-limited than P-limited grasslands in the Netherlands. We did preliminary fieldwork to check the N:P ratio of potentially interesting study areas in the summer of 2012 (Figure 1). We visited nature reserves of Natuurmonumenten, Staatsbosbeheer and Dunea in seven different provinces. We determined which plant species were present and took plant and soil samples for analysis. In the summer of 2014 we hope to continue our fieldwork at selected sites, investigating plant trait plasticity in the field in relation to N:P stoichiometry. We would like to thank the nature managers and field staff members that helped us locating interesting areas.





**Figure 1** | Professor Martin Wassen and former bachelors student Stef Koop in nature reserve Middenduin, July 2012 (Staatsbosbeheer/National Park Zuid-Kennemerland).

## Trait plasticity and the outcome of plant competition

To investigate the effect of trait plasticity on the outcome of plant-plant interactions we carried out a greenhouse experiment in spring-summer 2013. Using the results of the database analysis and the preliminary fieldwork, we chose six interesting species for our experiment: *Alopecurus pratensis* (Meadow foxtail) and *Rumex acetosa* (Common Sorrel) as likely N-limited specialists, *Briza media* (Quaking Grass) and *Centaurea jacea* (Brown knapweed) as likely P-limited specialists and *Knautia arvensis* (Field Scabious) and *Prunella vulgaris* (Selfheal) as likely opportunists.

We wanted to assess the competitive response (biomass of species A in monoculture vs. biomass of A in competition) as well as the relative dominance (biomass of species A vs. biomass of species B in competition), following Olde Venterink & Güsewell (2010). We therefore placed all species in monoculture, and made competition pots with specialists vs. opportunists. We used five different N:P ratios to cover the range from severe N-limitation to severe P-limitation. Combined with 3 different total nutrient levels (low, medium, high) this resulted in 15 different nutrient treatments. To compare long-term effects with short-term effects, we chose to harvest half of the experiment this year and half of the experiment next year. In the end, our experiment consisted of more than 2100 pots, each containing 4 plants (see Figure 2). During the harvest of this year, we measured several plant traits, such as leaf length, root:shoot ratio, specific leaf area, specific root length and root phosphatase production. We are currently busy with the first analyses of the experimental data. We will present these and other results during the next meeting in spring 2014. For more information (in Dutch) visit our project website: [www.uu.nl/copernicus/kasexperiment](http://www.uu.nl/copernicus/kasexperiment).



Figure 2 | The greenhouse experiment at the Botanical Gardens of Utrecht University, May 2013.

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# CONNECT

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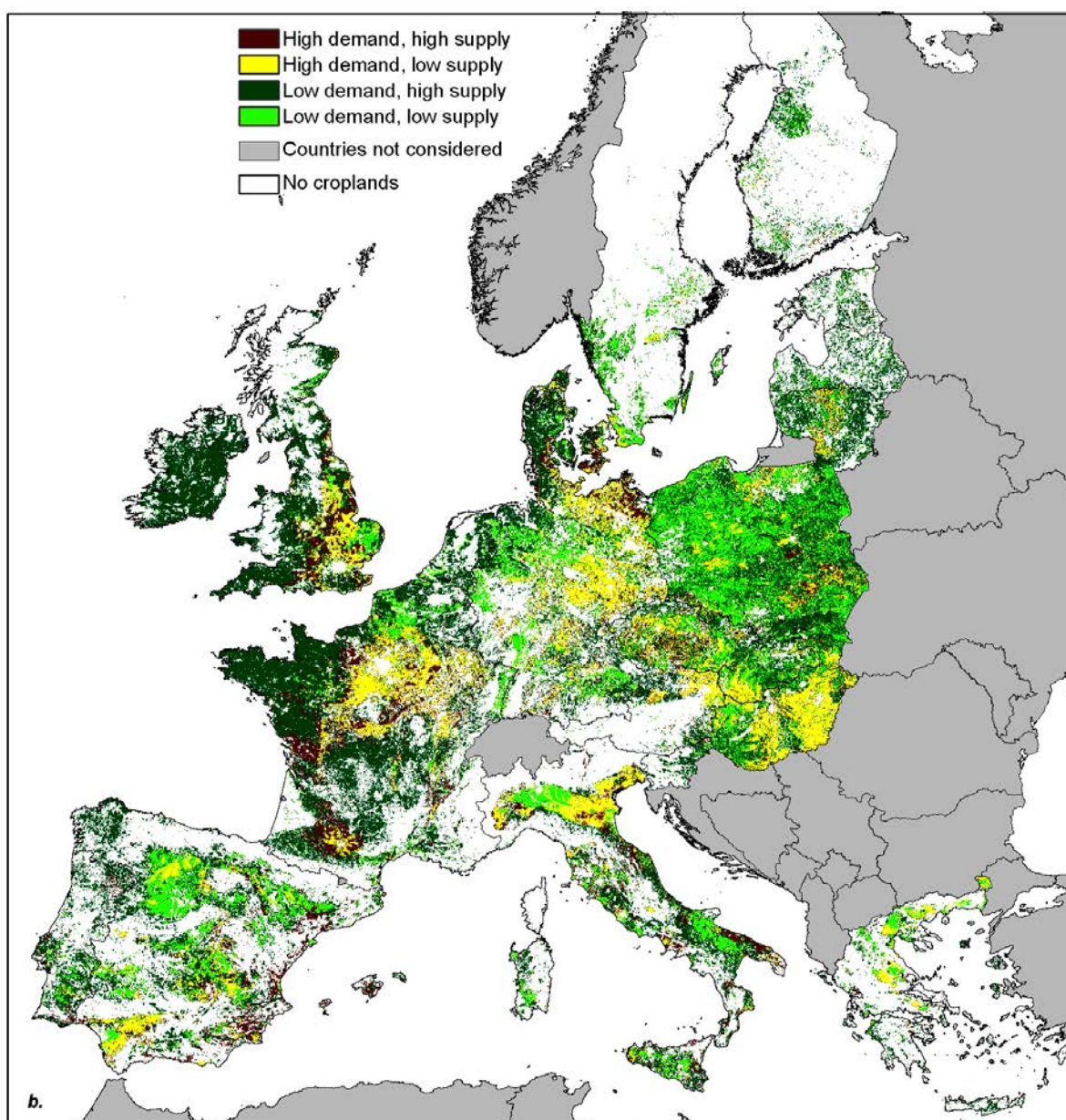
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CONNECT aims to link biodiversity with ecosystem functions, their services and economic values and to assess the effectiveness of policy options to conserve biodiversity. Researchers from IVM-VU are contributing to two topics in CONNECT: i) linking ecosystem functions with ecosystem services, and ii) developing, testing and evaluating novel methods for valuation of ecosystem services.

For linking ecosystem functions to services, we are focussing on mapping and modelling the demand and supply of ecosystem services at the European scale. Mapping the supply of ecosystem services is a well-worked-out topic, while attention for the actual use of ecosystem services by people has arisen only



**Figure 1** | Hotspots for the supply and demand for pollination and overlap between the hotspots.

<http://www.sciencedirect.com/science/article/pii/S1470160X13002768>

recently. Mapping the demand for ecosystem services and the match between demand and supply can be helpful for setting priorities for biodiversity conservation. It is therefore particularly interesting for EU policy makers.

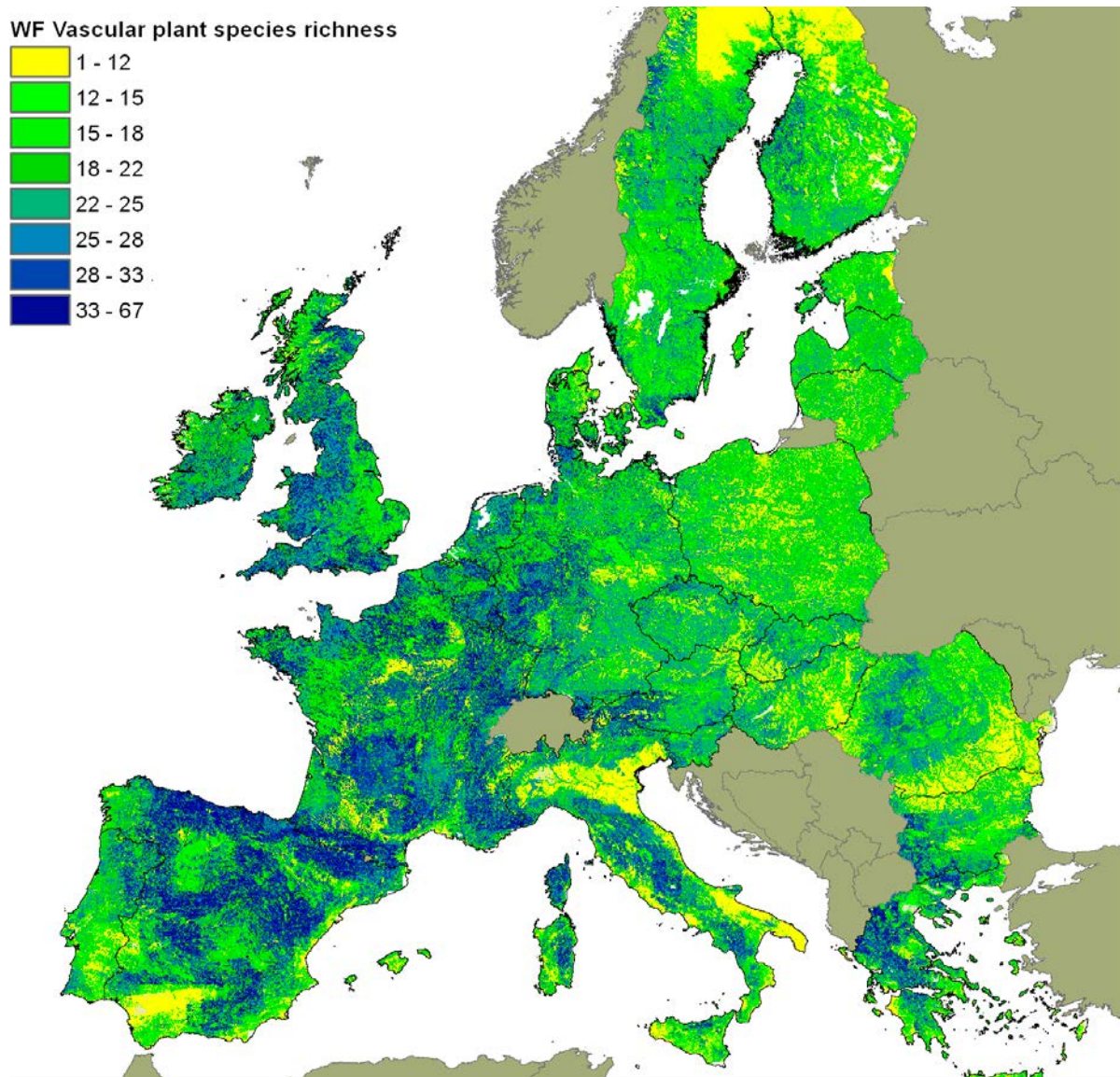


Figure 2 | Species richness of wild edible plants in Europe.

We analysed the ecosystem service of pollination by unmanaged pollinators. As a proxy for the efficiency of pollination at the scale of the EU, we first mapped suitable habitats in green linear elements, forest edges and small patches of nature. Next, the efficiency of pollination was mapped as a function of the distance to these habitats. To map the demand, croplands benefiting from biotic pollination were mapped. Finally, we analysed the match between demand and supply. We demonstrated that in a significant part of the EU the supply of pollination is dependent on the presence of small linear landscape elements. This study has been presented of the European Conference Conservation Biologists in Glasgow in 2012.

A second mapping study is an inventory of the supply and demand for wild food in the EU. Wild food is an ecosystem service that is rarely mapped due to a perceived low economic value and lack of data. By combining a systematic review with available data on species distribution and socioeconomic factors explaining the demand for wild food, we were able to provide a first Europe-wide map of this iconic and widely enjoyed ecosystem service.

As a third mapping topic, we are performing a map comparison and evaluation of existing European-scale maps of ecosystem services. Ecosystem services are increasingly becoming a target in EU policies and so there is a need for accurate maps and models. Several mapping and modelling approaches have been developed, in which for a few services a range of different maps are produced. We are identifying the resemblances and differences between maps and the reasons for these. We will give recommendations for good practices for mapping ecosystem services at continental scale. The initial results of this study were presented at the European conference of the International Association of Landscape Ecology in Manchester last September.



## Sympathy for the commons: Developing funding & support communities for the cultural ecosystem services of individual nature areas

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The overall aim of the research project 'Sympathy for the Commons' is to investigate whether online communities can be an effective way for translating the strong appreciation of individuals for specific nature areas into new ways of community support and funding for these nature areas. The diminishing amount of financial support from the Dutch government for nature conservation has resulted in policy makers and nature conservation organisations searching for new ways of financing nature conservation. Financing nature conservation continues to be a challenge in other countries as well. The focus of our research project is to discover effective ways of generating financial and other support through building online communities for individual nature areas. High biodiversity nature areas are commonly seen as public goods. Typically, although these areas may be valued by many people, and even though these people may all benefit individually from these areas and recognise a collective interest in conservation, effective collective action to support their conservation may not be appropriately set up yet. These online communities may be effective as a means of overcoming this 'illogic' of collective action around protected and appreciated nature areas. Furthermore, we think that given the reduced government support for nature areas there is much to learn from the latest developments in the marketing of private goods. Successful organisations in private markets are increasingly using customer engagement behaviour like blogging and word-of-mouth through Facebook and co-creation activities, volunteer work, collecting donations, etc. In this research project we consider 'customer engagement behaviour' to be a valuable tool for inspiring public involvement and commitment to nature areas. Online communities offer possibilities for this.

A central element of the project is the Hotspotmonitor (HSM), an online survey tool in which respondents designate their most attractive natural areas on an online map. This in itself already yields very useful and interesting information. At this moment we are using the HSM for a large survey in the Netherlands, Germany and Denmark, in which we aim to include a total of 5000 respondents. The HSM was developed some years ago, but it still being further refined. An addition to this survey round is a set of questions about respondents' personal and social values. This allows us to characterise people not just on the basis of demographics but also their personal values, using a method that is internationally applicable.

Later on in the project we want to increase the number of respondents for the Hotspotmonitor with the help of the media partners involved in the project, like the magazine *Psychologie* and the radio programme *Vroege Vogels*. Reaching more people is important because the HSM will form the starting point for our communities: we want to invite people who have completed the HSM to become a member of online communities around their favourite natural places. At the moment we are working on the websites that will provide the basis for the online communities. A number of nature conservation organisations (for instance Natuurmonumenten, Staatsbosbeheer) are involved in the project. They are sharing their ideas about the design of the online communities and later on they will help moderate part of the online communities. We are now busy formulating our ideas about what viable online communities for nature areas should look like. Also some experts on online communities and software development are involved in the project, like 'Science in action' and 'De Ontwikkelfabriek'. Minne Oostra from 'De Ontwikkelfabriek' is also a member of the project team. As software developer he is responsible for developing the software for the online communities. We are still in the phase of forming ideas and exploring the technical possibilities. Furthermore, the project is not just about the online

communities but also about the 'back office'. The aim of the 'back office' is to provide a management information system based on the HSM and the community data that nature conservation organisations can use for their nature areas.

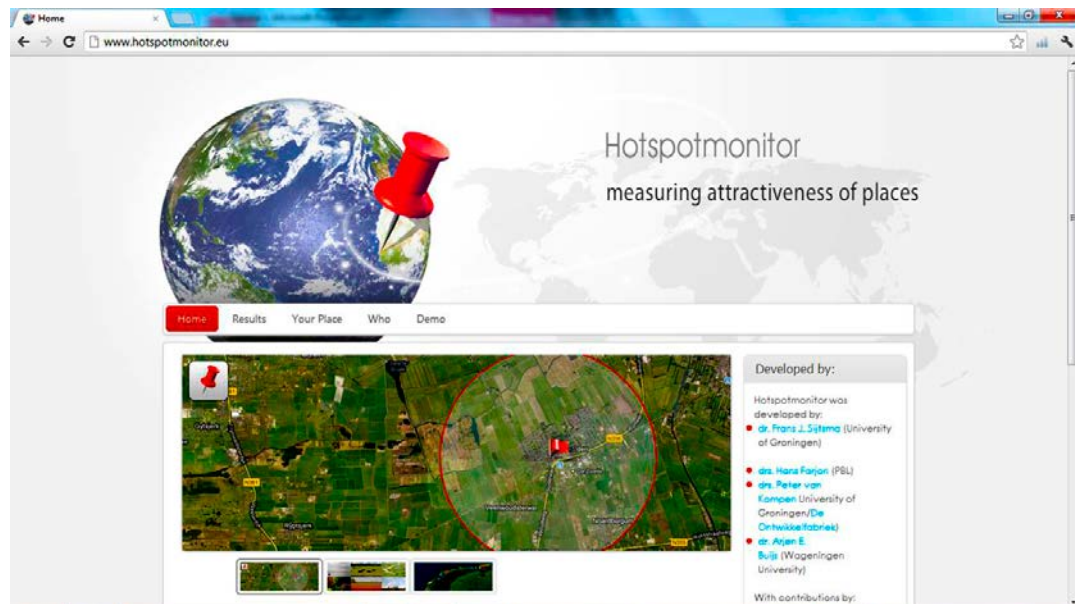


Figure 1 | Hotspotmonitor.

We presented our first ideas about the project at two international conferences: the International and Interdisciplinary Conference on Emotional Geographies in Groningen (1-3 July) and the European Regional Science Association Conference in Palermo, Italy (27-30 August). On both occasions the project was received very positively. In addition to their enthusiasm about the idea, the participants provided useful feedback on the project, which will help us to develop it further.

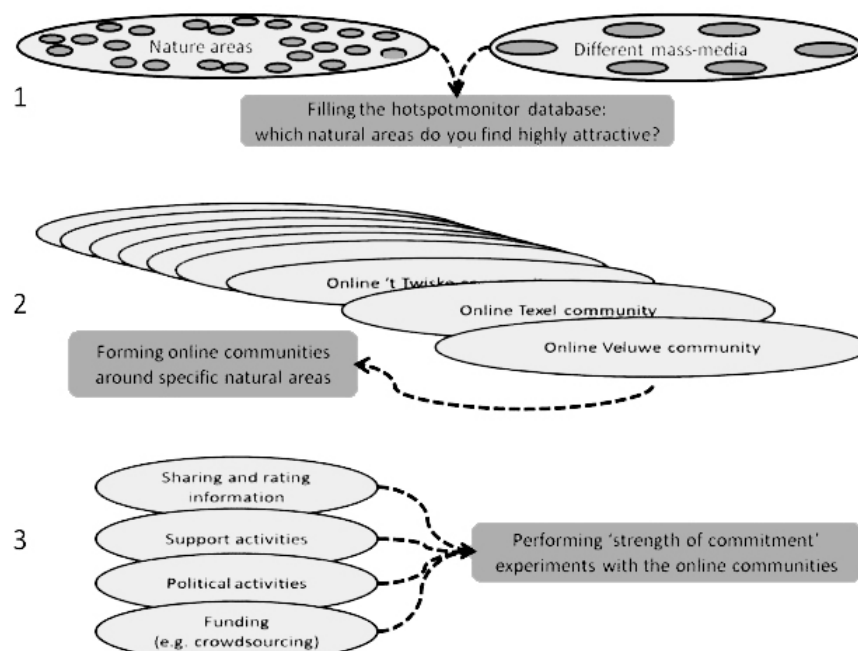


Figure 2 | Our three step research methodology.



Figure 3 | Presenting the project at the ERSA conference in Palermo.

## Links

[www.hotspotmonitor.eu](http://www.hotspotmonitor.eu)

[www.sympathyforthecommons.eu](http://www.sympathyforthecommons.eu)

## Related publications

F.J. Sijtsma, M.N. Daams, H. Farjon and A.E. Buijs (2012). Deep feelings around a shallow coast. A spatial analysis of tourism jobs and the attractiveness of nature in the Dutch Wadden area. *Ocean and Coastal Management*, 68, pp. 138-148. DOI: <http://dx.doi.org/10.1016/j.ocecoaman.2012.05.018>

F.J. Sijtsma, H. Farjon, S. van Tol, P. van Kampen, A. Buijs and A. van Hinsberg (2012). Evaluation of landscape changes -Enriching the economist's toolbox with the Hotspotindex. In: W. Heijman, & C. M. J. v. d. Heide (Eds.), *The Economic Value of Landscapes*. London: Routledge. pp. 136 - 164.

S. de Vries, A. Buijs, F. Langers, H. Farjon, A. van Hinsberg, F. Sijtsma (forthcoming). Measuring the attractiveness of Dutch landscapes: identifying national hotspots using Google Maps. *Applied Geography*.



## Provinces responsible in the future for Dutch wildlife policy

In the future, the provinces and public organisations will jointly be responsible for realising Dutch wildlife policy. By 2027 they must have created 80,000 hectares of new wildlife areas and important wildlife corridors must have been realised. State Secretary for Economic Affairs, Sharon Dijksma, and the provinces have agreed that with each other in the Wildlife Pact [*Natuurpact*].

The Wildlife Pact must guarantee a healthy balance between nature conservation and sufficient space for economic development. Up until the end of 2017, 800 million euros is available for the provinces and after that a structural budget of 200 million euros per year will be available. As an extra boost to the realisation of the policy, the provinces will acquire 4000 hectares of ground from the government against payment. At the same time the government will transfer 14,000 hectares of ground to the provinces. This will put the provinces in charge of how all ground is used for the realisation of a robust nature network in the Netherlands.

The full press release from the Ministry of Economic Affairs can be read here (in Dutch).

(Dit is de link die in het stuk moet worden geplaatst: <http://www.rijksoverheid.nl/nieuws/2013/09/18/economie-en-natuur-hand-in-hand-in-natuurpact.html>)